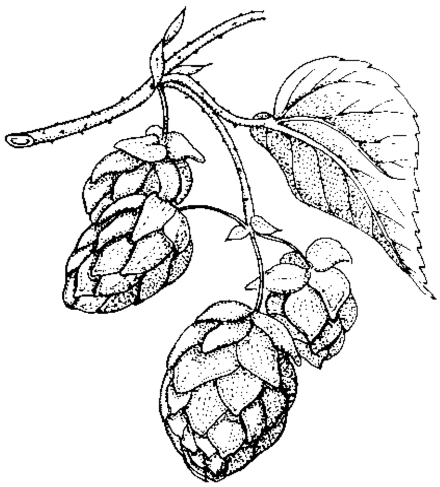
Bayerische Landesanstalt für Landwirtschaft

Gesellschaft für Hopfenforschung e.V.

Annual Report 2022

Special Crop: Hops

V



Bavarian State Research Center for Agriculture

- Institute for Crop Science and Plant Breeding -

and

Society for Hop Research e.V.

May 2023

LfL-Information

Imprint

Publisher:	Bayerische Landesanstalt für Landwirtschaft (LfL) *(Bavarian State Research Center for Agriculture)* Vöttinger Straße 38, 85354 Freising-Weihenstephan Internet: http://www.LfL.bayern.de
Edited:	Institut für Pflanzenbau und Pflanzenzüchtung, Arbeitsbereich Hopfen *(Institute for Crop Science and Plant Breeding, Hops Department)* Hüll 5 1/3, D-85283 Wolnzach E-Mail: Hopfenforschungszentrum@lfl.bayern.de Tel.: (+49) 81 61/86 40 23 00
Translation:	Cerevisia Communications LLC (Virginia, USA)
1ST Edition:	March 2023 (German); May 2023 (English)
Nominal fee:	15.00 €

Annual Report 2022

Special Crop: Hops

Foreword

The year 2022 will be remembered as …

The year when the Corona crisis finally came to an end and social life returned to normal.

The year Russia invaded Ukraine and started a prolonged war.

The year of extreme price increases for energy, supply chain difficulties, and economic upheaval.

The year of dramatic reductions in hop yields per hectare and simultaneously rising costs.

The hop industry now faces major challenges. The price-cost ratios are off balance, with long-term forward contracts involving ever-greater economic risks for both producers, processors, and the trades. The driving forces are energy costs, as well as energy-related inputs. Because hot kilning is highly energy intensive, the ongoing work of the IPZ 5a working group towards optimizing kilning processes has become of central importance.

Meanwhile, other major challenges of hop cultivation also remain unchanged. First, there is global warming. Its existence can no longer be denied and is causing major problems. The crop year 2022 was very dry and warm, causing yields to drop severely and acid values to reach record lows. With the release of Tango and, more recently, Titan, the Hüll hop breeding program has already provided significant responses. These new varieties are much more resilient in the face of drought and heat than many other strains and this deserves broader acceptance by brewers.

The other key objectives relate to the areas of ecology, sustainability, and biodiversity, in which Hüll is also well positioned. The EU "European Green Deal" aims to reduce pesticide use by 50% and fertilizer use by 20% by 2030. Biodiversity is the basis of our planet ecosystem and all life within it. In the spirit of Alexander von Humboldt, we need to approach nature more holistically as "everything being connected to everything else." Nature creates and nurtures all plants and living beings, including humans. Therefore, nature must again be treated with respect so that the livelihoods of futures generations are assured. Almost all working groups deal with one aspect of this topic or another. Most noteworthy in this context is the IPZ 5e working group research on natural resistances of hops to spider mites.

The current annual report outlines in detail the activities of the Hüll Center in the field of hop research. Success in such endeavors is always the result of hard work by a committed and creative staff to whom we wish to extend our sincere thanks.

Dr. Michael Möller
Chairman of the Board
Society for Hop Research

Dr. Peter Doleschel
Head of the Institute for
Crop Science and Plant Breeding

Table of Contents

Page

1 Statistical Hop Production Data

Managing Director (LD) Johann Portner, Dipl.-Ing. agr.

1.1 Acreage data

1.1.1 Structure of hop production

Table 1.1: Number of hop farms and their acreages in Germany

Year	Number of Farms	Hop acreage per farm in ha	Year	Number of Farms	Hop acreage per farm in ha
1975	7,654	2.64	2005	1,611	10.66
1980	5,716	3.14	2010	1,435	12.81
1985	5,044	3.89	2015	1,172	15.23
1990	4,183	5.35	2020	1,087	19.05
1995	3,122	7.01	2021	1,062	19.42
2000	2,197	8.47	2022	1,053	19.57

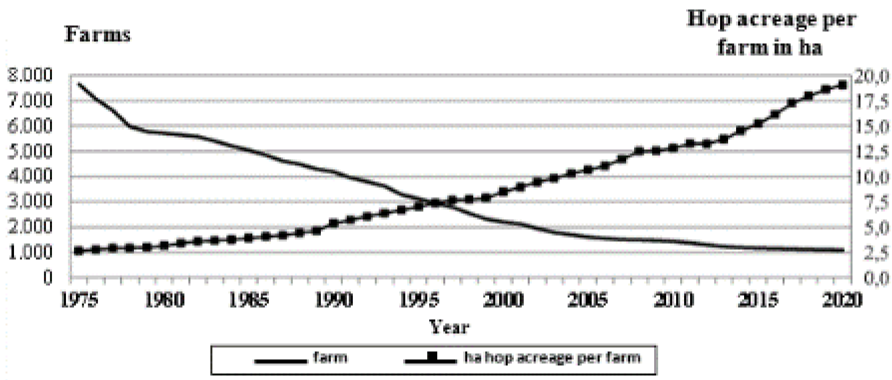


Figure 1.1: Number of hop farms and their acreages in Germany

Table 1.2: Area under hop cultivation, number of hop farms, and average acreage per farm in each of the German growing regions

Growing area	Hop acreage in ha 2021	Hop acreage in ha 2022	Increase + / Decrease - 2021 to 2022 ha	Increase + / Decrease - 2021 to 2022 %	Hop growers 2021	Hop growers 2022	Increase + / Decrease - 2021 to 2022 Farms	Increase + / Decrease - 2021 to 2022 %	Hop area per farm in ha 2021	Hop area per farm in ha 2022
Hallertau	17,122	17,110	- 12	- 0.1	860	854	- 6	- 0.7	19.91	20.04
Spalt	400	409	9	2.3	46	44	- 2	- 4.3	8.69	9.30
Tettnang	1,494	1,497	2	0.2	125	124	- 1	- 0.8	11.96	12.07
Baden, Bitburg, Rhein-Palatinate	22	12	10	- 46.1	2	2	± 0	± 0	11.00	6.00
Elbe-Saale	1,582	1,575	-6	- 0.4	29	29	± 0	± 0	54.55	54.33
Germany	**20,620**	**20,604**	**- 17**	**- 0.1**	**1,062**	**1,053**	**- 9**	**- 0.8**	**19.42**	**19.57**

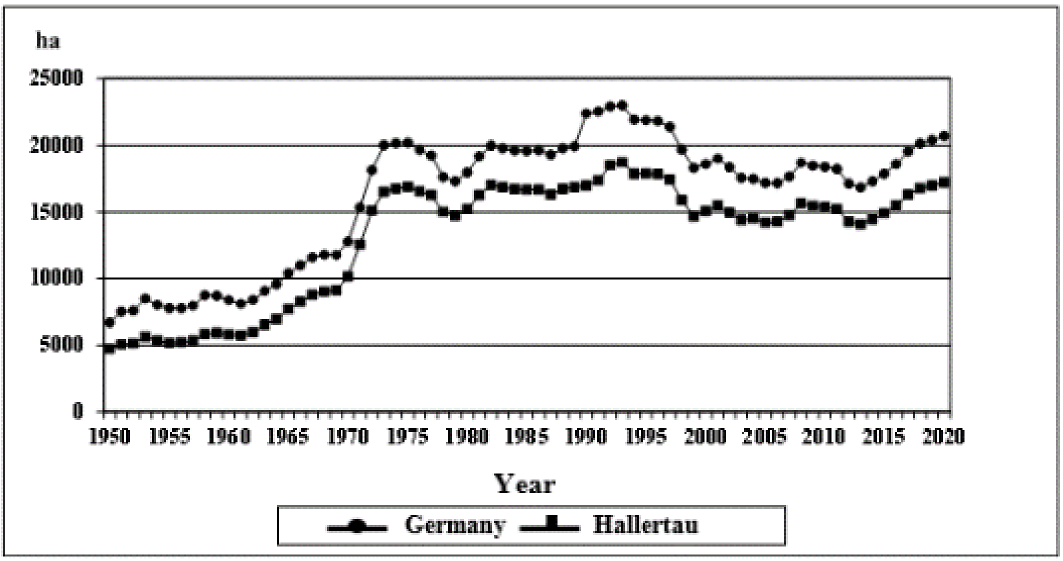


Figure. 1.2: Hop acreage in Germany and in the Hallertau

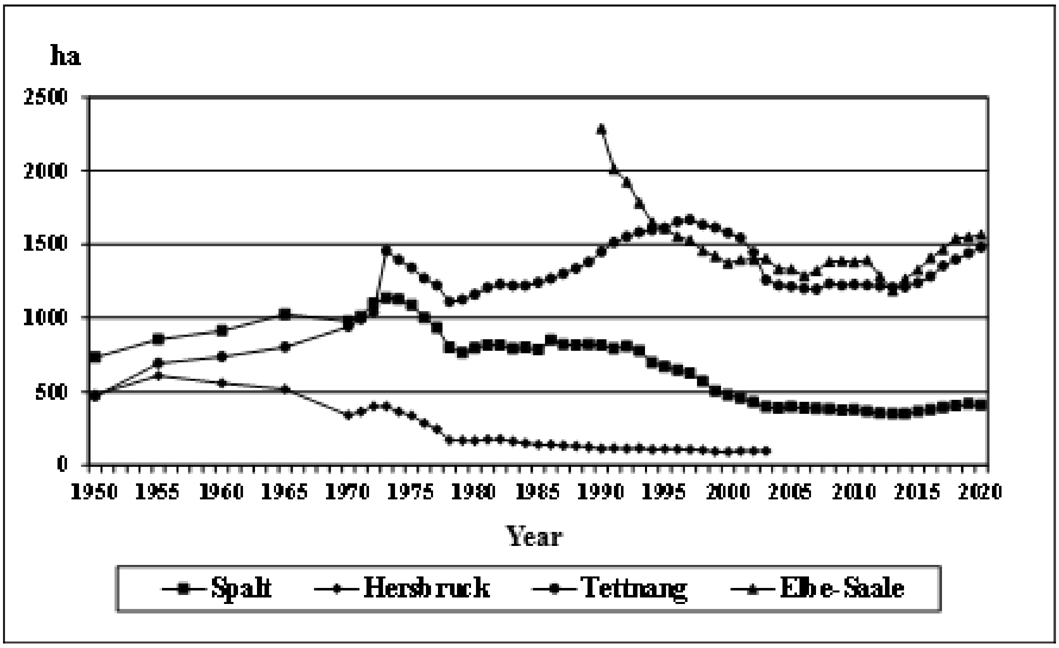


Figure 1.3: Hop acreage in Spalt, Hersbruck, Tettnang and Elbe-Saale

For statistical purposes, the Hersbruck region has been considered part of the Hallertau region, since 2004.

1.1.2 Hop varieties

With a decrease of 17 ha, the **hop acreage** in Germany has remained virtually constant at **20,604 ha** in 2022.

The share of **aroma varieties** fell slightly to 52.4%, with 31 aroma varieties cultivated on 10,800 ha. Most aroma varieties have lost acreage, with Hallertauer Tradition recording the largest drop (-58 ha). In addition, the clearing of landraces and other noble varieties is continuing. The so-called "flavor varieties" are suffering the same fate, while some new aroma varieties, such as Akoya and Tango, as well as the older Perle, have been experiencing increases in acreages.

The **bitter hop acreage**, on the other hand, rose again, this time by 181 ha. The total of 9,804 ha now accounts for 47.6% of all German hop cultivation. Again, older bitter varieties, such as Hallertauer Magnum and Hallertauer Taurus, lost acreage, while such high-alpha varieties as Herkules (+ 168 ha) and Polaris (+ 57 ha) once again gained acreage. This makes Herkules the most common Germany hop variety by far (7,142 ha), occupying more than one third of the total hop acreage.

Table 1.3: Hop varieties in German growing regions in hectares in 2022

Aroma Varieties

Variety	Hallertau	Spalt	Tettnang	Elbe-Saale	Other areas	Germany	Varieties in %	Changes in ha
Akoya	105		4	13		**122**	**0.6**	**19**
Amarillo	122		6	10		**138**	**0.7**	**-6**
Ariana	66	4	2			**72**	**0.4**	**-7**
Aurum			4			**4**	**0.0**	**2**
Brewers Gold	14					**14**	**0.1**	**-2**
Callista	37	1	8	14		**60**	**0.3**	**-3**
Cascade	52	4	2	3	1	**62**	**0.3**	**-2**
Comet	5					**5**	**0.0**	**0**
Diamant	10	6	0			**16**	**0.1**	**2**
Hallertau Blanc	109	3	12	5		**127**	**0.6**	**-21**
Hallertauer Gold	4	2				**6**	**0.0**	**0**
Hallertauer Mfr.	459	28	139	11		**636**	**3.1**	**-14**
Hallertauer Tradition	2,579	42	102	61	2	**2,786**	**13.5**	**-58**
Hersbrucker Pure	1	2				**3**	**0.0**	**0**
Hersbrucker Spät	803	6	0			**810**	**3.9**	**-11**
Hüll Melon	44	5	7			**56**	**0.3**	**-14**
Mandarina Bavaria	171	3	11	10		**195**	**0.9**	**-35**
Monroe	15		3			**18**	**0.1**	**-1**
Northern Brewer	115			115		**230**	**112**	**-25**
Opal	133	1	1			**135**	**0.7**	**-2**
Perle	2,895	41	131	280	6	**3,354**	**16.3**	**24**
Relax	3					**3**	**0.0**	**-2**
Rottenburger			1			**1**	**0.0**	**1**
Saazer	7			154		**160**	**0.8**	**-2**
Saphir	299	18	41	16		**374**	**1.8**	**-21**
Smaragd (Emerald)	51	1	14			**67**	**0.3**	**-6**
Solero	11		3			**13**	**0.1**	**2**
Spalter	0	106				**106**	**0.5**	**-2**
Spalter Select	426	84	23	4		**538**	**2.6**	**-18**
Tango	31	1	0			**32**	**0.2**	**32**
Tettnanger			654			**654**	**3.2**	**-27**
Total (ha)	**8,567**	**358**	**1,170**	**696**	**9**	**10,800**	**52.4**	**-198**
Percentage (%)	**41.6**	**1.7**	**5.7**	**3.4**	**0.0**	**52.4**		**-0.96**

Bitter Varieties

Variety	Hallertau	Spalt	Tettnang	Elbe-Saale	Other areas	Germany	Varieties in %	Changes in ha
Eureka (EUE05256)	3					**3**	**0.0**	**3**
Hallertauer Magnum	1,197	2		614		**1,813**	**8.8**	**-48**
Hallertauer Merkur	2	3		1		**5**	**0.0**	**0**
Hallertauer Taurus	157	1	0	3		**161**	**0.8**	**-8**
Herkules	6,659	44	299	137	3	**7,154**	**34.7**	**168**
Nugget	106			4		**110**	**0.5**	**-1**
Polaris	349		25	120		**494**	**2.4**	**57**
Record	1					**1**	**0.0**	**0**
Xantia	10					**10**	**0.0**	**8**
Others	61	1	2	1		**66**	**0.3**	**3**
Total (ha)	**8,543**	**51**	**327**	**880**	**3**	**9,804**	**47.6**	**181**
Percentage (%)	**41.5**	**0.2**	**1.6**	**4.3**	**0.0**	**47.6**		**0.88**

All Varieties

	Hallertau	Spalt	Tettnang	Elbe-Saale	Other areas	Germany	Varieties in %	Changes in ha
Total (ha)	**17,110**	**409**	**1,497**	**1,575**	**12**	**20,604**	**100.0**	**-17**
Percentage (%)	**83.0**	**2.0**	**7.3**	**7.6**	**0.1**	**100.0**		**-0.1**

1.2 Harvest volumes, yields, and alpha acid contents

The **2022 German hop harvest** was 34,405,840 kg (= 34,406 metric tons [MT]) and was thus significantly (-28%) below the excellent 2021 yield of 47,862,190 kg (47,862 MT). It was thus comparable to the crop failures in 2015 and 2003.

The **average yield** of 1,670 kg/ha is 651 kg/ha below that of the previous year. It was even worse in Spalt, where the old landrace by the same name is the predominant variety. Because Spalter hops are very susceptible to damage from drought and heat, the yield per hectare in this region was only half that of the previous year.

Likewise, the **alpha acid content** was also rather low. When multiplied by the low yield, older landraces and their related aroma varieties produced not even half of the amount of alpha acid of the previous year. The newer aroma and high alpha varieties, on the other hand, proved to be significantly more drought tolerant and thus suffered much smaller yield losses. Overall, the estimated amount of alpha acid produced in Germany in 2022 is roughly 3,720 MT, some 40% below the previous year's result.

Table 1.4: Harvest volumes and yields per hectare of hops in Germany

	2017	2018	2019	2020	2021	2022
Yield kg/ha	2,126	2,075	2,374	2,264	2,321	1,670
Acreage in ha	19,543	20,144	20,417	20,706	20,620	20,604
Total harvest in kg	41,556,250	41,794,270	48,472,220	46,878,500	47,862,190	34,405,840

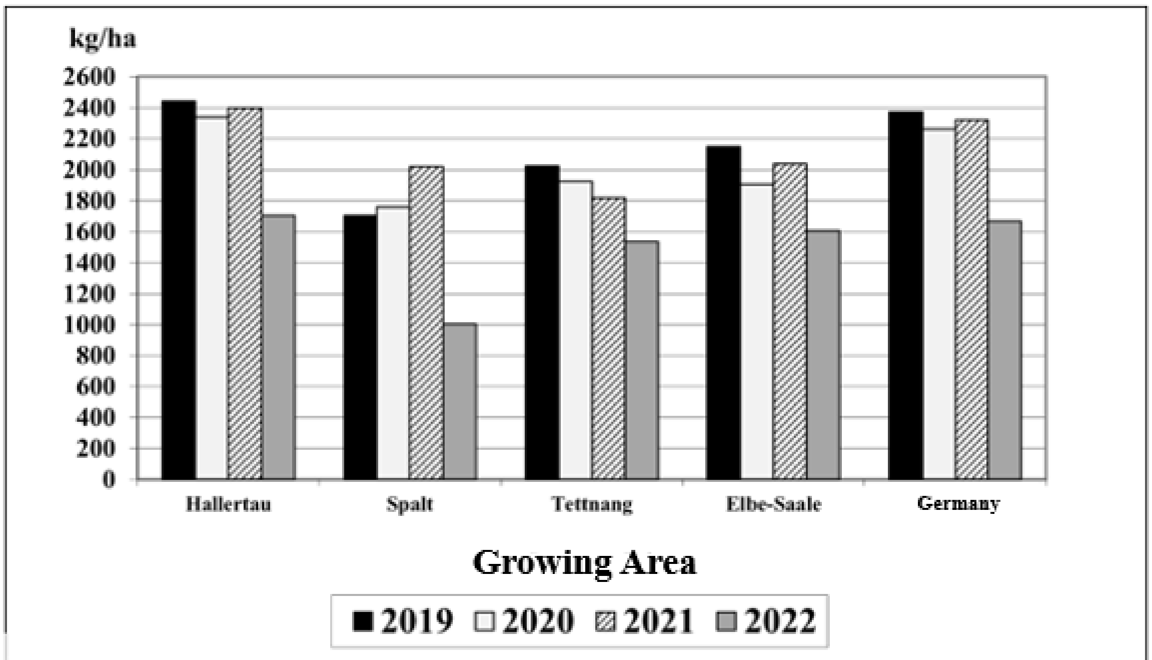


Figure 1.4: Average yields of the different growing regions in kg/ha

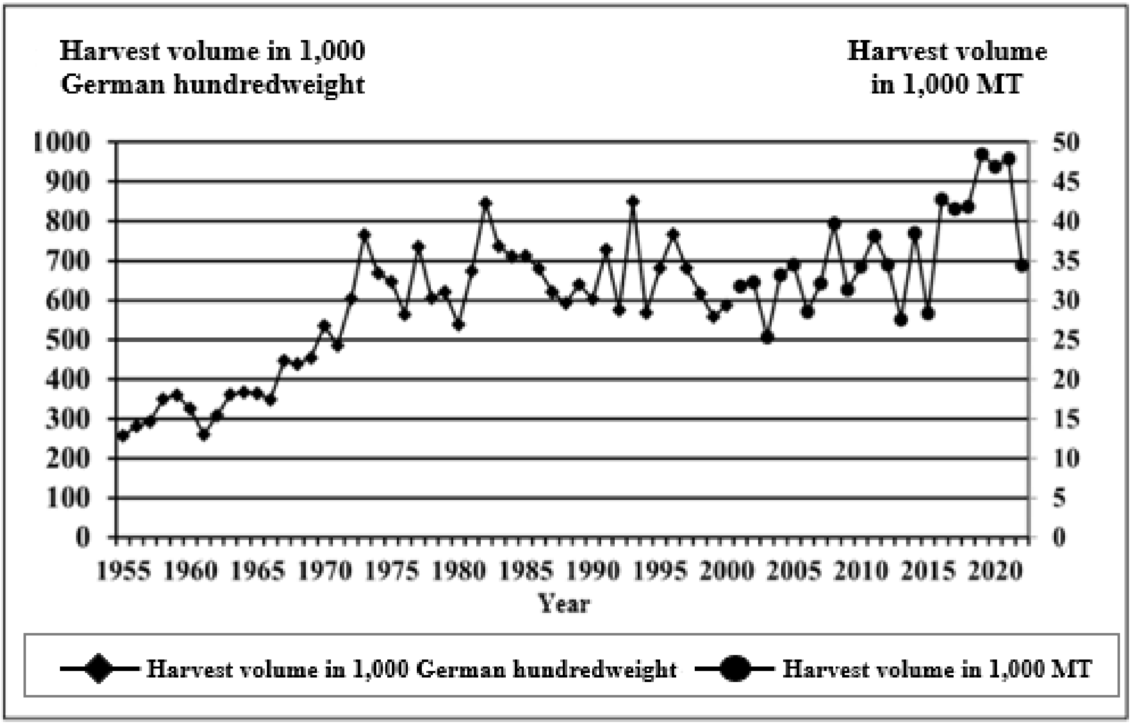


Figure 1.5: Total harvest volume in Germany

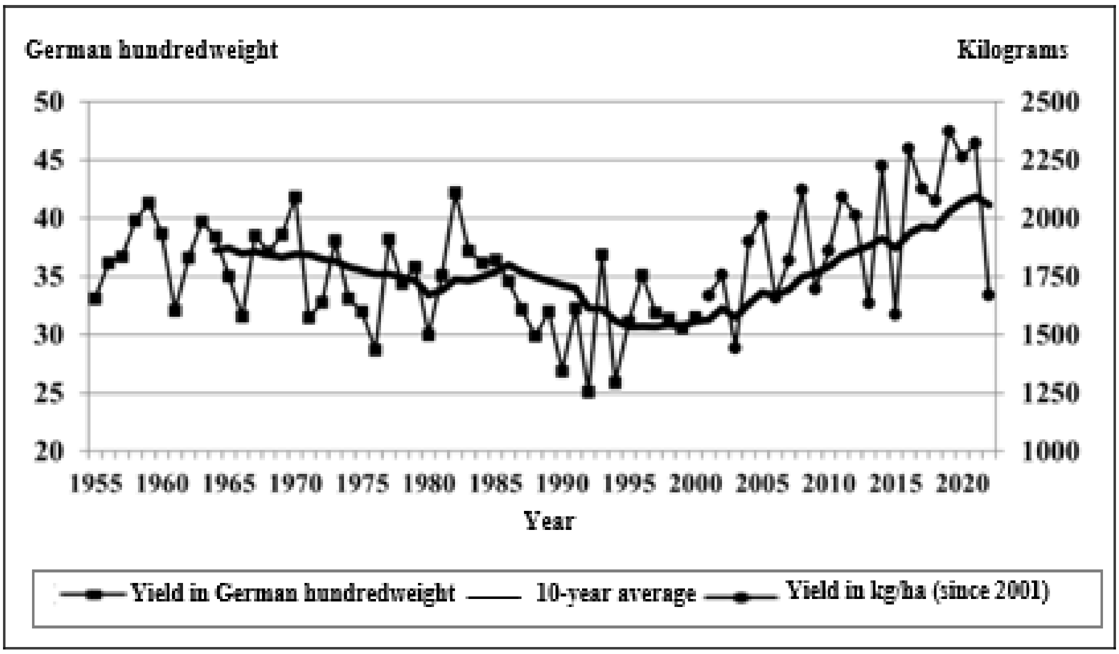


Figure 1.6: Average yield per hectare in Germany

Table 1.5: Yields per hectare in German cultivation areas

Growing area	Yield in kg/ha total area								
	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Hallertau	2,293	1,601	2,383	2,179	2,178	2,441	2,338	2,400	1,704
Spalt	1,980	1,038	1,942	1,949	1,564	1,704	1,759	2,020	1,005
Tettnang	1,673	1,370	1,712	1,677	1,486	2,024	1,927	1,818	1,538
Rhineland-Palatinate/ Bitburg	2,421	1,815	1,957	1,990	1,985	2,030	2,003	973	1,017
Elbe-Saale	2,030	1,777	2,020	2,005	1,615	2,150	1,906	2,038	1,704
∅ Yield/ha Germany (kg)	**2,224**	**1,587**	**2,299**	**2,126**	**2,075**	**2,374**	**2,264**	**2,321**	**1,670**
Total harvest Germany (MT)	38,500	28,337	42,766	41,556	41,794	48,472	46,879	47,862	34,406
Acreage Germany (ha)	17,308	17,855	18,598	19,543	20,144	20,417	20,706	20,620	20,604

Table 1.6: Alpha acid values of individual hop varieties in Germany

Growing area/variety	2013	2014	2015	2016	2017	2018	2019	2020	2021	**2022**	**Ø 5 Years**	**Ø 10 Years**
Hallertau Hallertauer	3.3	4.0	2.7	4.3	3.5	3.6	4.1	4.5	5.2	**3.1**	**4.1**	**3.8**
Hallertau Hersbrucker	1.9	2.1	2.3	2.8	2.3	2.0	2.5	3.3	4.6	**1.9**	**2.9**	**2.6**
Hallertau Hall. Saphir	2.6	3.9	2.5	4.0	3.0	3.3	3.3	4.2	4.3	**2.6**	**3.5**	**3.4**
Hallertau Opal	5.7	7.3	5.9	7.8	7.2	6.4	7.3	8.5	8.7	**6.1**	**7.4**	**7.1**
Hallertau Smaragd	4.3	4.7	5.5	6.2	4.5	3.0	5.0	5.8	7.6	**4.0**	**5.1**	**5.1**
Hallertau Perle	5.4	8.0	4.5	8.2	6.9	5.5	6.7	7.4	9.0	**4.9**	**6.7**	**6.7**
Hallertau Spalter Select	3.3	4.7	3.2	5.2	4.6	3.5	4.4	5.2	6.4	**3.3**	**4.6**	**4.4**
Hallertau Hall. Tradition	5.0	5.8	4.7	6.4	5.7	5.0	5.4	6.3	6.1	**5.2**	**5.6**	**5.6**
Hallertau Mand. Bavaria	7.4	7.3	7.0	8.7	7.3	7.5	7.9	9.0	9.9	**8.2**	**8.5**	**8.0**
Hallertau Hall. Blanc	7.8	9.0	7.8	9.7	9.0	8.8	9.0	10.9	9.9	**8.1**	**9.3**	**9.0**
Hallertau Hüll Melon	5.3	5.4	5.8	6.8	6.2	5.8	6.6	7.2	8.4	**6.3**	**6.9**	**6.4**
Hallertau North. Brewer	6.6	9.7	5.4	10.5	7.8	7.4	8.1	9.1	10.5	**6.4**	**8.3**	**8.2**
Hallertau Polaris	18.6	19.5	17.7	21.3	19.6	18.4	19.4	20.6	21.5	**18.5**	**19.7**	**19.5**
Hallertau Hall. Magnum	12.6	13.0	12.6	14.3	12.6	11.6	12.3	14.2	16.0	**12.2**	**13.3**	**13.1**
Hallertau Nugget	9.3	9.9	9.2	12.9	10.8	10.1	10.6	12.0	11.1	**9.9**	**10.7**	**10.6**
Hallertau Hall. Taurus	15.9	17.4	12.9	17.6	15.9	13.6	16.1	15.5	17.8	**14.6**	**15.5**	**15.7**
Hallertau Herkules	16.5	17.5	15.1	17.3	15.5	14.6	16.2	16.6	18.5	**15.4**	**16.3**	**16.3**
Tettnang Tettnanger	2.6	4.1	2.1	3.8	3.6	3.0	3.8	4.3	4.7	**2.6**	**3.7**	**3.5**
Tettnang Hallertauer	3.3	4.6	2.9	4.4	4.3	3.8	4.3	4.7	5.0	**3.2**	**4.2**	**4.1**
Spalt Spalter	2.8	3.4	2.2	4.3	3.2	3.5	3.9	4.7	5.2	**2.8**	**4.0**	**3.6**
Spalt Spalter Select	3.3	4.5	2.5	5.5	5.2	2.9	4.1	4.7	6.4	**2.8**	**4.2**	**4.2**
Elbe-S. Hall. Magnum	12.6	11.6	10.4	13.7	12.6	9.3	11.9	11.9	13.8	**12.0**	**11.8**	**12.0**

Source: Arbeitsgruppe für Hopfenanalytik (AHA); *(Hop Analytics Working Group)*

2 Weather and Growth Development 2022

Managing Director (LD) Johann Portner, District Administrator Anton Lutz (LR), and Agricultural Distract Administrator Stefan Fuß (LAR)

2.1 Weather and Growth Development

The 2022 hop year began with a warm spell and with little precipitation in the Hallertau. At Hüll, the average February temperature of 3.9 °C was almost 5 °C warmer than the long-term average. March also broke a record with only 9.1 mm of precipitation. This meant that all spring field work on wires could be completed on schedule, on dry soil. In spite of the mild winter, however, an unusually cold April delayed budding in the hop gardens by about one week compared to the annual average. The training of the bines, therefore, started only in May. This year, height and width pruning had only a small effect on the developing plants, but there were significant differences between sites with north and south exposure, as well as between crops at different altitudes. A dry and warm spell in May accelerated plant growth, and crops quickly reached average height levels. Tillage could take place under optimal conditions, but in June, the effects of the drought became more and more noticeable. The first extended heat wave, reaching a maximum temperature of around 36 °C on June 19, caused additional difficulties for the crop's development. The bines ended their vegetative growth prematurely and showed only weak side shoot formation in the upper bine and head area. At the same time, many stocks blossomed prematurely; and it did not help that July and August were dry and very hot, with extremely little precipitation. In some regions, monthly precipitation dropped to less than 20 mm. As a result, budding and side shoot development was below normal, and already near the end of July, the plants were so stressed that they delayed their normal cone formation. In some unfavorable sites, the plants shed their leaves and the cones remained very small.

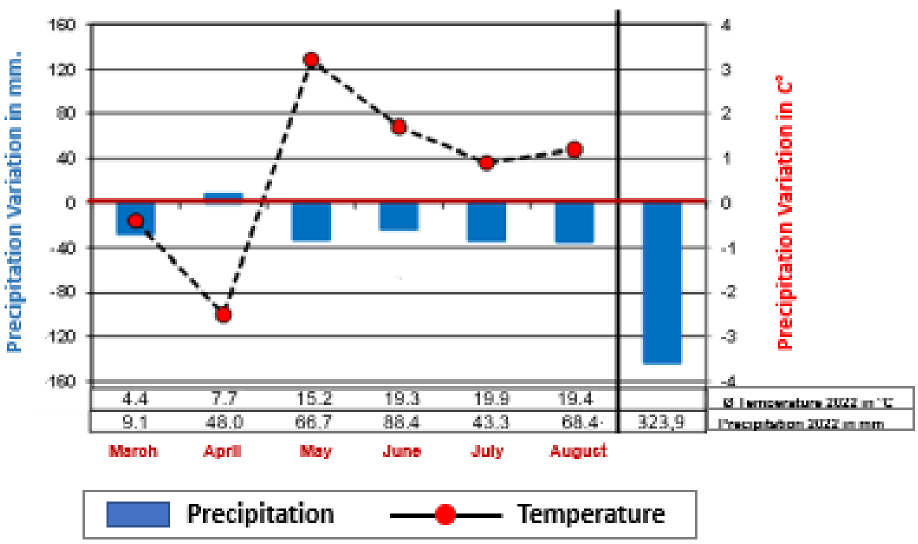


Figure 2.1: Weather during the 2022 growing season in Hüll by month, as a deviation from the 10-year average

Sufficient rainfalls around August 20 prevented an even worse situation. Landraces and other older cultivars suffered especially severely from the extreme weather. This resulted in significant losses in yield and quality, especially in terms of alpha acid content.

2.2 Problems resulting from disease and pest infestations

In the field of plant protection measures, 2022 differed significantly from the previous cool and damp year 2021. The dreaded pest, downy mildew (Peronospora), for instance, which thrives particularly well on wet leaves after a lot of precipitation, required only two interventions this growing season in plots with tolerant varieties, and only three interventions in plots with susceptible varieties, whereas the same pest required up to eight such interventions with much less effectiveness in 2021. Conversely, the dry and hot weather-loving common spider mite required much more vigilance this year. Already at the end of May, half of the hop yards in the monitoring program were already infested, with some plots showing infestation well above the intervention threshold. Likewise, hop aphids arrived extremely early and in full force already in mid-May. While hop aphid infestations can be controlled relatively easily with one or two protection measures, spider mites are more difficult to control and required repeated acaricide applications all the way up to the harvest.

The hop flea beetle too has become a rapidly increasing problem in recent years in spite of efforts to combat it. Adults surviving the winter start causing leaf damage even at the plant emergence stage, followed by additional damage from the next generation hatching in July, at which point the blossoms, cones, and shoots become part of the hop flea beetle diet. Severe infestations, therefore, can lead to significant damage. On the other hand, powdery mildew and *Verticillium* wilt, which caused severe sporadic losses in yield and quality in previous years, were less widespread in 2022, as a result of the weather.

2.3 Out-of-the-ordinary events in 2022

The hot weather led to local, violent thunderstorms. On May 19, for instance, a hailstorm caused considerable damage in the center of the Hallertau. Since the hops had barely reached half the height of the trellis at this point, many hours of work were required to stimulate the regrowing of side shoots.

On June 20, a second devastating hailstorm with strong gusts of wind passed through the southern part of the Hallertau from the northwest to the southeast. Even though the hailstones were small, they caused enormous damage. Up to 2,000 ha of hop acreage were affected in various degrees, and crops were not harvested on several hundred hectares because the low yields would have made that uneconomical.

Overall, the 2022 crop year will go down in history as an extremely dry year with high yield losses, especially for landraces and older cultivars. On the other hand, newer cultivars with significantly more efficient root systems demonstrated their improved climate resilience. In locations where water supplies became completely exhausted, however, even these varieties reach their performance limits. The ability to irrigate hops has rarely been more economically significant than in 2022.

*Table 2.1: Weather data for 2022 (monthly mean, maximum, and minimum values) compared to 10-year * and 30-year ** mean values*

Month		Temperature at 2 m elev. Mean (°C)	Min (°C)	Max (°C)	Relative Humidity (%)	Precip. (mm)	Days w/ Precip. >0.2 mm	Sunshine (hours)
January	2022	1.1	-2.0	3.9	98.9	42.0	14	21
∅	10-y	0.2	-3.3	3.7	93.3	68.4	17.4	39.5
	30-y	-2.3	-5.9	1.1	86.7	50.8	14.8	47.1
February	2022	3.9	-0.2	8.3	89.5	30.8	15	80
∅	10-y	0.6	-4.0	5.6	87.8	45.7	12.1	79.6
	30-y	-1.0	-4.9	3.1	81.4	46.8	13.3	72.1
March	2022	4.4	-2.3	12.2	71.9	9.1	3	233
∅	10-y	4.8	-0.9	10.8	81.5	35.7	12.6	156.1
	30-y	2.8	-1.7	7.8	78.9	47.7	13.8	132.2
April	2022	7.7	1.7	13.6	84.6	48.0	13	183
∅	10-y	10.2	3.3	16.0	73.1	40.8	9.4	207.6
	30-y	7.1	1.9	12.8	73.8	60.8	14.1	164.3
May	2022	15.2	8.3	22.0	83.5	66.7	14	229
∅	10-y	13.0	7.3	18.7	77.8	99.4	15.5	199.3
	30-y	11.9	6.1	17.7	73.9	82.3	15.4	203.6
June	2022	19.3	12.3	26.5	83.0	88.4	14	260
∅	10-y	17.6	11.3	23.7	77.5	112.2	12.9	239.7
	30-y	15.1	9.0	20.8	74.6	103.5	15.3	212.3
July	2022	19.9	11.5	27.9	75.8	43.3	9	286
∅	10-y	19.0	12.4	25.7	77.4	76.7	12.3	248.3
	30-y	16.7	10.5	23.1	74.3	90.5	14.1	236.8
August	2022	19.4	12.3	27.4	82.0	68.5	7	267
∅	10-y	18.2	11.8	25.1	81.9	102.7	12.1	235.9
	30-y	16.0	10.2	22.6	78.2	91.7	13.8	212.4
September	2022	12.8	7.7	19.1	94.7	77.3	18	135
∅	10-y	13.9	8.1	20.2	86.5	54.4	10.7	171.4
	30-y	12.7	7.4	19.1	80.7	67.9	11.6	175.0
October	2022	11.8	6.7	18.4	98.0	73.1	12	121
∅	10-y	9.2	4.5	14.3	91.9	53.0	11.4	109.3
	30-y	7.6	3.2	13.1	84.2	51.1	11.0	117.2
November	2022	5.2	1.6	9.8	99.4	53.6	18	64
∅	10-y	4.4	1.0	8.2	94.9	50.9	11.8	49.7
	30-y	2.6	-0.6	6.1	85.5	57.5	14.4	52.9
December	2022	1.4	-1.7	4.1	99.0	58.9	14	20
∅	10-y	1.8	-1.4	5.7	95.1	51.4	15.1	39.9
	30-y	-0.9	-4.3	1.8	86.5	52.2	15.0	38.7
Ø-Year	**2021**	**10.2**	**4.7**	**16.1**	**88.4**	**659.7**	**151**	**1.899.0**
10-Year Mean		**9.4**	**4.7**	**14.8**	**84.9**	**791.3**	**153.3**	**1.776.3**
30-Year Mean		**7.4**	**2.6**	**12.4**	**79.9**	**802.8**	**166.6**	**1.664.6**

* The 10-year mean covers the years 2012-2021

** The 30-year mean covers the years 1961-1990

3 Research and Permanent Technical Tasks

3.1 IPZ 5a – Hop growing production technology

Current research projects of IPZ 5a (hop production, production technology) funded by third parties

Working Groups Project Management, Project Operations	Project	Project Duration	Cost Allocation	Collaborators
IPZ 5a J. Portner, A. Schlagenhaufer	Composting trial using shredded hop bines to optimize the nutrient efficiency of organically bound nitrogen (6141)	2018-2022	Erzeugergemeinschaft HVG *(HVG Hop Producer Group)*	Prof. E. Meinken, Dr. D. Lohr, Prof. T. Ebertseder (all HSWT), M. Stadler, AELF PAF; IPZ 5c
IPZ 5a J. Portner	Production and quality initiative for agriculture and horticulture in Bavaria — TS and alpha acid monitoring — Aphid and spider mite monitoring — Chlorophyll measurements to estimate the N-supply status	2019-2023	Bayerisches Staatsministerium für Ernährung, Landwirtschaft und Forsten (StMELF) *(The Bavarian State Ministry for Food, Agriculture and Forestry)*	Hopfenring e.V. *(Hop Circle)*
IPZ 5a J. Portner, S. Huber, M. Fischer	Detection of possible sources of error when determining the representative active alpha acid content of a hop batch (6906)	2022	Erzeugerge-meinschaft HVG *(HVG Hop Producer Group)*	IPZ 5c, Dr. K. Becker, HVG Mainburg
IPZ 5a J. Portner	Obtaining and testing the suitability of the fibers from the hop plant for the production of nonwovens (6907)	2022-2023	Bayerisches Staatsministerium für Ernährung, Landwirtschaft und Forsten (StMELF) *(The Bavarian State Ministry for Food, Agriculture and Forestry)*	Service contracts with various cooperation partners

Permanent tasks: Product-technical trials

AG	Project	Duration	Collaborators
5a	Training and continued education of hop growers	Permanent task	
5a	Specialized production engineering and business management consulting in hop production	Permanent task	
5a	Development and updating of documents for consulting services	Permanent task	
5a	Dissemination of advisory strategies and exchange of information with group advisory services	Permanent task	Hopfenring e.V. *(Hop Circle)*
5a	Generation of *Peronospora* infestation forecasts and warning messages	Permanent task	
5a	Generation of business data for calculating profit margins and other business accounting issues	Permanent task	

AG	Project	Duration	Collaborators
5a	Optimization of PS applications and device technologies	Permanent task (2022-2023)	
5a	Optimization of techniques and measures to prevent soil erosion and to promote soil fertility in hop cultivation	Permanent task	IAB Soil: constant
5a	Development of strategies and measures in hop cultivation to avoid nitrate movements in the soil and run-off	Permanent task	IAB, water consult-ant, AELF PAF and AB-LA, ECOZEPT
5a	HopNO$_3$ - practical optimization of the nitrogen cycle in hop cultivation	2016-2021 (2022)	ECOZEPT LfU Leader-AG
5a	Optimization of drying processes in belt dryers	2018-2022	Hop growers
5a	Simulation of agro-PV systems in hops with regard to the occurrence of hop pathogens, yield, and quality	2021-2022	Tubesolar, Augsburg; hop grower
5a	"Shot-in-the-dark" test with Utrisha™ N (plant strengthener by Corteva)	2022	Hop growers
5a	Testing of different materials as a substitute for plastic strings on hop trellises	2022	Various twine wire suppliers; hop farms
5a	Temperature measurements in the foil tunnel for the use of solar energy for drying hops	2022	Asparagus farmer

3.2 IPZ 5b - Crop protection in hop production

Ongoing research projects of IPZ 5b (crop protection in hop cultivation) funded by third parties

Working Groups Project Management Project Operations	Project	Project Duration	Cost Allocation	Collaborators
IPZ 5b S. Euringer, K. Lutz	GfH project for *Verticillium* research	2017-2023	Gesellschaft für Hopfenforschung (GfH) *(Society for Hop Research)*	IPZ 5c Dr. Radišek, Slovenian Institute of Hop Research and Brewing
IPZ 5b S. Euringer, K. Lutz	*Verticillium* in selected gardens: Niederlauterbach (2015-2021) Engelbrechtsmünster (2016-2022); Gebrontshausen (from 2020)	2015-2024	Erzeugergemeinschaft Hopfen HVG *(HVG Hop Producer Group)*	IPZ 5c

Working Groups Project Management Project Operations	Project	Project Duration	Cost Allocation	Collaborators
IPZ 5 S. Euringer, C. Krönauer, F. Weiß	CBCVd-Monitoring	2020-2022	Bayerisches Staats-ministerium für Ernährung, Land-wirtschaft und Forsten (StMELF) *(The Ba-varian State Ministry for Food, Agriculture and Forestry)* Erzeugergemeinschaft Hopfen HVG *(HVG Hop Producer Group)*	IPZ 5a, IPS 4b, IPS 2c
IPZ 5 b S. Euringer, C. Krönauer, F. Weiß	Pre-project CBCVd	2022	Erzeugergenossen-schaft HVG *(HVG Hop Producer Group)*	IPS 2c

Permanent tasks: Crop protection trials

Working Group	Project	Duration	Collaborators
5b	Official means test	Permanent task	
5b	Execution and supervision of residue analyses in hop cultivation (GEP portionl)	Permanent task	
5b	Spray tower experiments to monitor the potential development of resistance in hop aphids	Permanent task	
5b	Aphis fly monitoring	Permanent task	
5b	ELISA-Testing for ApMV and HpMV in hops for breeding purposes	Permanent task	
5b	Monitoring of the plant protection product approval situation in hop growing	Permanent task	
5b	Preparation of emergency use applications according to Art. 53	Permanent task	Verband dt. Hopfenpflanzer *(German Hop Growers Association);* Hopfenring e.V. *(Hop Circle)*
5b	Technical commentary on emergency permit applications for individual farms, according to Art. 22	Permanent task	Verband dt. Hopfenpflanzer *(German Hop Growers Association);* Hopfenring e.V. *(Hop Circle)*
5b	Viroid monitoring (CBCVd and HSVd)	Permanent task	IPZ 5c, IPS2c
5b	Technical support in the implementation of the plant permits in hops	Permanent task	
5b	Implementation of the Eppo Guideline PP 1/239 (Leaf Wall Area) in hop growing	2018-today	
5b	Maintenance of the reporting address, hop.pfla@lfl.bayern.de, for special fertilizers, plant nutrients, bio-stimulants, and pesticides in hop cultivation	2019 to present	

3.3 IPZ 5c – Hop breeding research

Current research projects of IPZ 5c (hop breeding research) funded by third parties

Working Groups Project Management Project Operations	Project	Project Duration	Cost Allocation	Collaborators
IPZ 5c A. Lutz, Dr. E. Seigner	Development of high-performance, healthy, high alpha varieties with particular suitability for cultivation in the Elbe-Saale region	2016-2024	Thüringer Ministerium für Infrastruktur und Landwirtschaft; *(Thuringian Ministry of Infrastructure and Agriculture);* Ministerium f. Umwelt, Landwirtschaft und Energie des Landes Sachsen-Anhalt *(Ministry for Science, Energy, Climate Protection and the Environment of the State of Saxony-Anhalt);* Sächsisches Staatsministerium für Energie, Klimaschutz, Umwelt und Landwirtschaft *(Saxon State Ministry for Energy, Climate Protection, Environment and Agriculture);* Erzeugergem. Hopfen HVG *(HVG Hop Processing Cooperaive) e.G.*	IPZ 5d: Dr. K. Kammhuber & Team; Hopfenpflanzerverband Elbe-Saale e.V. (*Hop Growers Association Elbe-Saale e.V.*); Betrieb Berthold, Thüringen *(Hop Farm Berthold, Thuringia);* Hopfengut Lautitz, Sachsen (*Hop Farm Lautitz, Saxony*); Agrargenoss. Querfurt, Sachsen-Anhalt *(Agricultural Cooperative Querfurt, Saxony-Anhalt)*
IPZ 5c Dr. E. Seigner	Research and work on *Verticillium* wilt in hops — molecular proof of presence	2015-2023	Erzeugergemeinschaft Hopfen HVG *(HVG Hop Producer Group)*	IPZ 5c: A. Lutz; IPZ 5b: S. Euringer, K. Lutz; Dr. Radišek, Slovenian Institute of Hop Research and Brewing, Slovenia

Permanent tasks: Hop breeding research

Working Group	Project	Duration	Collaborators
5c	Breeding hop varieties with excellent brewing quality	Permanent Task	IPZ 5d: Dr. K. Kammhuber & Team; Beratungsgremium der GfH *(Society of Hop Research Advisory Committee)*; TUM, Lehrstuhl Getränke- und Brautechnologien (*Department of Beverage and Brewing Technology)*; Bitburger Versuchsbrauerei *(Bitburger Pilot Brewery)*; Versuchsbrauerei St. Johann *(Pilot Brewery St. Johann)*; Breweries worldwide Hop growers

Working Group	Project	Duration	Collaborators
5c	Breeding of quality varieties with increased levels of health-promoting, antioxidative, and microbial substances; as well as for alternative areas of application of hops outside the brewing industry	Permanent task	IPZ 5d; EpiLogic, Freising
5c	Testing for aphid resistance	Permanent task	IPZ 5b: M. Felsl
5c	Leaf system for testing hops for *Perono-spora* tolerance for the purpose of breeding disease-tolerant hops	Permanent task since 2012	
5c	Faster availability of healthy hops through improved *in vitro* tissue culture	Permanent task since 2015	IPZ 5b: M. Mühlbauer; IPS 2c: Dr. L. Seigner
5c	Cultivation, assaying, and harvesting of hops for approval and permitting by the CPVO (Community Plant Variety Office of the EU)	Permanent task	IPZ 5d: Dr. K. Kammhuber & Team
5c	Serial trial cultivation in commercial hop farms	Permanent task	IPZ 5d: Dr. K. Kammhuber & Team
5c	Biogenesis trials to generate information for the hop and brewing industries about ripe-ness states, and hop harvest forecasts	Permanent task	IPZ 5d: Dr. K. Kammhuber & Team; IPZ 5a

3.4 IPZ 5d – Hop quality and hop analytics

Permanent tasks: Hop quality and hop analytics

Working Group	Project	Duration	Collabrators
5d	All analytical investigations in support of the Working Groups of the hop division, and in particular, those regarding hop breeding	Permanent task	IPZ 5a, IPZ 5b, IPZ 5c, IPZ 5e
5d	Development and optimization of a reliable method for the analysis of aromas using gas chromatography-mass spectroscopy	Permanent task	
5d	Establishment and optimization of NIRS-methods for analyses of hop bitter substances and water content	Permanent task	
5d	Development of methods for analyzing hop polyphenols	Permanent task	Arbeitsgruppe für Hopfenanalytik (AHA) *(Hop Analytics Working Group)*
5d	Organization and evaluation of chain analyses for hop contracts	Permanent task	Labore der Hopfenwirtschaft (*Laboratories in the hop industry*)
5d	Analysis, evaluation, and dissemination of fol-low-up and control examinations for hop contracts	Permanent task	Labore der Hopfenwirtschaft (*Laboratories in the hop industry*)
5d	Administrative assistance in the analyses of hop varieties for food safety authorities	Permanent task	Lebensmittelüberwachung der Land-ratsämter *(Food safety monitoring by dis-trict offices)*
5d	Supervision of IT and the Internet for the Hop Research Center in Hüll	Permanent task	AIW ITP

3.5 IPZ 5e – Ecological issues in hop cultivation

Current IPZ 5e research projects of (ecological issues in hop cultivation) funded by third parties

Working Groups Project Management Project Operations	Project	Duration	Cost Allocation	Collaborators
IPZ 5e Dr. F. Weihrauch, S. Kaindl, M. Obermaier	Reduction in the use of copper-containing crop protection agents in organic, as well as integrated hop cultivation	2014-2022	Erzeugergemeinschaft Hopfen HVG e.G. *(HVG Hop Producer Group)*	Betrieb Robert Drexler, (*Farm Robert Drexler*) Riedhof; Forschungsinstitut für Biologischen Landbau (FiBL), Frick, Schweiz *(Research Institute for Organic Agriculture, Frick, Switzerland)*; IFA-Tulln Institut für Umweltbiotechnologie, Österreich *(IFA-Tulln Institute for Environmental Biotechnology, Austria)*
IPZ 5e Dr. F. Weihrauch, M. Obermaier	Further development of culture-specific strategies for organic crop protection with the help of divisional networks - Hop Division.	2017-2022	Bundesanstalt für Landwirtschaft und Ernährung (BLE), BÖLN-Projekt 2815OE095 (*Federal Agency for Agriculture and Food BLE)*	Bund Ökologische Lebensmittelwirtschaft (BÖLW e.V.) *(Organic Food Production Alliance; BÖLW e.V.)*
IPZ 5e Dr. F. Weihrauch, Dr. I. Lusebrink, M. Obermaier	Development of a catalog of measures to promote biodiversity in hop cultivation	2018-2023	Erzeugergemeinschaft Hopfen HVG e.G. *(HVG Hop Producer Group)*	IGN Nierderlauterbach; AELF PAF, FZ Agraökologie *(Center of Expertise for Agroecology;* UNB am Landratsamt PAF; LBV, KG PAF *(Nature Conservation Authority, District of Pfaffenhofen ad Ilm)*
IPZ 5e Dr. F. Weihrauch, Dr. I. Lusebrink, M. Obermaier	Induced resistance in hops to spider mites	2021-2026	Deutsche Bundesstiftung Umwelt (*German Federal Foundation for the Environment) DBU* (FKZ 35937/01-34/0)	20 commercial farms practicing integrated hop cultivation; AG IPZ 5d

4 Hop Cultivation, Production Techniques

Managing Director (LD) Johann Portner, Dipl.-Ing. agr.

4.1 N_{min}-Investigation 2022

Analyses of soils for available nitrogen and N_{min} is a central component of determining fertilizer requirements. It is also mandatory for companies that manage hop areas in the "red areas".

In 2022, more than half the hop-growing farms in the Bavarian growing regions of the Hallertau and Spalt took part in N_{min} studies. A total of 2,959 hop gardens were examined (2021: 3,344 samples) for the N_{min} content. The average N_{min} content of all soils used for hop cultivation in Bavaria was 49 kg N/ha, around 10 kg below the previous year's value. As is the case every year, there were large fluctuations from one farm to the next, as well as among individual hop plots and different varieties cultivated by the same farm.

According to the German Fertilizer Ordinance (DüV), every hop farm must calculate its nitrogen fertilizer requirements (N) annually, while considering the amount of N that is already in the soil before the first round of fertilization. This applies to all plots or management units, according to defined specifications.

Hop farms in the so-called **“green” or non-nitrate-endangered areas**, which are not obliged to carry out N_{min} assessments or did not collect N_{min} results for all plots, were permitted to use regionalized averages listed in Table 4.1.

Table. 4.1: Number of sample, preliminary, and final N_{min} values 2022 *in the various hop growing districts and regions (current as of April 8, 2022)*

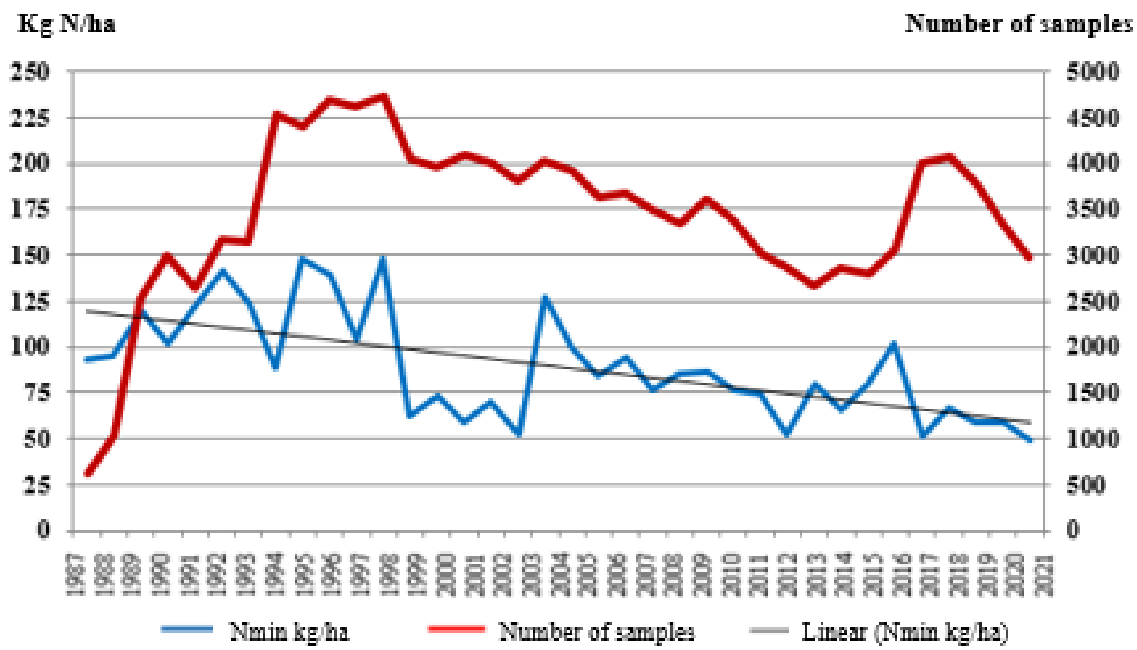
County/Region	Number of tests	Preliminary N_{min} value (As of March 16, 2022)	Final N_{min} value
Eichstätt (including Kinding)	214	43	**60**
Freising	292	37	**45**
Hersbruck	72	-	**40**
Kelheim	1,165	48	**51**
Landshut	180	43	**51**
Pfaffenhofen (and Neuburg-Schrobenhausen)	937	39	**44**
Spalt	99	65	**65**
Bavaria	**2,959**	**45**	**49**

Hop growers without their own N_{min} values were permitted to calculate their nitrogen requirements using the provisional N_{min} averages for their district or growing region. They needed to correct these values if the final, empirically determined N_{min} value is more than 10 kg N/ha higher than the provisional N_{min} value in the table.

In 2022 this was the case in the Eichstätt (including Kinding) growing region, where the average final N_{min} value was 17 kg N/ha above the provisional N_{min} value. Hop growers in this region who had calculated their requirements using the provisional N_{min} value of 43 kg N/ha, therefore, had to correct their fertilizer requirement calculations using the higher final N_{min} value of 60 kg N/ha. For hop growers in the Hersbruck region, there was no preliminary N_{min} value for 2022. Therefore, they had to calculate their fertilizer requirements using the final N_{min} value.

Farms in the **"red areas"** had to test at least 3 plots for N_{min}, in 2022. If they operated additional hop plots in the red area, the average N_{min} values had to be transferred to these as well!

The figure below shows the number of N_{min} tests and N_{min} amounts in Bavaria over several years of testing.



N_{min}-Tests and N_{min}-Content of the Hop Farms in Bavaria

Figure 4.1: N_{min} investigations, N_{min} amounts and the trend line for N_{min} values in hop gardens in Bavaria over the years

4.2 Experiments with composting and recycling of hop bine chaff to optimize the nutrient efficiency of organically bound nitrogen (ID 6239)

Sponsor:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Hopfenbau, Produktionstechnik (IPZ 5a) (*Bavarian State Research Center for Agriculture, Institute for Plant Production and Plant Breeding, AG Hop Production, Production Technology (IPZ 5a))*
Financing:	Erzeugergemeinschaft HVG e. G. *(HVG Hop Producer Group)*
Project Management:	J. Portner
Team:	A. Schlagenhaufer, J. Stampfl, S. Fuß (LfL), Dr. Dieter Lohr Hochschule Weihenstephan-Triesdorf (HSWT)
Collaboration:	Prof. Dr. Meinken, Institut für Gartenbau, *(Horticultural Research Institute)* Hochschule Weihenstephan-Triesdorf (HSWT) Prof. Dr. Ebertseder, Fakultät Nachhaltige Agrar- und Energiesysteme, *(Faculty of Sustainable Agriculture and Energy Systems)* Hochschule Weihenstephan-Triesdorf (HSWT) M. Stadler, Fachzentrum Agrarökologie, *(Centre of Expertise for Agroecology),* AELF Pfaffenhofen
Duration:	September 1, 2018 to February 28, 2022

In the Hallertau hop-growing region, 854 farms cultivate 17,000 ha of hops and produce a total of roughly 230,000 MT of shredded hop bines each year. Around 80% of this plant matter is currently being returned to the soil as organic fertilizer after harvesting is complete.

These bines, however, contain significant amounts of nitrogen. With the implementation of the new German Fertilizer Ordinance, farmers are required to use the nitrogen contained in the shredded bines as efficiently as possible, while avoiding N-dispersion into other ecosystems. To meet these requirements, extensive composting and field trials with shredded hop bines were conducted over a number of years.

Objectives

- Risk assessment of increased nitrate leaching as a result of the application of shredded hop bines in the fall in accordance with current practice
- Development of environmentally compatible and practicable composting processes for shredded hop bines
- Investigation of the nitrogen effects of the various composts/substrates in field trials
- Comparison of the different processes with regard to economy, ecology, and practicality
- Reduction of nitrogen losses in shredded bines
- Legally compliant, practical, and environmentally friendly recycling of the shredded bines with optimal use of the organically bound nitrogen.

Method

The experimental setup of the project is divided into four “work packages” (AP 1 to 4): The experiment is based on composting tests (AP 1), to develop the basic conditions for aerobic composting on a small scale (size approx. 1.5 m³). At the same time, in a further experiment after the harvest, shredded bine material is simply stored aerobically and composted or siloed (AP 2) using the no-turning, microbial carbonization (MC) compost technique developed by Walter Witte (MC composting). This composting trial under practical conditions has several objectives. On the one hand, the knowledge gained under small-scale conditions should be verified for its real-world practical applicability. On the other hand, aerobic composting should be compared to the three other trial variations regarding the practicality and the conservation potential for the nitrogen present in the shredded hop bines.

Furthermore, these trials should produce the material for plot tests to determine the N-efficiency of the four materials (stored shredded hop bines; aerobic and MC compost; and silage), which form the third project part (AP 3). The material for the fourth part of the project, that is, practical experiments to determine N-dynamics in hop gardens (AP 4), is also based on these tests. All four sub-projects were started at the same time after the hop harvest in the fall of 2018. In addition, in 2017, as part of a bachelor's thesis, vascular tests with shredded bines were conducted. This work continued as part of this project.

Figure 4.2: Representation of the experimental scheme:
Top: AP 2, Practical composting experiment
Bottom left: AP 4, field trial with hops, shredded bines applied in May
Below right: AP 3, plot tests with shredded bines

Results

Many test results have already been published in the previous annual reports of the special crop hops. A final report on the research project is to be published in early spring 2023. The experimental work of the project was completed in spring 2022.

However, the "hops field test" (AP 4) will be continued in order to be able to investigate the long-term N-fertilization effect of hop bine shreds and, since 2022, also of liquid biogas fermentation residues in hops. A system comparison is made in which a classic application of bine shredding in autumn and an application of liquid biogas fermentation residues in June are compared with a mineral-fertilized variant on the same total N-basis (Figure 4.2).

Table 4.2: Overview of variations of "Field Trials Hops" 2022

Month KW	October 19		April				May					June				July				Total [kg N/ha]
	Bine Chaff	N-Gas	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
Control					50				40											90
Bine Chaff Autumn	15t	90			50				40											180
Biogas Ferment. Residues	7 m³				50				40			90								180
Mineral-rich					50				40				45				45			180

Bine chaff   Nitrogen-Phosphorus-Potassium (15% each) Mixed Fertilizer   Biogas Fermentation   Potassium-based liquid 15% (removed superfluous leaves and bines from hop plants in the spring)

The N-fertilization effect of the hop bine chaff and the liquid biogas fermentation residue can be determined based on the N-removal at the time of harvest. In 2022, the test area was severely damaged by hail at the end of May with the plant growth height at around 40% of the trellis height. However, through intensive follow-up, a relatively uniform hop stock could be restored. In order to generate more reliable results, the size of the harvest plots was increased from 20 to 40 bines from the 2021 trial year - because the plot size permitted it - which, with 4 repetitions per variant, resulted in 160 bines per variant. In Figure 4.3, the nitrogen withdrawal can be seen broken down into residual plant withdrawal and cone withdrawal. It is noticeable that the nitrogen removal due to hail was significantly lower than in previous years. However, the gradation between the variants confirms the results from the previous test years (Figure 4.4). The variant with bine shreds in 2022 was able to absorb 13 kg more N than the control (2019-2022: 15 kg N). The mineral-fertilized variant was able to extract 46 kg more N than the control in 2022 (2019-2022: 65 kg N). Of the 90 kg total N that was applied with fermentation residues, 21 kg N could already be absorbed in the first year.

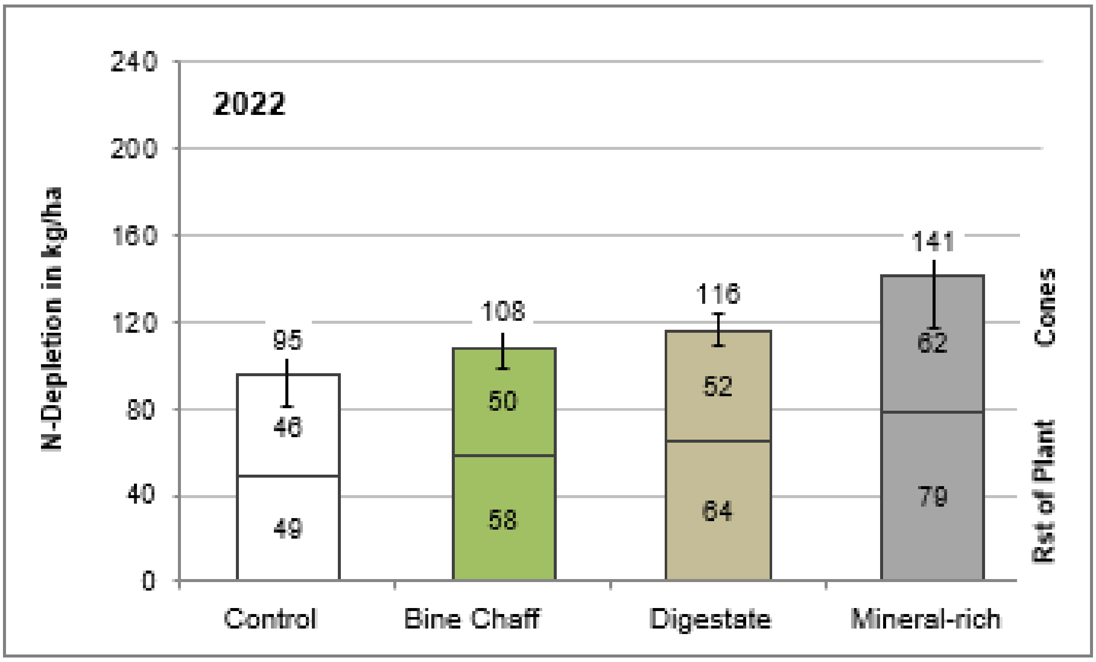


Figure 4.3: Mean N-removal broken down into cone and residual plant removal depending on N fertilization (control = 90 N mineral; autumn bines= 90 N mineral + 90 N via bines; digestate = 90 N mineral + 90 N via digestate; mineral = 180 N mineral) 2022 (hail year), variety Herkules, loamy sand

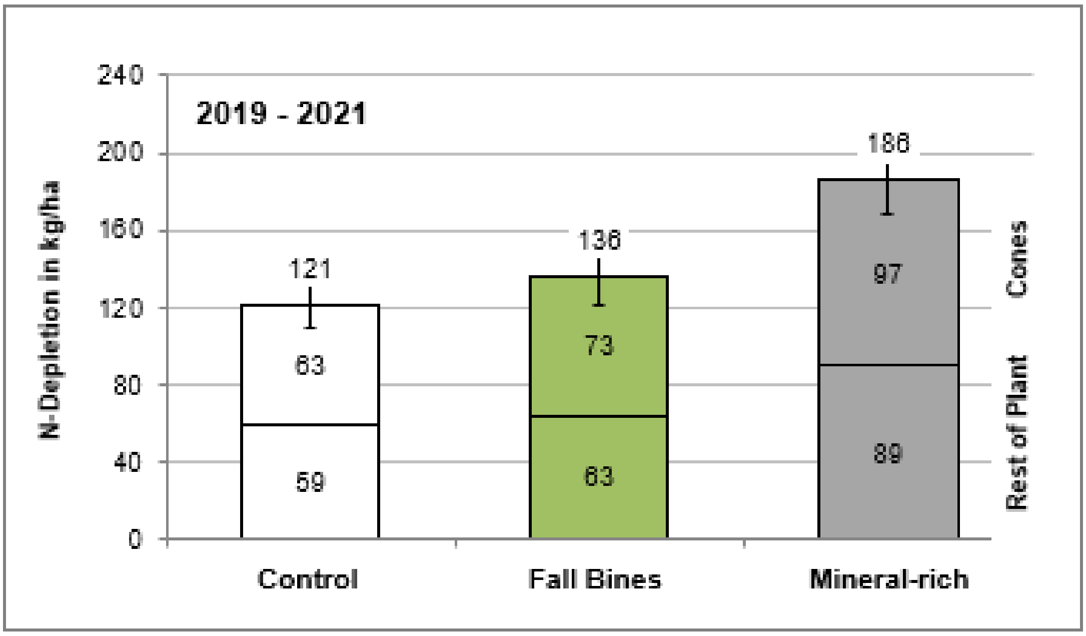


Figure 4.4: Average N-removal from 2019-2022 broken down into cone and residual plant removal depending on N fertilization (control = 90 N mineral; autumn bines = 90 N mineral + 90 N via bines.; mineral = 180 N mineral) 2019-2021, variety Hercules, loamy sand

The tests are to be continued for many years so that the long-term fertilizing effect of the organically bound nitrogen in the bine shreds and digestate can be better assessed.

4.3 A "shot-in-the-dark" experiment with the biostimulant experiment with Utrisha™ N

Background

Because of the nitrogen fertilization specifications and restrictions contained in the new German Fertilizer Ordinance, the optimization of N-fertilization is becoming progressively important in the struggle to ensure the continued yield and quality of the harvest, while also protecting the environment. This begs the question of whether nitrogen efficiency can be increased by binding atmospheric nitrogen via a biostimulant and in parallel to also using conventional mineral and organic N-fertilization products that rely on nitrogen-fixing bacteria (*methylobacterium*). It would be a great step forward if any such biostimulant were capable of supplying up to 25% of the plant's N-requirement by fixing atmospheric nitrogen to form ammonium. The nitrogen obtained in this manner could contribute to plant nutrition and possibly serve as a partial replacement of nitrogen fertilizers. In order to investigate the use of biostimulants based on nitrogen-fixing bacteria as a contributor to optimizing N-fertilization in hops, a product called Utrisha ™ N, made by the Corteva company, was tested in a field trial.

Method

The test location was a medium-heavy soil plot planted with Herkules near Neuhausen in the eastern Hallertau. The experiment was divided into two halves, each with 2 false repetitions. One half of the area served as the control. It was fertilized as usual. The other half received both Utrisha™ N and conventional fertilization. The recommended application rate for the Utrisha™ N was 500 g/ha, applied on June 20th, 2022, riding on 1,200 l of water per ha dispersed via a 5-nozzle blower sprayer with a driving speed of 2.7 km/h at a pressure of 22 bar. Two nozzles at the top and one at the bottom remained closed. From the beginning of June to mid-August, the leaves in the plots were examined for their chlorophyll content with a SPAD meter and for their N-content using the Dumas method in a laboratory. In addition, the yield was mapped via satellite technology and image processing software; and an index was constructed to reflect the N-image of the area. Both variants were harvested, as were the two fake repetitions. Next were the determinations of the cone yield, the alpha acid content, and the biomass and nitrogen removal in the cones and the residual plant matter.

Results and Discussion

The harvest results showed that there was a clear difference in yield between the variants. The yield of the control was around 700 kg/ha higher than that of the variant in which Utrisha™ N was applied and the alpha acid content was almost the same. However, the total nitrogen removal was 19 kg N/ha higher in the control at harvest time.

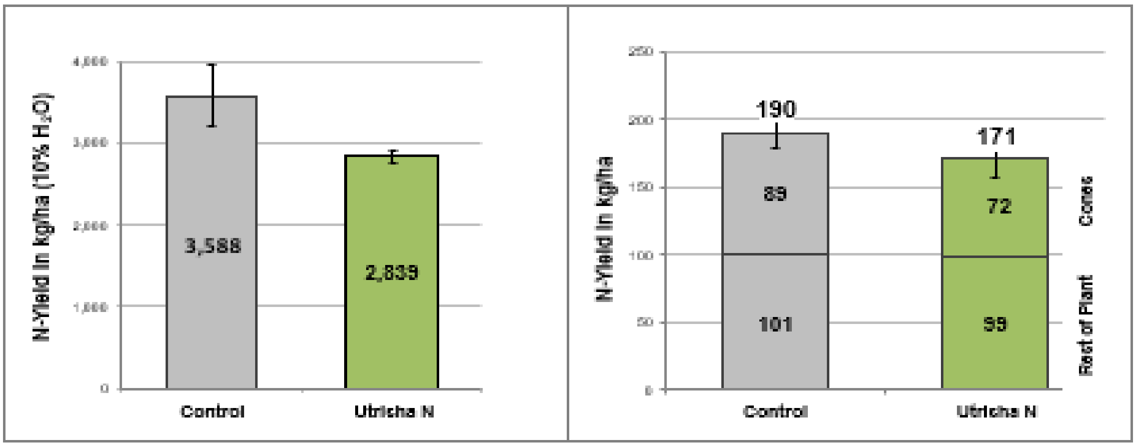


Figure 4.5: Cone yield in kg/ha at 10% H2O and nitrogen removal at harvest time divided into removal of cones and residual plants in kg N/ha according to variants at the Neuhausen Herkules location

After evaluating the satellite data, it became apparent that the nitrogen uptake and thus the yield potential of the soil on the test plot was rather inhomogeneous and the plot arrangement was rather unfavorable for the Utrisha™ N variant.

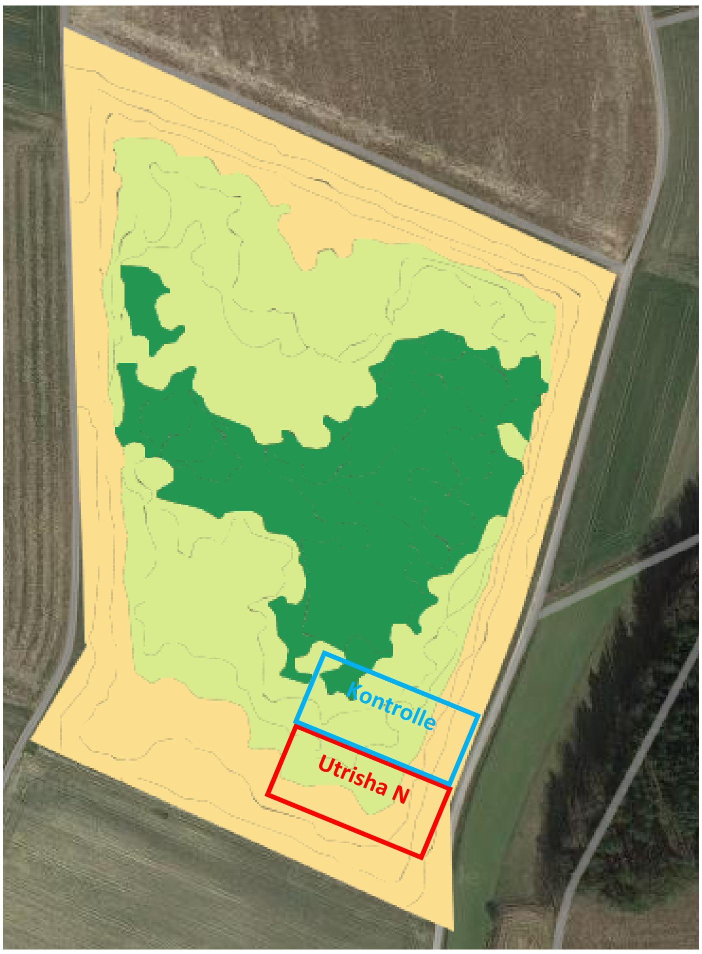


Figure 4.6: Nitrogen uptake map (green +15%, light green Ø, yellow -43% N uptake)

4.4 Simulation of agro-PV systems on hops with regard to pathogens, yield, and hop quality

Background

Agri-photovoltaics (Agri-PV) describes a process in which agricultural land is used simultaneously for both food production and PV power generation. This parallel land use allows for the expansion of renewable energies in open spaces without losing agricultural land. Hop fields are ideal for Agri-PV insofar as the trellises can be used as part of the support structure for PV modules. This 2-year simulation test examines the extent to which the shade cast by the modules influences hop growth, yield, and quality, as well as the occurrence of pathogens.

Experimentation and Methodology

In two hop gardens, a net with a spacer (approx. 20 cm) was installed over the hop trellises in a sub-area (30 m x 20 m). In 2021, the net was a mesh with 50% light transmission. Because the initial results from 2021 showed that the shade had indeed a very strong influence on the hop plants, another net with a higher light penetration rate of 70% was installed in 2022. In 2021, two varieties, Herkules and Perle, were tested; and both behaved similarly when shaded. Therefore, to reduce the workload for the test, only a single variety, Herkules, was tested in 2022, but with the two shading variants.

During vegetation period, the effects of the two types of shade on growth, yield, and quality, as well as on disease and pest infestation were compared to a control. The assessments were made on 7 consecutive double rows in the middle of the shaded plots, as well as offset in the unshaded part of the field (the control). For pest rating, 50 leaves were removed at different heights and the number of aphids and spider mites were counted by sight using a magnifying glass. The counts were done for both years. The laboratory in Hüll, on the other hand, examined the quality in terms of alpha acids (HC method) and total oil contents.

Observations and Assessments

<u>Growth Curve</u>

Both varieties had a growth advantage in the shade in 2021. The leaves were larger and softer in the upper half of the plants. In addition, the side shoots were longer. In 2022, however, because of the weather conditions that year, the shading caused even greater differences in plant development; and at the second assessment date at the end of August 2022, the difference could be seen even with the naked eye.

<u>Disease and Pest Infestation</u>

As for powdery mildew, there were no noticeable differences in the degree of infestation in 2021. However, downy mildew primary and secondary infestations were present in all variants. Both varieties, especially Herkules, had heavy downy mildew infestations shortly before harvest. The symptoms suggest that the infestations must have started already during the flowering phase.

There were plenty of dead blossoms, which obviously reduced the number of cones. In the dry year 2022, on the other hand, there was no evidence of any downy and powdery mildew infestations. Instead, there were heavy flea infestations equally across all variants without any detectable differences in the shaded variants.

While at the first assessments in mid- to late-June, the occurrence of aphids was higher in the control variants, all aphids had disappeared from all variants at harvest time, probably because of effective mitigation measures.

The examination of spider mite infestations revealed clear differences between the shaded variants and the control throughout the growing season. Table 4.3 shows the spider/egg averages as recorded on August 30th, 2022, before the harvest:

Table 4.3: Infestation with spider mites/eggs on August 30, 2022

Bines	Control	Shading 30%	Shading 50%
Top	8.2/0.2	2.1/1	28.3/1
Center	16.6/7.2	12.6/4.4	39.7/7.3
Bottom	279.5/460.6	27.6/30.7	16.5/2.9

Results and Discussion

Growth Curve

From the start of the growth period in 2021until the plants reached the trellis height, Perle and Herkules showed better growth in the shade. In addition, the leaves were larger and softer; and the plants had longer side shoots. This growth behavior is typical for shaded plants that are not exposed to direct sunlight.

During the generative development, both varieties in the shaded variant formed long side arms and developed cones mostly in the upper third of the plants. The uneven distribution of cones was apparently slightly more pronounced in Herkules than in Perle. In plants at normal exposure (that is, without a light-blocking net), the cones reached all the way to the bottom (Perle) or only half-way up the bines (Herkules). In 2022, the difference between the two types of shades was even more pronounced. The variant with 50% shading developed substantially longer side shoots than the variant with only 30% shading. Therefore, the unequal distribution of cones depends both on the variety and on the amount of light, which is also observable in commercial practice. Hop plots with lush vegetative development with tops that have grown together receive only little light below the canopy and usually form cones only in the upper exposed area of the plants. Varieties with slender growth patterns, on the other hand, such as Perle, receive more light throughout, and therefore, develop more blossoms and cones on the lower bines.

Finally, the lack of light in the shaded variants (those with a net) also impaired the growth of weeds; and cover crops failed to develop almost entirely between the rows.

Figure. 4.7: Variant with 50% shading (front), a transition area (middle), and the control (back), in 2021

Disease and Pest Infestation

At the first assessments at the end of June, during the peak application times for key disease control measures, there were no noticeable differences in disease infestations between the variants.

The situation was different for pest infestations. For both hop varieties, the shaded plots had fewer aphids than the unshaded ones. For Herkules, the reduction was about 20% in 2021, while it was about one-half for Perle. The results were similar in 2022, when there were also fewer aphids in the shaded plots. To date, there is no known explanation for this difference. We can only assume that aphid flies trying to colonize hop plants in the spring are hampered by the net or that they find conditions for colonization in the shaded variants less attractive for some mysterious reason.

In 2021, the difference in infestations was even more pronounced for common spider mites than for aphids. For Perle, the average spider mite infestation across all plant heights was just under 20% in the shaded plot compared to the unshaded one. When plant height is taken into account, most spider mites resided on the upper leaves in the shaded plot, but they preferred the middle leaves in the unshaded plot. For Herkules, the overall infestation was slightly higher than for Perle, but in the shaded plot it was only one-third that of the control plot.

As far as the distribution by plant height is concerned, there were no differences between the Herkules plots. In the dry and hot crop year 2022, all infestation differences outlined above were more pronounced, as expected. On the second assessment date, the plot with 30% shading had only 10% of the spiders relative to the control plot, while the plot with 50% shading had only 6%.

The common spider mite is known to be very warmth-loving. As a result, the greater proliferation of these mites in the light-flooded variants is probably the result of greater solar radiation and thus higher temperatures. However, temperature measurements were not taken in these plots to verify this assumption.

Yield

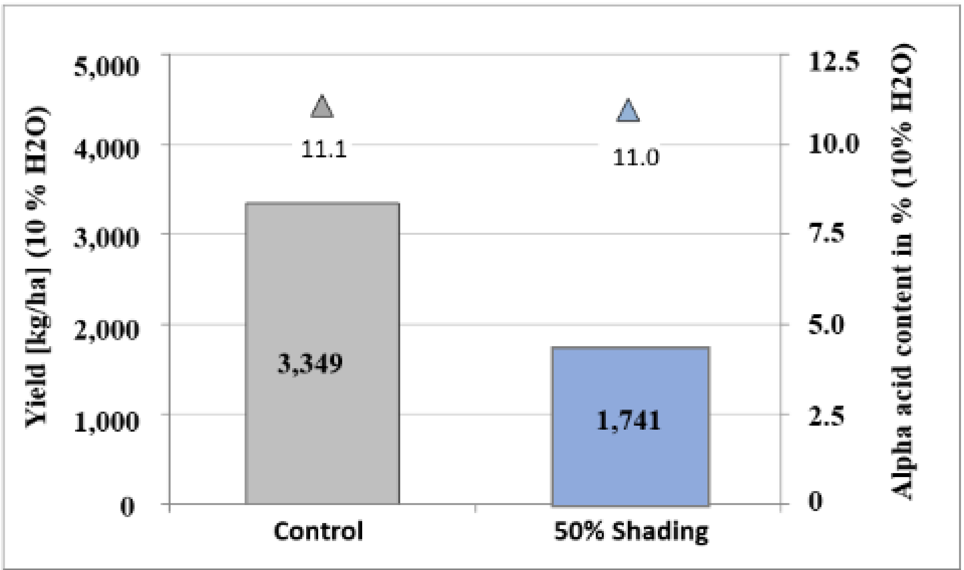


Figure 4.8: Yield and alpha acid content in 2021 for Perle

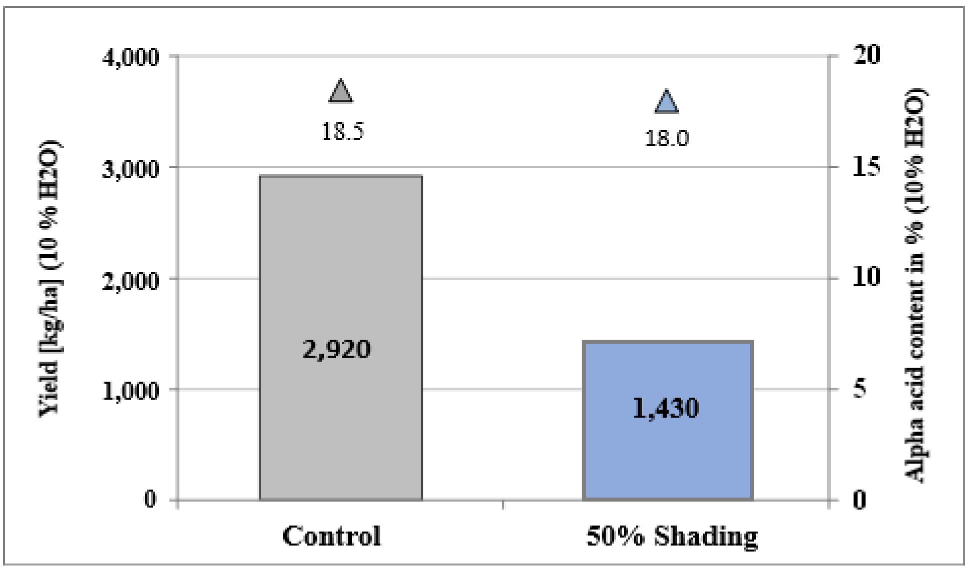


Figure 4.9: Yield and alpha acid content in 2021 for Herkules

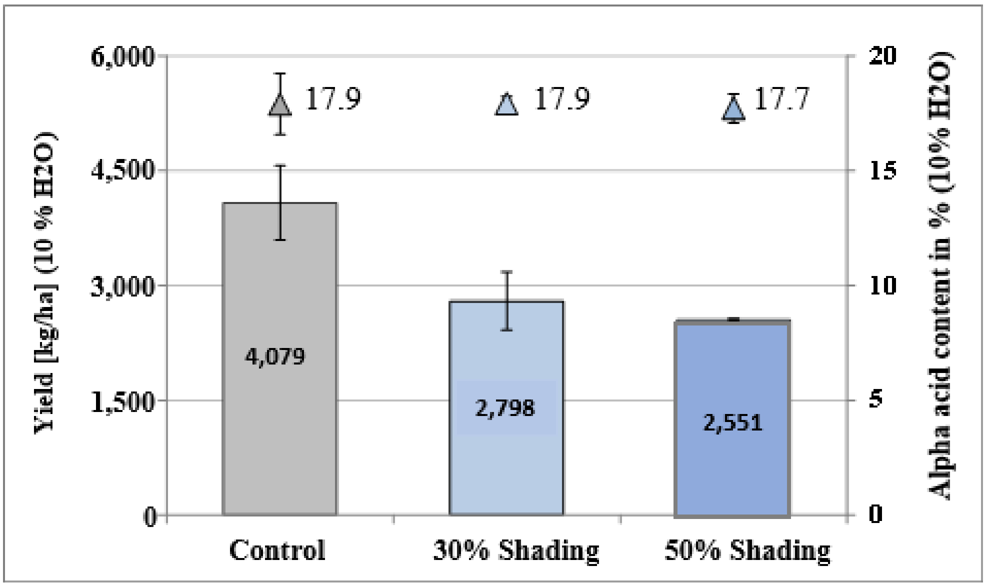


Figure 4.10: Yield and alpha acid content in 2022 for Herkules

<u>Quality</u>

Alpha acid content is a significant quality parameter for hops. However, laboratory analyses of the variants showed no differences between shaded and unshaded plots in either year. Shading had no effect on alpha acid formation during the rainy vegetation period of 2021 (with very few hot days and temperatures ≥ 30 °C, as well as exceptionally high alpha values) nor during the following year, when opposite conditions prevailed.

Oil content, on the other hand, was influenced by shading. In 2021, Herkules in the shaded plot had a 20% lower oil content than in the unshaded plot. In the case of Perle, the oil content in the shaded plot decreased by the same amount as the yield. Likewise, in 2022 shading caused the oil content to drop by almost 10% in both varieties. Oil synthesis, therefore, appears to be more dependent on solar radiation or light intensity than alpha acid formation.

Note: Because the experiment was conducted only once, without repetitions, precise statistical pronouncements about yields and qualities are not possible. Instead, the experiment merely reflects what might be a trend.

4.5 Temperature measurements in a foil tunnel to capture solar energy for drying hops

Objective

The goal of this investigation is to determine the extent to which a solar-heated foil tunnel for air can possibly increase the intake air temperature during hop drying and thus save fuel.

Method

An empty foil tunnel used for this investigation was supplied by an asparagus and berry farm in Sandharlanden. The tunnel's dimensions are 90 m x 9 m x 4 m (length x width x height). It runs from east to west on a slight northeast slope. Two axial fans positioned on the raised west side of the foil tunnel extract solar-heated air. According to the manufacturer's information, each fan has an air flow rate of 8000 m³/h and an air outlet speed of 11 m/s at an air pressure of 100 Pa. Two hoses, each with a diameter of 560 mm, were installed halfway up the inside of the rear end of the tunnel to extract the air.

Several data loggers were installed over the entire length of the tunnel at a height of 3 m to document the temperature and relative humidity. On the one hand, it was determined how high the temperature rises during the day and, on the other hand, to which extent the temperature changes during operation of the fans. The temperature of the outflowing air was also recorded using data loggers attached to the axial fans. A weather station located 200 m away from the site provided the relevant weather data.

Figure 4.11: Foil tunnel and axial fan with air hoses

Result

The following graphic shows an example of the temperature difference between the outside air and the heated air drawn in from the foil tunnel by the axial fans. The values were recorded during a partially sunny day on September 14, 2022. The inflow temperatures (measured inside the air hose in the tunnel) and the outflow temperatures (measured outside at the air outlet of the axial fan) were always identical for both fans.

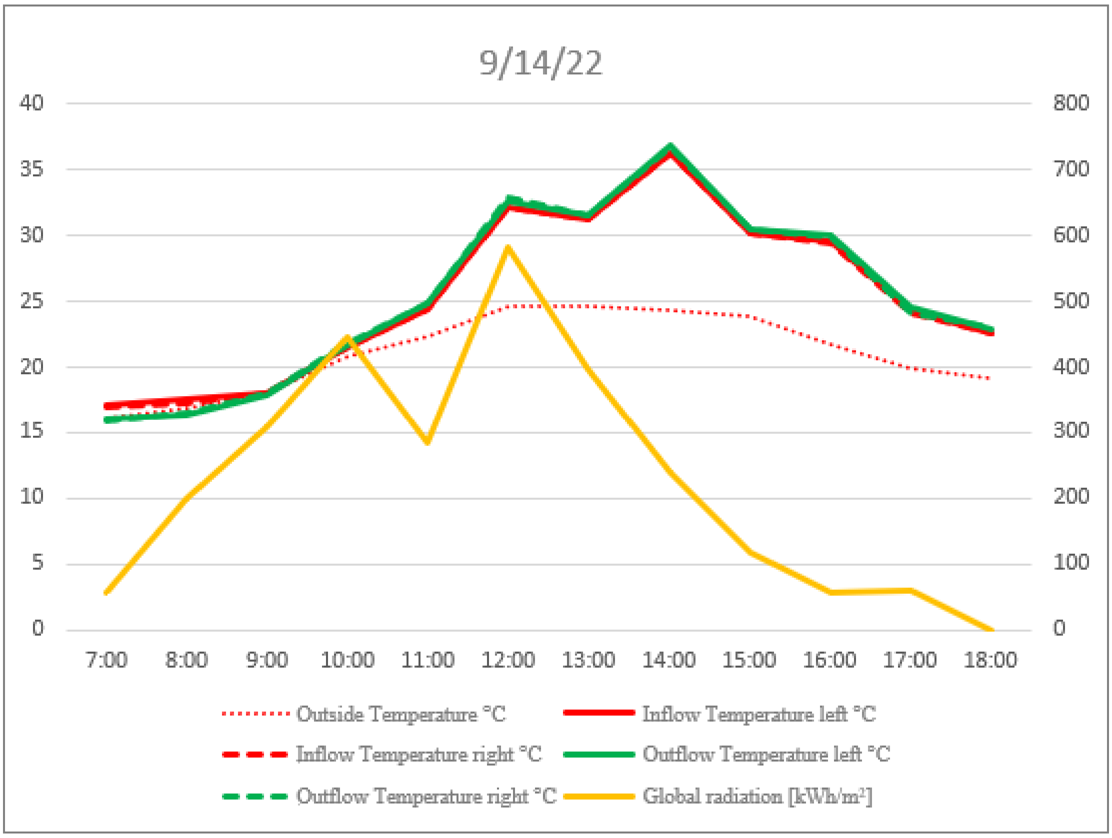


Figure. 4.12: Comparison of inflow and outflow temperatures

Since there were no temperature differences over the entire length of the foil tunnel during extraction, it can be concluded that more solar-heated air could be used with more powerful fans.

Discussion and Outlook

When using alternative energy sources for drying hops, all or part of the intake air flow is preheated. The higher the temperature of the intake air, the less energy has to be used to heat the drying air to approx. 65 °C and the more fuel can be saved. The following assumptions were made for calculating the extent to which an increase in intake air into the tunnel during hop drying can replace heating oil:

The total extracted air volume should correspond to the air volume of a hop drying system with a drying area of 16 m². With an assumed air speed of 0.35 m/s and the difference between an assumed drying temperature of 65 °C and the blow-out temperatures measured at the fans, a possible fuel oil saving for the fictitious kiln size of 16 m^2 can be calculated in %. (Figure 4.13).

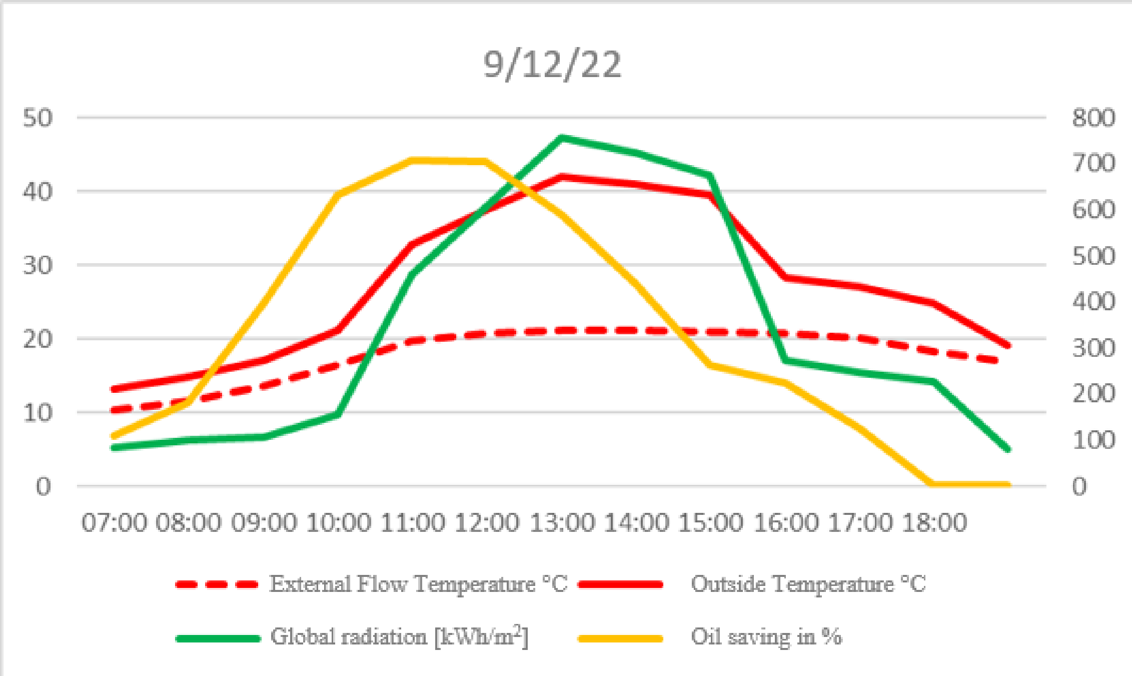


Figure 4.13: Calculated heating oil savings over the course of the day

Figure 4.13 shows that potential heating oil savings vary depending on global radiation and outside temperature.

In practice, during harvest days, hop drying usually starts at 6 a.m. and ends at 10 p.m. This means that solar heating is not available in the morning and evening. Therefore, heating oil savings must be put into their proper perspective. The following graphic shows adjusted potential heating oil savings for different days during the 2022 harvest.

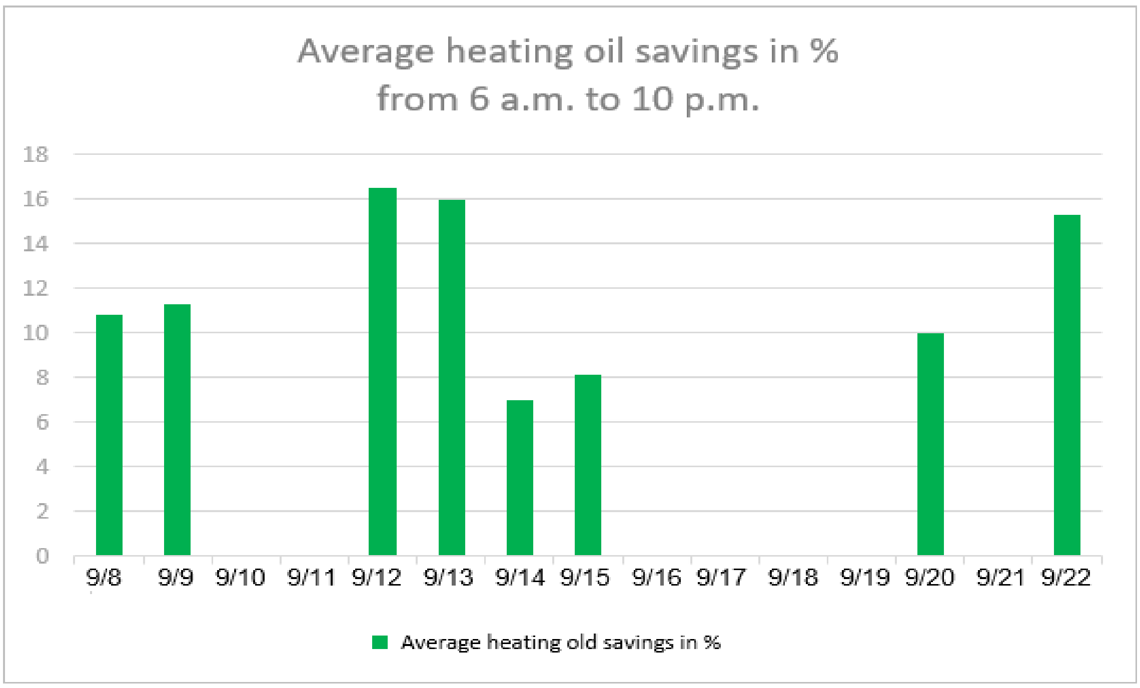


Figure. 4.14: Calculated daily heating oil savings during hop drying on different days of the 2022 harvest

The figure shows that possible heating oil savings are very dependent on the external weather conditions and varied between 7% and 16% on the different days during the 2022 test period. The greater the global radiation with simultaneously low outside air temperatures, the higher the expected heating oil savings. The absolute amount of heating oil savings can only be determined in pilot operations and is also influenced by the tunnel dimensions and thus the available air volume.

Whether the use of solar-heated air in tunnels to save energy in the drying of hops is economical depends not only on the weather conditions, but also on the size of the capital investment and other potential uses of the tunnel in addition to the brief period of hop drying.

4.6 Optimization of drying processes in belt dryers

One research focus in the production technology of hop cultivation is the optimization of the drying process in belt dryers. In recent years, many new developments have occurred in this area. Some of these are outlined in the LfL information brochure "Drying and conditioning of hops," which is available for viewing or downloading on the LfL hops page.

www.lfl.bayern.de/publikationen/informationen/252689/

Below are summaries of modifications and innovations in belt dryer technologies that contribute significantly to the optimization of the drying processes.

Improvement of air distribution

For optimal, high-performance drying, air must flow evenly over the entire hop surface. This is made possible by modifying older air distribution systems, which propel air in a right angle to the travel direction of the conveyor belt, so that the air now travels in the same direction as the belt. This involves the use of special distribution and smoothing grids that deflect and thus redirect the air at a 90° angle. Experience with this modification has shown that it improves air distribution and thus achieves an improved and more homogeneous drying performance over the entire drying area, including the sides even at different air speeds.

Loading of the upper drying belt with green hops

For proper drying, the belt dryer must be loaded evenly with green hops, at the same density and depth over the entire belt width all the way to the sides. With most belt dryers, this is currently done via a feeding belt.

When converting old or installing new belt dryers, results improve if the feeding belt is installed transverse to and at an incline directly above the upper drying belt.

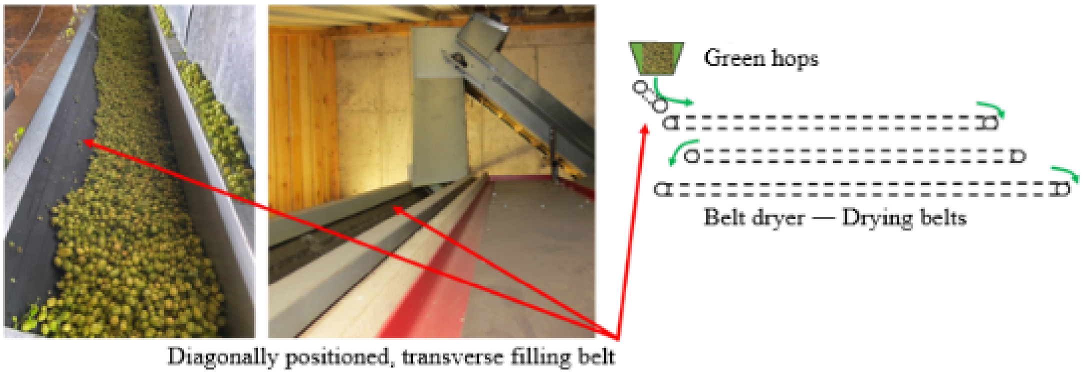


Figure 4.15: Inclined, transverse feeding belt for loading the belt dryer with green hops

This type of arrangement ensures that the hops are deposited loosely without heaps and clumps. This continuous, homogeneous loading of the upper drying belt is essential for uniformly drying the hops while adapting the throughput to the blower output. In addition, this loading system saves space because the feeding belt does not require a separate footprint.

Heat Recovery

Because of rising energy costs, heat recovery systems are becoming more and more economical. The warm exhaust air from the drying process can be used to heat the intake air via plate or cross-flow heat exchangers. In this process, a blower forces the warm exhaust air through a heat exchanger before releasing it to the outside. At the same time cooler air from the outside is sucked into the warm heat exchanger in the opposite direction. The higher the temperature difference between exhaust and intake air, the higher is the temperature rise of the process air and the more efficient, the system. An evaluation of drying logs shows a potential savings of roughly 20-30% in thermal energy through such heat recovery systems.

Extension of the drying area by pre-drying

Existing belt dryers are increasingly augmented by a single pre-drying belt to increase throughput. The area of the pre-drying belt usually amounts to 25-50% of the base area of the main dryer.

When drying hops, the moisture on the cone surfaces is removed first. At this stage, air velocity has a greater influence on the drying speed than air temperature. Therefore, the preheated air from the heat recovery system is already sufficient for this step. If necessary, the air temperature can be raised with heated air from the regular air heater.

It is essential that the preheated cones are sent straight into the main drying process at the end of the pre-drying process. They must not cool down, which would interrupt the drying process and lower the quality because of condensation.

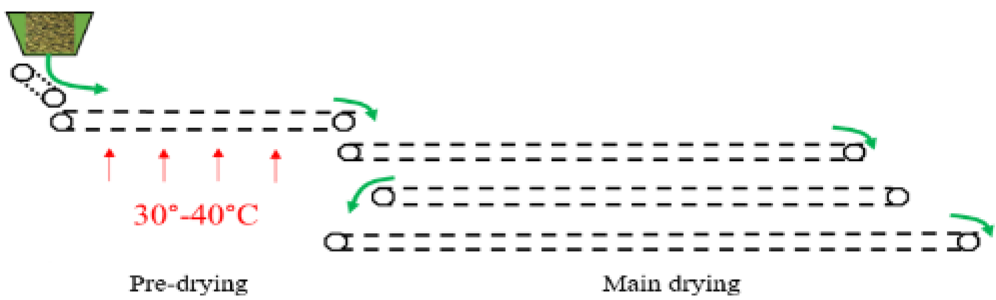


Figure 4.16: Schematic representation of pre-drying in belt dryers

4.7 Testing various materials as substitutes for plastic cords at the "string wires"

Background

In the Hallertau, it is conventional to use training wires with polypropylene (PP) cords at the end as part of the trellis structure in almost half the hop acreage under cultivation. The purpose of these plastic cords is to minimize the number of bines that might fall to the ground during severe wind and storm events. Compared to wire, the flexible cords do not rub against the trellises. Thus, they do not become potential bine breaking points. Instead, they provide more stability. The cords usually do not tear off during the harvest and remain on the trellises for years. However, the UV radiation from the sun can cause the plastic to become porous and, after a few years, their non-degradable residues may enter the ground. To prevent this, different replacement materials for the plastic wire ends were tested at two locations in 2022.

Method

The test sites were in the northern Hallertau near Ilmendorf and Forchheim. They were open to prevailing westerly winds which created especially challenging conditions for hop cultivation. The hop variety was Herkules. The training wires with the different test materials were strung in regular fashion in early spring. In addition, one each of the teat materials was fastened to the two barbed wires stretching along a row.

Various manufacturers supplied different non-synthetic materials for the test. Because the quantities of the alternative materials used for the test were limited, not all materials could be strung along the entire length of the hop garden. For some material, only 100 twines were available. The materials arrived on spools and had to be tied by hand to the iron wires, which were then attached to the barbed wire.

The alternatives to plastic cords were:

- Two lines from two different manufacturers made from polylactide (PLA) or polylactic acid. These were of different strengths.
- Cellulose cord

The reference materials for the experiment were:

- 12 mm plastic cord wire from various manufacturers
- 13 mm iron wire

Figure 4.17: Different materials as a substitute for plastic cords at the ends of "cord wires"

At the beginning, the difficulty of attaching the training wires was assessed, and the test area was checked for downed bines, until the harvest time.

Results

The table below lists the materials used, rates their ease of handling, and provides a count of the number of downed bines at both locations:

Table 4.4: Overview of trellis string materials, type of knots, ease of handling, and number of fallen bines

No.	Variant/ Material	Mfr.	Knotting	Handling	Remarks	Location Forchheim		Location Ilmendorf	
						Total no. of wires	Fallen bines	Total no. of wires	Fallen bines
1	Plastic cord wire (Reference)	A	Machine	+++	Normal plastic cord	320	0	270	0
2	Bio. thick cord from PLA	A	Machine	++	Thicker than plastic	320	0	270	0
3	Bio. thick cord from PLA	A	Manual	++	Thicker than plastic	100	0	100	0
4	Bio. thick cord made of Cellulose	B	Manual	---	Lack of inherent stability (knot)	100	0	100	1
5	Plastic cord wire (Reference)	C	Machine	+++	Normal plastic cord	320	0	270	0
6	Bio. thick cord from PLA	C	Manual	++	Thicker than plastic	100	0	100	0
7	Bio. thin cord from PLA	C	Manual	0	Somewhat sticky	100	1	100	0
8	Iron wire 13 mm (Reference)	C	-	+++	Normal iron wire	320	0	270	0

Table 4.4 shows that the plastic cords and iron wires (variants 1, 5 and 8), which are currently preferred, are also the easiest to handle. The somewhat thicker PLA lines (variants 2, 3 and 6) performed only slightly worse, which is why it is quite conceivable that they become practical replacements. Because of its sticky surface, the thinner PLA cord (variant 7) received only a mediocre rating for handling. The cellulose cord (variant 4) did not prove practical because of its lack of rigidity. These cords tend to knot prematurely, which makes it more difficult to attach them to the barbed wire.

In the entire experiment, there were only two downed bines (variant 7, PLA thin cord, at the Forchheim site; and variant 4, cellulose cord, at the Ilmendorf site). However, because of the small number of bines in the test, the percentage of torn cords remained below 0.1%, which makes it impossible to draw statistically significant conclusions from the result. Nevertheless, the poor handling characteristics of variant 4 (cellulose) and the average handling of variant 7 (PLA), suggest that these two materials are not practical - even when taking the downed bines into account.

The thicker PLA cords, which can be knotted by machine, seem to have the needed physical properties as replacements for the plastic cords. In theory, these plastics are biodegradable only at temperatures above 55 °C, which means there are certain times of the year when they will not decompose in the ground.

For a competitive and sustainable solution, alternative products should be tear resistant, easy to handle, and soil degradable. Therefore, the experiment will continue in 2023 with other potentially promising materials.

4.8 LfL Projects within the Scope of the Production and Quality Initiative

Between 2019 and 2023, in support of greater production and quality of agriculture in Bavaria, the Bavarian State Research Center for Agriculture has collected, recorded, and evaluated representative yield and quality data of selected agricultural crops. The association partner Hopfenring e.V. carried out these activities for the IPZ hops working group. The objectives of these hop projects are outlined below with a summary of the results for 2022.

4.8.1 Dry matter and alpha acid monitoring

From August 16 to September 27, 2022, samples of Hallertauer Mittelfrüh, Hallertauer Tradition, Perle, Hersbrucker Spät, Hallertauer Magnum, and Herkules were harvested and kilned separately in one-week intervals at 10 commercial hop gardens throughout the Hallertau (1 row each; 5 plants each of the aroma varieties, and 7 plants each of the bitter varieties). The day after the harvest, the dry matter and alpha acid content of the green hops at 10% residual water content were determined by an accredited laboratory and passed on to the LfL hop advisory service for evaluation. The results were averaged, tabulated, converted to a graphic representation, and posted with comments on the Internet. Farmers could use these data to figure out the optimal harvest maturity of the most important hop varieties.

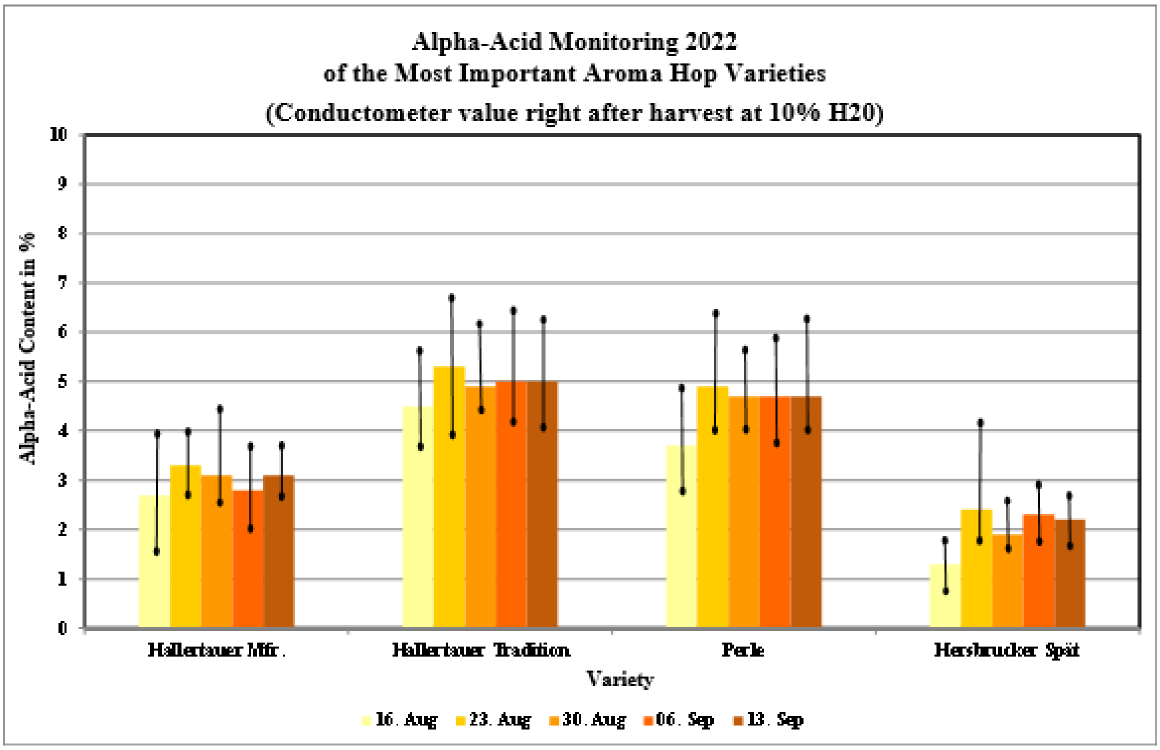


Figure 4.18: Monitoring of the alpha acid content of the key aroma varieties, in 2022

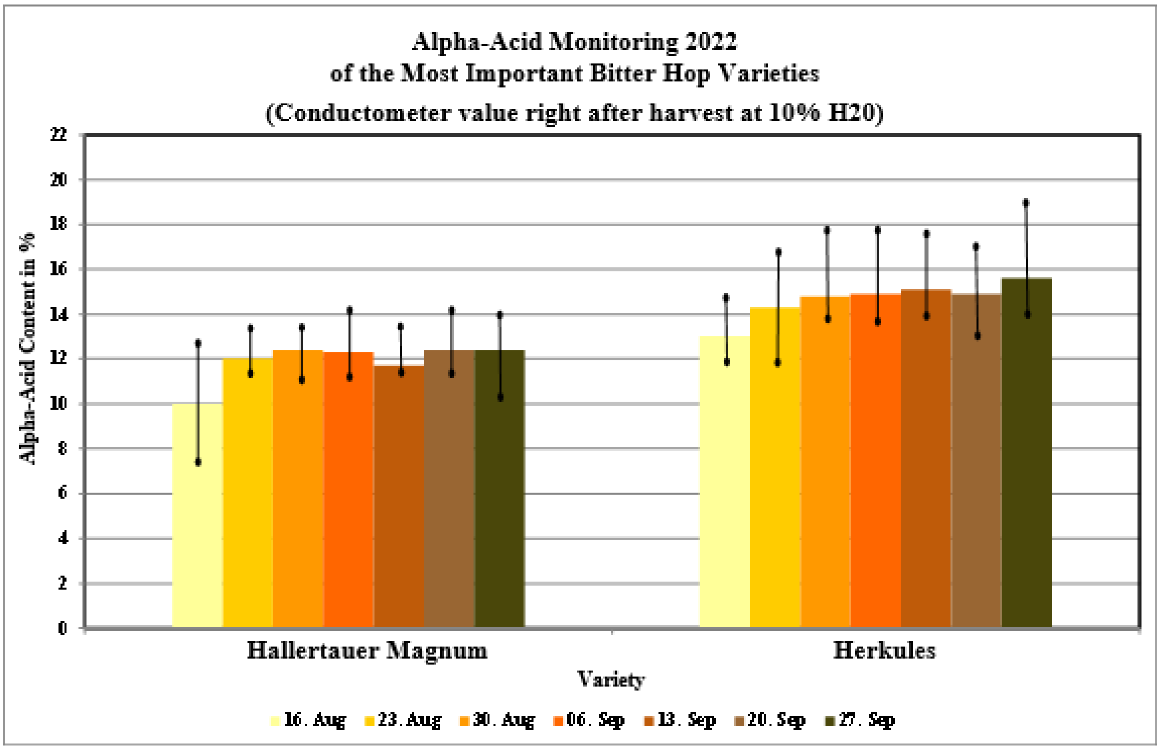


Figure 4.19: Monitoring of the alpha acid content of high-alpha varieties in 2022

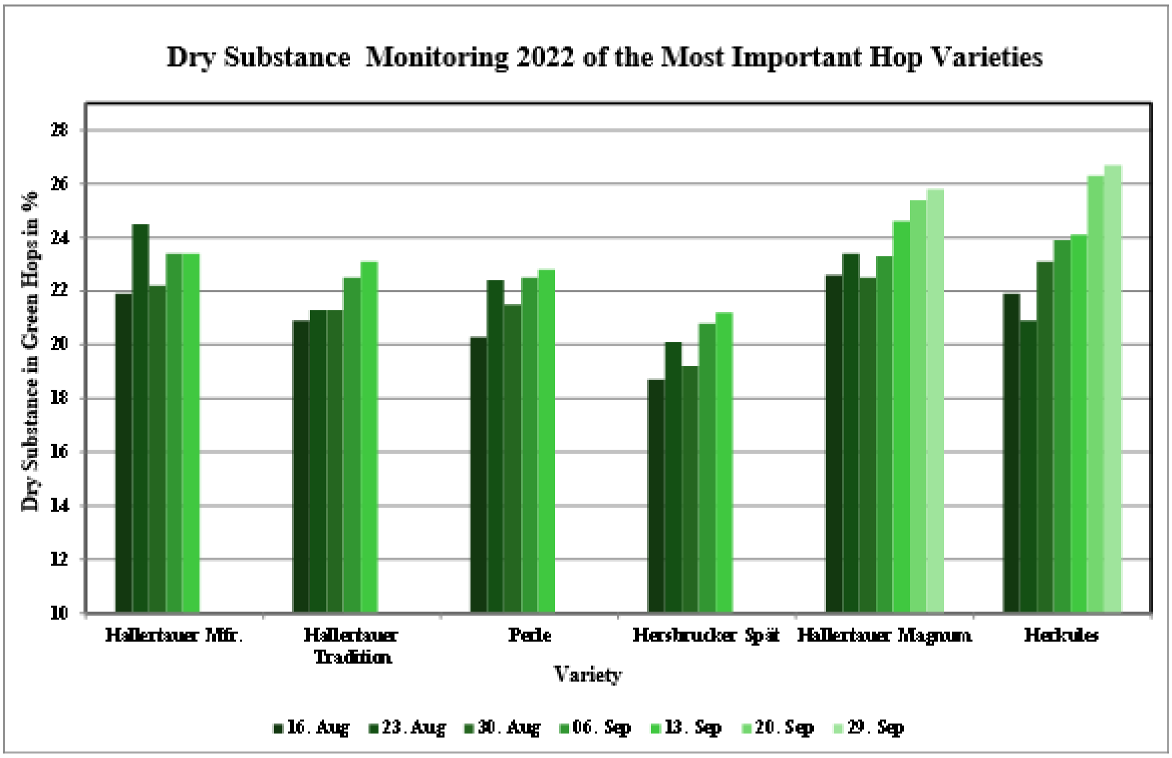


Figure 4.20: Monitoring the dry substance in key hop varieties in 2022

The graphic representation shows a data comparison between 2021 and 2022, as well as the average of the past 6 years, for Perle and Herkules for different harvest dates. The alpha acid values varied greatly from one location to the next; and overall, the data has been disappointing and were at the lowest level since the start of monitoring in 2014.

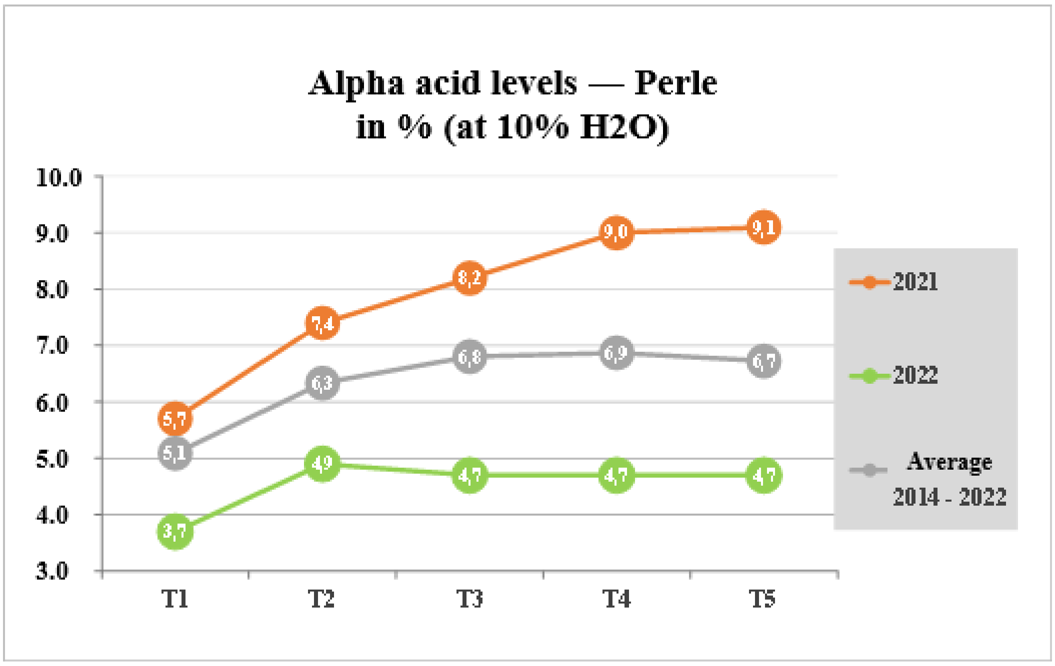


Figure 4.21: Development of the alpha acid content in Perle in previous years

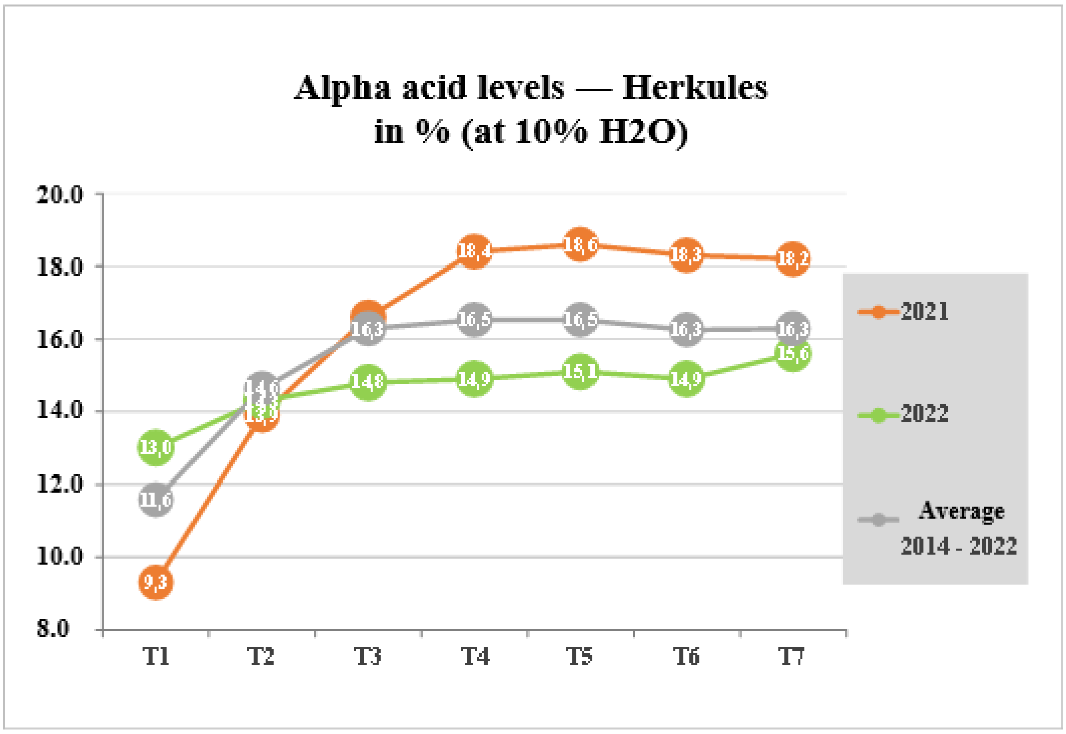


Figure 4.22: Development of the alpha acid content of Herkules in previous years

4.8.2 Annual survey and investigation of pest infestation in representative hop gardens in Bavaria

To assess aphid and spider mite infestations and to determine which steps can be taken to control them requires precise on-site surveys and evaluations in actual commercial hop gardens. Thus, 33 representative hop gardens, including 3 organic production sites, planted with different varieties were studied for hop aphid and common spider mite infestations, for 12 weeks in weekly intervals, between May 23 and August 8, 2022. The results for aphids were tabulated by numerical averages, while those for spider mites were quantified via an infestation index. Both became the basis for advice to farmers and for the design of control strategies.

An example of the progression of the spider mite infestation index is shown below.

Because of the warm spring in 2022, spider mites appeared relatively early and the infestation progressed at a similar rate as in 2020. However, unlike in 2020, the spider mite infestation rate increased steadily, so that the threshold for control measures was reached already in calendar week 24 in many plots. Once implemented, these measures lead to a decrease in the infestation index. Starting in calendar week 29, the infestation index increased again, which is highly unusual. This called for an emergency authorization for plant protection measures at this later stage.

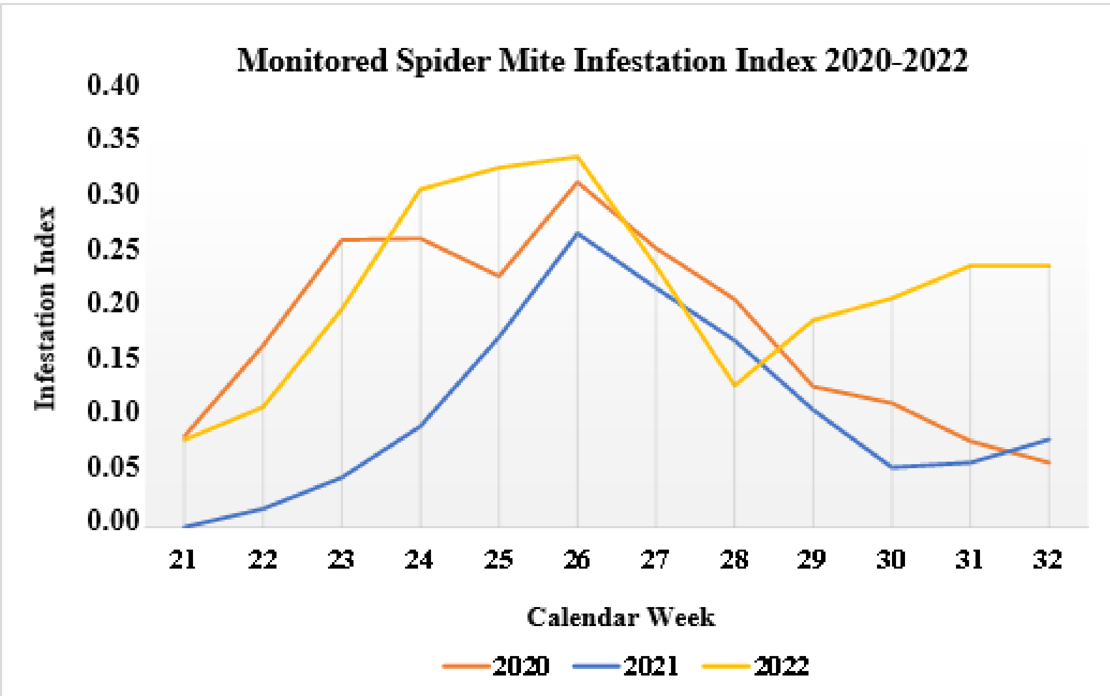


Figure 4.23: The average spider mite infestation index across all 33 monitored locations

4.8.3 Chlorophyll measurements on hop leaves to estimate both nitrogen supplies and fertilizer requirements

Objective

The specifications and restrictions contained in the new German fertilizer ordinance pose major challenges for hop growers. On the one hand, it is important to maintain optimal yields and quality; on the other hand, there is a growing need to protect the water supply. This means that nitrogen fertilizers nitrogen must be administered on a strict need's basis. They must be targeted in a nutrient-efficient manner. However, because the main nitrogen uptake period for hops is June and July, nitrogen fertilizer distributed in severely dry soils may not dissolve, while it might mineralize when organically bound in excessively wet soils. Therefore, regular leaf examinations at different locations and of different varieties can serves as guides for determining the nutritional status and thus the fertilizer needs of the hop plants.

Method

For this, chlorophyll measurements with a SPAD ("soil plant analysis development") meter (SPAD-502 plus) of hop leaves are a suitable method. Such measurements are taken between the end of May and mid-August, in 10 weekly intervals, using 2 varieties at 2 different locations in the Hallertau. This make the results statistically representative, on each date, 20 individual measurements were taken in 4 repetitions on leaves at an approximate height of 1.6 m. In order to assess the N supply status, the 20 leaves are separated, collected, dried, and examined for their total N-content, using the Dumas method. The SPAD values are displayed individually for each variety and location and an average value is calculated. This means that the relationship between measured chlorophyll values and N levels can then be examined using linear regression models.

In 2019, this procedure unearthed clear differences in N-supplies (see the annual report for 2019). In 2020 and 2021, such measurements were also used in a field test project entitled "Trials for composting and recycling of hop bine chaff" to determine if N-supply differences could be caused, among other factors, by the fertilizing hop plants with shredded bine material. Initially, SPAD meter could detect only small differences in the nitrogen supply between the variants. Starting in mid-June, however, these differences became larger. Linear regression models used in these tests also confirmed a connection between the SPAD meter values and the actual N-contents in the leaves (see the annual reports for 2020 and 2021).

Then, in 2022, 10 hop varieties in 2 breeding gardens were examined for the relationship between the SPAD meter values and N-supplies at the same location.

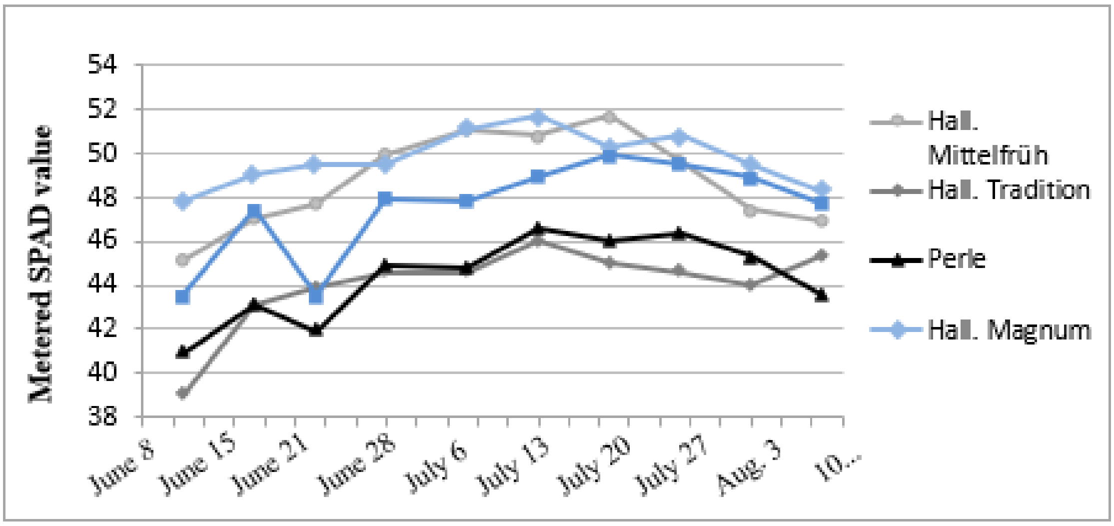


Figure 4.24: SPAD meter values over the course of 2022 at the Stadelhof site over 10 dates for 5 hop varieties

Figure 4.24 shows the differences in SPAD meter values between hop varieties, even when they receive identical nitrogen fertilization. The average difference in SPAD values for all dates between Hall. Magnum and Perle, for example, was 5.4. It is likely, however, that part of the difference is the result of different leaf colors between the 2 varieties (Hall. Magnum leaves are significantly darker than Perle leaves) and not just of different nitrogen uptakes. However, as previous studies have shown, if the SPAD value difference is 5.4 points for the same variety, only a N-deficiency is responsible for such a discrepancy. This means that SPAD meter differences in hops are only valid withing a single variety.

In addition, Figure 4.25 shows be seen that the nitrogen contents of the values for Hall. Mittelfrüh were significantly lower across all dates even though the SPAD meter values of Hall. Mittelfrüh were significantly higher than those for Perle and Hall. Tradition (Figure 4.24 above). This confirms that the SPAD meter values can differ greatly depending on the variety, regardless of the N supply status.

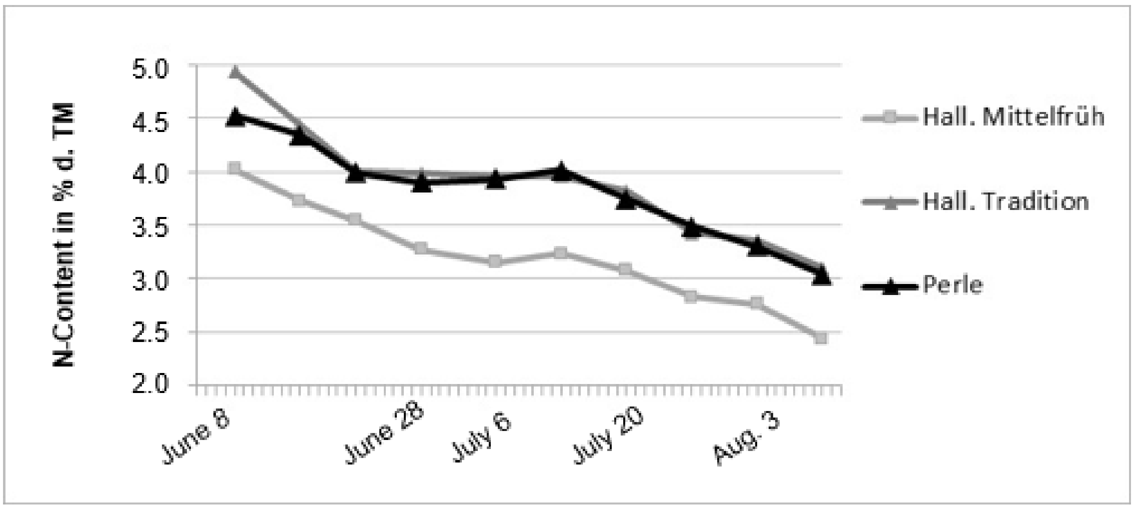


Figure 4.25: Nitrogen content in % of total mass in the leaves in 2022, at the Stadelhof location, measured for 3 hop varieties over 10 dates

4.8.4 Chain analyses for quality assurance in the determination of alpha acids requirements in hop supply contracts

For years, hop suppliers have used supplementary contractual agreements that take into account the alpha acid content of the delivered hops when determining payments. The alpha acid content is determined in government laboratories, company laboratories, and private laboratories depending on the available testing capacity. The procedures for sampling and storage are precisely defined in the brochure, "Working Group for Hop Analysis." There are also specifications for laboratory follow-up tests and permissible tolerance ranges of the test results. To ensure the quality of such alpha acid analysis and to serve the interests of hop growers, a so-called chain analysis method is used. It includes a final evaluation by the Bavarian State Institute for Agriculture as a neutral body.

As part of the project, the task of the Hopfenring (Hop Circle) is to carry out the sampling of a total of 60 randomly selected hop batches on 9 to 10 dates in the Hallertau and to provide the samples to the LfL laboratory in Hüll.

4.9 Consulting and training activities

In addition to conducting applied field research in hop cultivation production technologies, the working group Hop Cultivation, Production Technology (IPZ 5a) is tasked with the preparation of the test results, along with advice and practical recommendation, as well as making them directly available to hop growers. These tasks may include special consultations, lectures, organizing working groups, training courses, seminars, print media, and internet content. Specific examples are the organization and implementation of a downy mildew warning service, updating instructions for this warning service, cooperating with various hop organizations, and providing training and technical support to such partners as the Hopfenring. Below is a summary of such training and consulting activities during the past year:

4.9.1 Written information

- The "Green Book" hops 2022, covering cultivation, variety, fertilization, plant protection, and harvest details, was updated in cooperation with the plant protection working group and the advice centers of the federal states of Baden-Württemberg and Thuringia. The press print run was 2,000 copies, distributed by the LfL to the ÄELF and to research institutions; and by the Hopfenring Hallertau to hop growers.
- The LfL used an established Hopfenring fax network to distribute time-sensitive cultivation instructions and warnings in 33 faxes to roughly 1,000 hop grower subscribers in the Hallertau, in Spalt, and in Hersbruck.
- Publication of advice and specialist articles for both hop growers and the brewing industry in a Hopfenring circular, in 5 monthly issues of the Hopfen-Rundschau, as well as 1 article in the Hopfenrundschau International.

4.9.2 Internet and Intranet

Warnings, advice, technical articles, and lectures were also made available to hop growers via the internet.

4.9.3 **Telephone advice, announcement services**

- The Peronospora warning service by the Working Group on Hop Cultivation and Production Technology, located in Wolnzach, was active from May 10 to August 29, 2022. The service was available for warnings, instructions, and inquiries via an answering machine (Tel. 08161 8640 2460) or the internet. The serve was updated 76 times.
- The technical advisers of the same working group also provided information during roughly 1,200 telephone inquiries, as well as one-on-one consultations in meetings or on site.

4.9.4 **Education and training**

- Examination of 3 projects written by master students as part of their examination
- 11 lessons about hop cultivation at the Pfaffenhofen agricultural school
- 2 study days during the summer semester at the agricultural school in Pfaffenhofen
- 1 information event for Pfaffenhofen vocational school students
- 1 meeting of the "Hops Management" working group

5 Plant protection in hops

Simon Euringer, M.Sc. Agricultural Management

5.1 Pests and Diseases of Hops

5.1.1 Downy mildew warning service 2022

During the 2022 growing season, three recommendations for spraying against the downy mildew secondary infection had to be issued. Two of these applied to all varieties, while the spraying recommendation of July 1 was only for susceptible varieties.

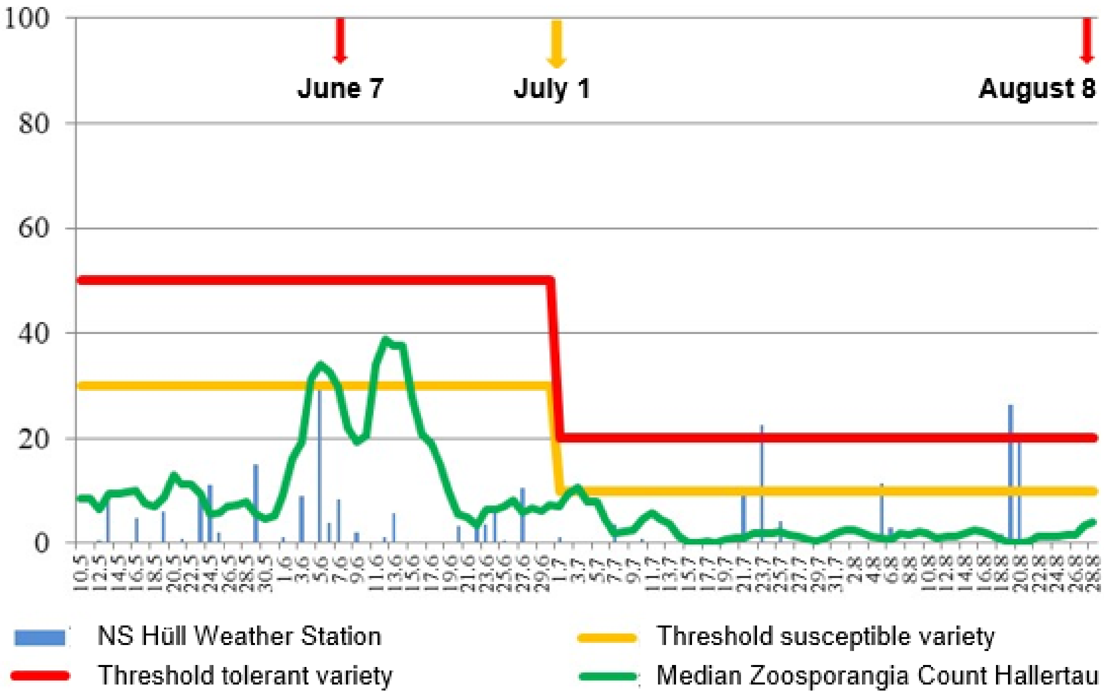


Figure 5.1: Representation of downy mildew warnings 2022 (mean zoosporangia count in the Hallertau; 4-day total, 5 locations, and spraying recommendations), IPZ 5a

5.1.2 Arrival of Aphis Flies in 2022

During the 2022 Aphis fly migration, intervention spraying needed to be carried out at the Siegertszell site on June 2. Therefore, the graph shown here does not represent the total migration pattern for 2022, when Aphis flies began to arrive between May 9 and 12, causing a relatively high infestation compared to previous years.

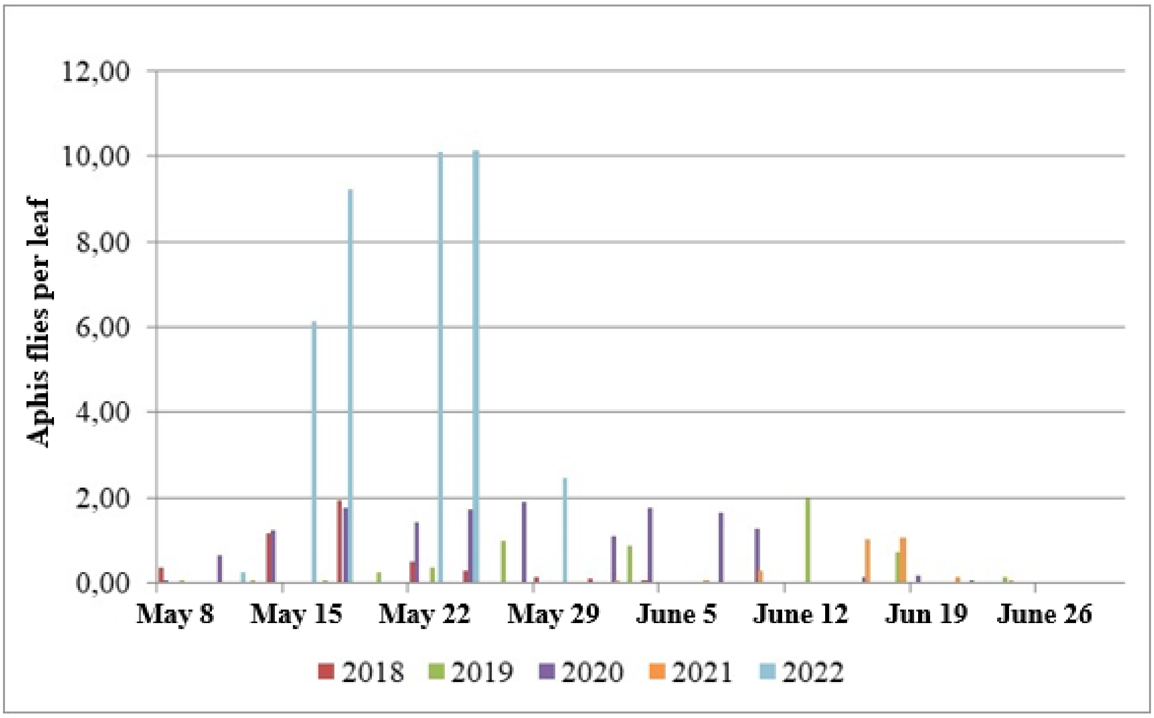


Figure 5.2: Arrival dates of Aphis flies at the Siegertszell location, 2018 – 2022

5.2 Official Effectiveness Tests

Management: S. Euringer

Team: R. Obster, A. Baumgartner, M. Felsl, K. Kaindl, K. Lutz, M. Mühlbauer, J. Weiher

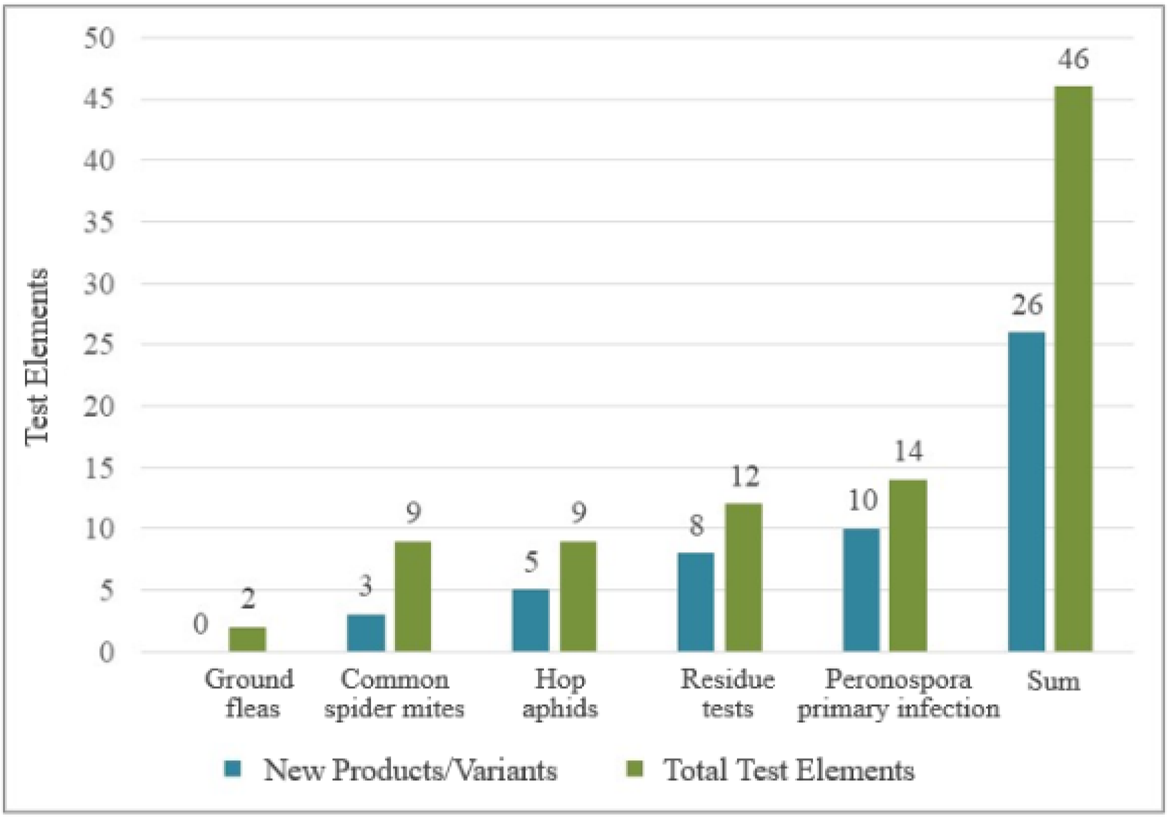


Figure 5.3: Official GEP tests in 2022

In 2022, ten so-called GEP tests (gene expression profiling) were carried out according to GEP standards for official efficacy test trials involving agrochemical products.

In addition, three non-GEP-compliant residue tests (for Floupicolide, Folpet, and Captan) were carried out outdoors, as well as a greenhouse test for powdery mildew and a test for an autumn application of herbicides.

5 indications were covered in the GEP trials. A total of 26 new products or combinations were tested in 46 test sections on approx. 13 ha.

5.3 Creation of a test garden for testing the effectiveness of crop protection products

A test hop garden was created in 2021 for official effectiveness tests of the new agrochemicals to provide early support in the development of crop protection products and thus ensure that new products are quickly available for practical use. The fresh hop area was planted with certified Herkules seedlings in October 2021 and maintained as a young hop area in 2022. It has an area of roughly 1 ha, which is sufficient space for nine experimental units.

The first efficacy trials for crop protection products are planned for 2023. However, only one efficacy trial per year can be carried out at the test site. This means that even after 2023 additional trials need to be carried out in commercial hop gardens.

The GfH (Gesellschaft für Hopfenforschung) covers the leasing cost for the test area.

5.4 Purchase of weather stations

When conducting product tests in plant protection, it is extremely important to collect weather data from the test site. However, at some locations existing weather stations are more than 5 to 15 km distant, which is a problem, because it prevents local precipitation, for instance, from being recorded. However, for the meaningful implementation and evaluation of the experiments, knowing when the first precipitation after the treatment occurred is of crucial importance. Such precipitation could wash off the active substance leading to a lower but inaccurate effectiveness rating or a premature follow-up application. In particular, for the so-called "Biologicals" product group, such parameters as temperature and the amount of moisture on leaves before and after the application can make all the difference.

Thanks go out to Mr. Ingo Fanieng of Agrarmeteorologie Bayern for making available the first two weather stations for official efficacy testing during the 2022 season.

5.5 Resistance and efficacy tests against hop aphids in a spray tower

Management: S. Euringer

Team: A. Baumgartner, M. Felsl, M. Mühlbauer

Hop aphids attack all hop varieties every year. However, the withdrawal of several important insecticides from the market makes it much more difficult to alternate active ingredients and avoid the build-up of resistances. The repeated use of the same active ingredient or ingredients relying on the same containment strategy, unfortunately, leads to a one-sided selection of harmful organisms and resistances against them, which eventually makes successful pest control impossible. Therefore, current and new active ingredients against hop aphids need to be validated in spray tower experiments. Laboratory tests producing consistent results can detect resistances at an early stage. Such laboratory results for different substances, however, can deviate greatly from field applications and are, therefore, not published. In 2022, four active ingredients were tested in seven concentrations each.

5.6 Enzyme-linked immunosorbent assay (ELISA) for the identification of hop mosaic virus (HpMV) and apple mosaic virus (ApMV) infections in hops

Management: S. Euringer

Team: A. Baumgartner, M. Mühlbauer, M. Felsl

Viral diseases are widespread in all hop-growing regions. In order to identify virus-infected plants, the Hop Research Center Hüll uses the ELISA.

Table 5.1: ELISA test results in 2022

	Total number of plants	ApMV		HpMV		Total plants	
		n.n.	positive	n.n.	positive	n.n.	positive
Mother plants for hop propagation	287	277	10	284	3	274	13
Breeding material IPZ 5c	400	399	1	398	2	397	3

* n.n. = undetectable

Samples that result in values close to detection limit are considered positive to minimize the risk of introducing potentially infected material into propagation.

Of 687 plants tested, 16 were discarded. The healthy plants were provided as breeding material and as mother plants for GfH contract propagation (Table 5.1).

5.7 CBCVd-Monitoring 2022

Sponsor: Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung
(Bavarian State Research Center for Agriculture, Institute for Plant Production and Plant Breeding)

Financing: Bayerische Staatsministerium für Ernährung, Landwirtschaft und Forsten (StMELF)
(The Bavarian State Ministry for Food, Agriculture and Forestry)
Erzeugergemeinschaft HVG e. G.
(HVG Hop Producer Group)

Project Management: S. Euringer

Team: Dr. C. Krönauer, F. Weiß

Duration: April 1, 2022 to March 31, 2023

Sampling Period: June 2022 to September 2022

Planning and Execution

In 2022, citrus bark cracking viroid (CBCVd) monitoring was carried out again in the Hallertau. As in the previous year, all plots of previously CBCVd-infected operations, selected neighboring plots in the infected areas, and one plot each of the suppliers of a Hallertau natural bio-gas plant were examined. Drones were used over all monitored areas to search for and identify symptomatic plants. In addition, voluntary monitoring was offered to all other farms so that they too could have samples from suspected plants tested for CBCVd. Reporting of results from these tests has remained anonymous.

Just as in 2021, all samples consisted of a mix of 10 plants. They were tested for CBCVd infection using qPCR. With the support from eight temporary workers and personnel from the HVG and the DHWV, more than 450 samples were taken and more than 400 plots of about 200 operations were examined (Table 5.2). The selected plots and the exact locations of each sampled plant were digitally recorded using a geographic information app. This made the later data evaluation much easier and allowed for an improved overview of the assessed and affected plots.

Table 5.2; Number of farms, locations, and mixed samples tested in 2022

Monitoring Group	No. of Farms	No. of Locations	No. of (mixed) samples
Infested farms	10	124	131
Ancillary areas	42	134	136
BEH**	149	150	151
Voluntary monitoring*	not recorded	not recorded	50
Total	> 201	> 408	468

* *including plants with a "Plant Passport" (an official cultivation permit issued by the European Union)*

** *Bio-Erdgasanlage Hallertau (natural bio-gas plant in the Hallertau)*

Findings

All farms that had been found to be CBCVd-infected last year, were still infected this year. In addition, the viroid was detected in three new hop farms. This means that roughly 110 hectares belonging to 12 farms are currently affected (Table 5.3). The new farms are located in the areas that were already known to carry CBDVd; and thus far the infestation density is low. Only a few plants stood out in each plot and the conditions for transmission is not yet clear. There is hope, however, that farmers will consider any early detection as an opportunity for targeted clearing and other measures to prevent any transmission to additional areas. The eradication of CBCVd appears to be possible, as the example of a farm infected in 2020 demonstrates. The infested area was cleared in the fall of 2020, and tests for CBCVd have been negative in all other plots of the same farm, both in 2021 and 2022 (Table 5.3).

Table 5.3: Area and number of establishments with CBCVd certification 2019 - 2022

	2019	2020	2021	2022
Affected farms*	3	7	9	12
Infested hop area [ha]	44	83	109	110

**Only farms with proven CBCVd infections in the listed year are counted*

The spread of CBCVd varies even within a farm; and CBCVd generally spreads further in the Hallertau than elsewhere (Table 5.4). Because the current clearing measures are not sufficient for true containment, continued annual checks, as well as pertinent support for and advice to the affected farms will remain a necessity in the foreseeable future.

This year, infested plants were generally easy to recognize. The drought and high temperatures may have exacerbated the symptoms caused by CBCVd. It is therefore possible that this year plants were discovered that had been infected in previous years but had not yet developed severe symptoms. Because of this year's clearly detectable phenotypes and the low infestation rate in the newly recorded plants, there is hope that the extent of the spread of CBCVd in the Hallertau is now well recorded.

Table 5.4: Acreage spread plots with positive CBCVd detection by farm in ha

Farm	2019	2020	2021	2022	Tendency
I	14.3	17.7	28.6	35.4	↗
II	28.9	33.0	33.0	29.4	↘
III	1.2	2.8	9.0	8.2	↘
IV		2.5	0.0	0.0	negative
V		2.1	2.8	4.1	↗
VI		4.7	4.7	4.7	→
VII		20.1	24.7	14.2	↘
VIII			1.3	3.5	↗
IX			3.9	3.9	→
X			1.0	2.4	↗
XI				0.4	new
XII				2.4	new
XIII				0.9	new
Total	44.5	82.9	109.1	109.7	

Outlook

A CBCVd research project is planned for 2023. Field trials will be conducted to test how long infested plots need to be taken out of production and which measures can effectively curb the spread of CBCVd. In addition, there will be observations to ascertain if different hop varieties have different susceptibilities to CBCVd. If there are tolerant varieties, these should be candidates for future breeding. As part of the research project, selected farms will also be monitored in 2023.

The Hüll Hop Research Center (LfL IPZ) is supported financially and with staff by StMELF, the German Hop Industry Association, and the HVG.

5.8 CBCVd Preliminary Project

Sponsor:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung *(Bavarian State Research Center for Agriculture, Institute for Plant Production and Plant Breeding)*
Financing:	Erzeugergemeinschaft HVG e. G. *(HVG Hop Producer Group)*
Project Management:	S. Euringer
Team:	Dr. C. Krönauer, F. Weiß
Duration:	July 1, 2022 to March 31, 2023

Single stock rating in CBCVd infested areas

In order to be able to track the spread of CBCVd within an area more precisely over the next few years, individual stock assessments were carried out in eleven selected field sections. The plants were divided into categories according to their phenotype "optically healthy plant", "plant with unspecific signs of stress", "plant with symptoms of disease" and "plant with clear CBCVd symptoms." These categorizations were digitally recorded. In addition, drones flew over the plots to capture high-resolution, distortion-free photos. The severity of the infestations from low with individual symptomatic plants to very heavy with roughly 30% of the plants showing symptoms. Additional observations in the next few years should provide further understanding on whether the different cultivation methods practiced by the farmers influence the infection process. The 2023 research project will also test if special phytosanitary measures can contain the spread of CBCVd.

Yield and alpha acid measurements

The growth of hop plants infected with CBCVd is stunted, the leaves are smaller, the lateral bines are shorter, and the cones are smaller and malformed. These characteristic symptoms obviously lead to reduced yields. To obtain more quantitative data in preparation for the CBCVd research project, the yield and alpha acid content of Perle and Herkules plants were determined at one location, at one time, in 2022.

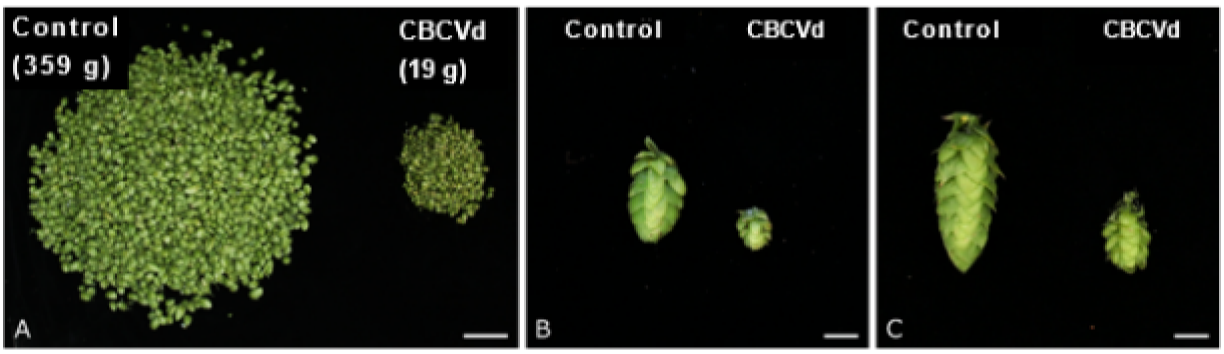


Figure 5.4: CBCVd causes yield losses in hops A) Yield of a representative Perle plant. Scale = 10cm. B) Perle cones. Scale = 1 cm C) Herkules cones. Scale = 1cm. Photos: Dr Christina Krönauer, LfL 2022

Sampling for the Perle and Herkules varieties took place at the time of harvest on August 30, 2022 and September 9, 2022 respectively. Four plants each with clear CBCVd symptoms and four non-symptomatic control plants were selected for the trial harvest. It is noteworthy that the plants infected with CBCVd are not phenotypically uniform. Because the infestation in the test area had existed there for a long time, many severely affected or dying plants no longer formed cones. For the yield and alpha acid measurements, therefore, average plants were selected that showed clear symptoms of a CBCVd infection but had a cone count that was still sufficient for laboratory measurements. A qPCR analysis confirmed that all selected plants were infected with CBCVd. The cones were picked and dried by hand. The cone dry weight of Perle was 358 g for healthy plants and 19 g, for CBCVd-infected plants. This corresponds to a yield reduction of 95% (Figure 5.4 A). Because of the small cone size, an even lower yield can be expected with mechanical harvesting of CBCVd-infected plants. Alpha acid levels were also lower in CBCVd-infected plants than in control plants. On average, the values for Herkules dropped from 16.6% to 13.9% and for Perle, from 5.3% to 3.3% (Figure 5.5).

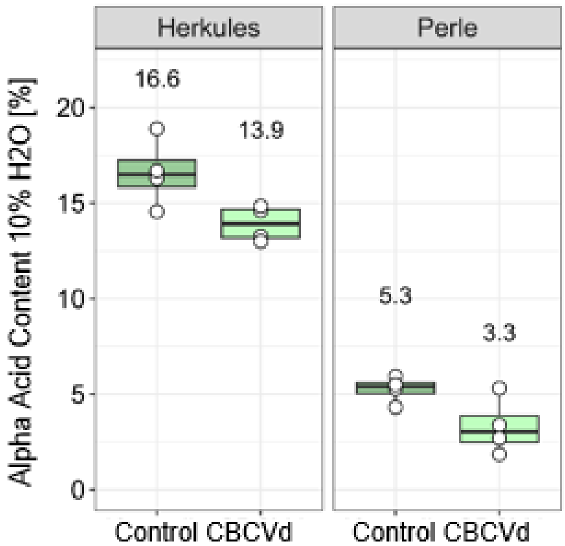


Figure 5.5: CBCVd causes a decrease in alpha acid content in hops. Mean alpha acid content of four plants each of Herkules and Perle.

Because of small sample sizes, the results of the preliminary project represent only a small portion of the varieties and conditions in the Hallertau. Nevertheless, the serious effects of progressive CBCVd infestations on hop cultivation are already apparent. The 2023 CBCVd research project plans to compare yield declines and the influence of CBCVd on alpha acid levels and other aspects at different locations and at different times. The planting of a hop garden with different varieties will also allow for a broader assessment of CBCVd symptoms.

5.9 CBCVd Project on *Verticillium* Research

Sponsor:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung (*Bavarian State Research Center for Agriculture, Institute for Plant Production and Plant Breeding)*
Financing:	Gesellschaft für Hopfenforschung (GfH) *(Society for Hop Research, e.V.)* Erzeugergemeinschaft HVG e. G. *(HVG Hop Producer Group)*
Project Management:	S. Euringer
Team:	K. Lutz, Team IPZ 5b
Collaboration:	AG Züchtungsforschung Hopfen (IPZ 5c) *(Hop Breeding Research Working Group)* P. Hager, R. Enders, A. Lutz, J. Kneidl AG Produktionstechnik Hopfen (IPZ 5a) *(Working Group, Hop Production Techniques)* A. Schlagenhaufer, S. Fuß Slovenian Institute of Hop Research and Brewing (IHPS): Dr. S. Radišek
Duration:	June 1, 2017 to October 29, 2023

Objectives

Lethal *Verticillium nonalfalfae* strains, the causative agent of aggressive form of hop wilt, have been in Bavaria at least since 2005. Since then, this pathogen has spread continuously in the Hallertau growing region. *Verticillium* is a soil-dwelling fungus that can thrive on a broad range of hosts. It can survive in the soil for up to 5 years as a permanent mycelium without a host plant. There is yet no pesticide to combat it. Therefore, fighting it requires an integrated approach of phytosanitary measures, breeding efforts, and specially adapted cultivation techniques. A rapid dissemination of knowledge is intended to provide affected hop growers with assistance in implementing management measures and successful remediation as quickly as possible.

Alternative remediation concepts: Biological soil decontamination

During the project, various soil refurbishment concepts will be examined. In addition to classic remediation of planting grains, which are not host plants, alternative concepts of biological soil decontamination were tested.

Method

In a test remediation in the summer of 2018, a Hallertauer Mittelfrüh hop garden in Bruckbach that was heavily contaminated with lethal *Verticillium* strains was divided into five plots. One contaminated plot was not cleared so that it could serve as a control. The remaining plots had been cleared in the fall of 2017. One was planted with rye as an intermediate crop for a year. At the same time, all dicotyledonous weeds were chemically suppressed to keep the remediation area free of host plants, especially around the trellises. Another plot was planted in May 2018 with *Verticillium*-free rhizomes of the wilt-tolerant Herkules without a lengthy break in hop cultivation. In addition, one plot was subjected to a form of biological soil decontamination, which involved the elimination of the fungus by depriving it of oxygen while also adding the protein-containing preparation Herbie 72, which breaks down anaerobic microorganisms in the soil.

To accelerate the biological decontamination, the hop plants were cleared and all plant debris was removed before the granules were worked into the soil. Then, the surface was flooded and covered with diffusion-tight foil. The anaerobic microorganisms are supposed to break down the fungus in about four to six weeks. In addition, the fungus is harmed by the anaerobic conditions and the high temperatures that develop under the foil. The aim is to reduce the oxygen content (< 3%) under the film as much as possible. In a final plot, the surface was also covered with foil, but without any prior application of granules to initiate ground solarization. In both decontamination plots, rye was then sown before replanting them with hops. In May 2019, the three plots planted with rye were re-stocked with *Verticillium*-free rhizomes of Hallertauer Tradition (Table 5.5).

Table 5.5: Percentage of symptom-bearing hop plants per plot during the trial years

Test Section	**Control**	**Direct Planting Without Sanitization**	**1-year Soil Remediation (Rye)**	**Ground Solarization**	**Biological Soil Decontamination**
Variety	Hal. Mittelfrüh	Herkules	Hal. Tradition	Hal. Tradition	Hal. Tradition
Clear	—	Fall 2017	Fall 2017	Fall 2017	Fall 2017
Sanitizing	— —	0.5 year Rye	1.5 year Rye	1.5 year Foil cover	1.5 year Granules + foil cover
Planted	Old stock	Spring 2018	Spring 2019	Spring 2019	Spring 2019
2017	21%	34%	41%	45%	83%
2018	22%	Young hops	Rye	Rye	Rye
2019	14%	8%	Young hops	Young hops	Young hops
2020	31%	13%	5%	5%	1%
2021	22%	25%	2%	15%	10%
2022	Fall 2021 cleared	10%	2%	4%	15%

Results

Before the clearing in August 2017, all symptom-bearing plants in the hop garden were counted (Table 5.5). In this way, the percentage of infested plants per plot could be determined. The test control plot gives an indication of the annual weather-related fluctuations in infestations. If new plants were planted immediately after clearing, even Herkules, a variety known to be *Verticillium*-tolerant, was infected in this experiment. In this plot, in which one-third of the Hallertau Mittelfrüh plants were infested with wilt in 2017, substantial infestations recurred already in the first year of new production, in 2019. The wilt infestation in the Herkules plot increased steadily until every fourth plant showed symptoms by 2021. This shows how quickly the fungus can adapt to a tolerant cultivar in the absence of countermeasures and that a sufficiently high level of *Verticillium* infestation in the soil can attack even a cultivar that is considered tolerant to the fungus. In the long run, this infestation becomes uneconomical for a hop farm.

On the other hand, a significant reduction in infection pressure was achieved with a one-year remediation with rye. The choice of Hallertau Tradition, which is susceptible to wilt, clearly amplifies this effect. During 2020 to 2022, however, a slight infestation returned, indicating that infection pressures could not be completely eradicated in just a single year. In practice, therefore, a longer rest period of three to five years should be recommended to grow healthy, wilt-free hops again on this soil. The more susceptible the subsequently cultivated variety is, the longer should the rest period be.

Initially, the remediation success of biological soil decontamination seemed obvious. Among young Hallertau Tradition plants, only one showed visual symptoms of the disease after one year. However, such decontamination cannot lower the infection potential of the fungus in the ground permanently; and a new infestation established itself after just a few years (Figure 5.6). Likewise, the high expenditure of time and money does not justify this type of renovation. Even the cheaper variant of ground solarization did not have the desired effect. Therefore, the classic method of growing grain as an intermediate crop is still the recommended strategy for hop growers.

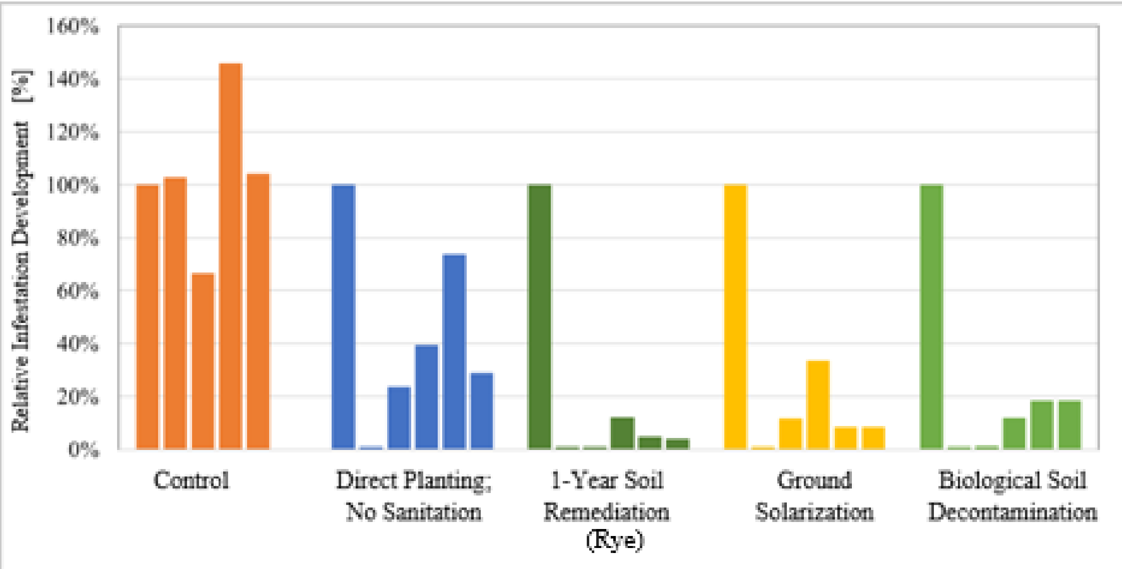


Figure 5.6: Comparison of infestation developments of symptom-bearing plants in relation to the initial infestation in 2017. In the variant "direct planting without sanitation," the wilt infestation increased again rapidly after replanting

6 Hop Breeding Research

District Administrator A. Lutz (LR), Dr. S. Gresset & Team

6.1 Crossings in 2022

In 2022, the Hüll Hop Research Center created 97 successful crossings, of which 57 were aroma variety hybrids and 40 were bitter variety hybrids. Because of a hail storm in the breeding plots, not all new hybrid offspring could be harvested.

6.2 Marker-guided post-sequencing of hop varieties of G-Hop Project

Introduction

The global hop market is constantly changing. The challenge for hop breeding is not just to react to new consumer trends, but primarily to meet the challenges of climatic and social change through breeding. Modern genome-analytical (non-genetic engineering) methods are already part of the standard repertoire in animal and plant breeding, such as for corn or other cereals (Heffner et al., 2009). German hop breeding does not yet use these new genome-based opportunities for accelerated variety development, but it can meet increasing international competition only with a boost in innovation. The competitiveness of German hop growers must be increased by developing new, robust, and high-performing varieties, particularly in relation to the USA, which is the world's largest hop producer next to Germany. The supply of innovative quality hop varieties guarantees reasonable prices and more sustainable hops for the brewing industry. With precision genetic techniques, German hop breeding has an innovative tool that goes beyond the traditional selection process that has been based just on phenotype characteristics. The development of marker-based breeding is an important milestone in making breeding more efficient and competitive. In recent years, the project "Genome-based precision breeding for future-oriented quality hops," G-Hop for short, has been carried out in cooperation between the LfL, the University of Hohenheim, the GfH and the HVG. It is largely financed by the GfH, the HVG and the Landwirtschaftliche Rentenbank (Agricultural Pensioners' Savings Bank).

As part of the G-Hop project, extensive phenotypic chemical and agronomic data has been generated over the past five years as a reference hop portfolio for linking characteristics with genetic data. The portfolio includes a great variation of hop varieties. The quality of the genetic data upfront was not sufficient to establish clear associations and to identify suitable markers for precision breeding. Therefore, post-sequencing of associations became necessary for the practical assessment and implementation of the results of the G-Hop project. This effort was financed by the Scientific Station for Brewing in Munich e.V.

Execution

At the beginning of August 2022, the breeding research department took leaf samples from hop varieties, breeding strains, and wild hops. Then, in cooperation with a sequencing service provider, it identified more than 1,000 genome markers that can be used to clearly distinguish between the examined hop varieties. For further statistical calculations, Dr. Albrecht from the LfL working group on genome-oriented breeding methods provided phenotypic and genotypic data, which is currently being processed.

Results

First results indicate a very high predictive reliability of the newly generated genome markers. Thus, assuming that closely related hop varieties have more of the same genome markers than do distantly related hop varieties, the relationship of the hop varieties traditionally handed down by breeders could be reproduced very well by statistical calculation. Together with extensive field observations, genome markers could, therefore, be identified using classic quantitative genetic models that explain varietal differences in reactions to such important hop diseases as powdery mildew. Currently, tests are under development to verify these findings. Should genome markers turn out to be robust predictors, they could partially replace the previous lengthy and expensive study phase in greenhouses, climate chambers, and in the field. This can accelerate the breeding process and increase the selection success for disease resistance.

In addition to the identification of genome regions that have an impact on disease characteristics, an overall model of genome-wide predictability is a current work-in-progress. Analogous to current dairy cattle breeding strategies, the hereditary performance of male hop offspring in terms of yield and value components will be evaluated, so that a selection for these characteristics and thus a sustainable breeding progress can be derived from the fathers' genes.

Outlook

In the medium term, the results of this project will be combined with the results of previous projects in the practical work of breeding research at the Hop Research Center in Hüll. This will increase the quality of the progressive selection process and lead to the development of even more efficient varieties for sustainable, stable, and economically viable hop cultivation in Bavaria.

Heffner, E.L., Sorrells, M.E., and Jannink, J.-L. (2009). Genomic Selection for Crop Improvement. Crop Sci. 49, 1.doi:10.2135/cropsci2008.08.0512.

6.3 The new Hüll high-alpha variety Titan as a supplement to Herkules ensures more sustainability in hop growing

Project Management:	A. Lutz, Dr. S. Gresset
Team:	A. Lutz, J. Kneidl, Team IPZ 5c
Collaboration:	Dr. K. Kammhuber, Team IPZ 5d
	Beratungsgremium der GfH *(Society of Hop Research Advisory Committee)*
	Forschungsbrauerei Weihenstephan, Technische Universität München-Weihenstephan, Lehrstuhl für Getränke- und Brau-technologie *(Research Brewery Weihenstephan, Munich Technical University, Chair of Beverage and Brewing Technology)* Prof. Becker, Ch. Neugrodda
	Versuchsbrauerei *(Pilot Brewery)* Bitburger-Braugruppe, Dr. S. Hanke
	Versuchsbrauerei *(Pilot Brewery)* St. Johann, A. Gahr
	National and international brewing partners
	Partners in hop processing and the hop trade
	Verband Deutscher Hopfenpflanzer *(Association of German Hop Growers)*
	Hop growers

Titan is the most recent high alpha variety from the Hop Research Center in Hüll. In numerous brewing tests, Titan has demonstrated that it has an excellent bitter quality that is comparable to that of the high-alpha variety Herkules, the current market leader. In addition, Titan meets the goals of the Hüll breeding strategy of "low input - high output." It combines excellent brewing quality with climate stress tolerance, as well as optimized cultivation and resistance properties. It thus meets the requirements of a high-quality and sustainable breeding variety that serves as a future-proof alternative to Hercules for brewers and hop growers alike.

Climate change and environmental protection make it necessary to realign hop production with new, modern varieties that ensure the high-quality supply of raw materials for the brewing industry in the future.

The success story of Herkules

The launch of Herkules in 2006 started an unprecedented success story. With a yield potential of more than 50% above that of the high-alpha variety Hallertau Magnum, which was the world's leading high-alpha variety at the time, Herkules brought about a breeding progress that few had thought possible. As early as 2014, Herkules became the largest bitter variety in the world with 3,345 hectares under cultivation. It is now cultivated nationwide on more than 7,100 hectares. In the Hallertau, 39% of the total hop acreage is now planted with Herkules. It thus forms the backbone of basic hopping in most breweries worldwide.

However, the dominance of this high alpha variety also creates a few problems in cultivation. In the Elbe-Saale region, for example, Herkules is still not a total replacement of Hallertauer Magnum because the soil and weather conditions there favor rot, which prevent the economically viable cultivation of Herkules.

In addition, Herkules was largely resistant to powdery mildew when it was launched. This resistance has now been broken by the natural adaptation of the fungus. Thus, combating powdery mildew in Herkules plots has become an ever-greater challenge for hop growers. In addition, the use of effective pesticides is limited more and more by environmental legislation. Yet, many farms still plant Herkules on more than half their acreage because of its profitability. At the same time, the strong focus on a single variety also represents economic risks for a hop-growing operation and the entire hop-growing region. The same applies to the brewing industry. To prevent such risks, there need to be alternatives available to secure supplies without having to make compromises in terms of quality.

Pedigree and agronomic properties of Titan

The idea behind the classic crossing that led to Titan (Table 6.1) was the further improvement of the outstanding characteristics of Herkules through the targeted combination with other good gene sets from the Hüll gene pool. Thus, Herkules served as the Titan grandmother, paired with a male Hüll breeding line, while Polaris, itself a product of Hüll breeding lines, served as the mother, who was then paired with the male offspring of the Herkules-Hüll cross. Polaris is the world's highest alpha acid variety with only minor alpha fluctuations from one year to the next, even under extreme conditions. In addition, Polaris shows very good plant health, which it has demonstrated even under the difficult growing conditions of the Elbe-Saale region. Because male hops do not form cones, their flavor and brewing characteristics are largely unknown. Their selections, therefore, are based mostly on their potential for resistance genes. The grandfather (crossed with Herkules) passed on to Titan a new mildew resistance and an improved tolerance to cone infestations with *Peronospora*.

The Titan plant has a beautiful cylindrical growth pattern and a uniform cone distribution. It has relatively small leaves and its foliage is of only medium density. Thus, plant protection measures are easier and more effective, as spraying can reach the entire hop plant and do so with a reduced amount of water. Thus, Titan's growth pattern combined with its improved resistances reduces the amount of pesticides needed to keep it healthy and productive.

Extensive cultivation tests

Titan has been tested extensively in various cultivation tests in breeding gardens with different soil qualities, as well as in a series of trial cultivations and in large plot cultivation at different locations. Overall, there were well over 100 individual cultivation tests. In 44 of these, the results could be compared directly to those for Herkules. In the fall of 2017, he was proposed to the GfH advisory board as a promising new high-alpha variety with breeding line number 2011/71/19. It was received very well by raw materials experts in the entire hop and brewing industry, who judged the raw hop aroma profile as being similar to that of Herkules.

In the fall of 2019, the advisory board assayed the new breeding line again along with other high-alpha breeding lines. After confirming the initial positive evaluation, the committee suggested to the GfH board of directors that it be released for large-scale cultivation and that extensive brewing trials be started to secure the small-scale trial brews for the determination of its bitter quality.

In 2020, following the expert and GfH board of directors' recommendations, hop processors and wholesalers financed the first large-scale field trials with 2011/71/19 at different locations in German hop-growing regions. The aim of these trials was to gain further cultivation experience and to collect enough hops for processing and brewing trials.

Because of the great interest in the new high alpha variety, the large plot trials were extended to other locations and areas in 2021 and 2022, including six test locations in the Hallertau and one location each in the Spalt and Elbe-Saale growing areas.

Processing study

With the 2021 trial harvest, two separate processing studies were carried out at the St. Johann hop finishing plant. Some of the pellets produced were then processed into an extract in order to be able to offer interested master brewers both pellets and extract for brewing trials. The processing studies revealed no abnormalities in a direct comparison with Herkules. Thus, Titan was ready to be introduced broadly.

Aroma in the raw hops

There are still certain minor differences between Titan and Herkules as raw hops (Figure 6.1). While Herkules has aromas of green fruit and stronger citrus notes next to its beautiful hoppy base note, the aroma profile of Titan is somewhat more subtle. It is pleasant and very balanced in spite of a significantly higher total oil content compared to Herkules. Classic hop-typical notes dominate, supported by sweet fruit and some menthol. The citrus note clearly perceptible in Herkules is almost imperceptible in Titan.

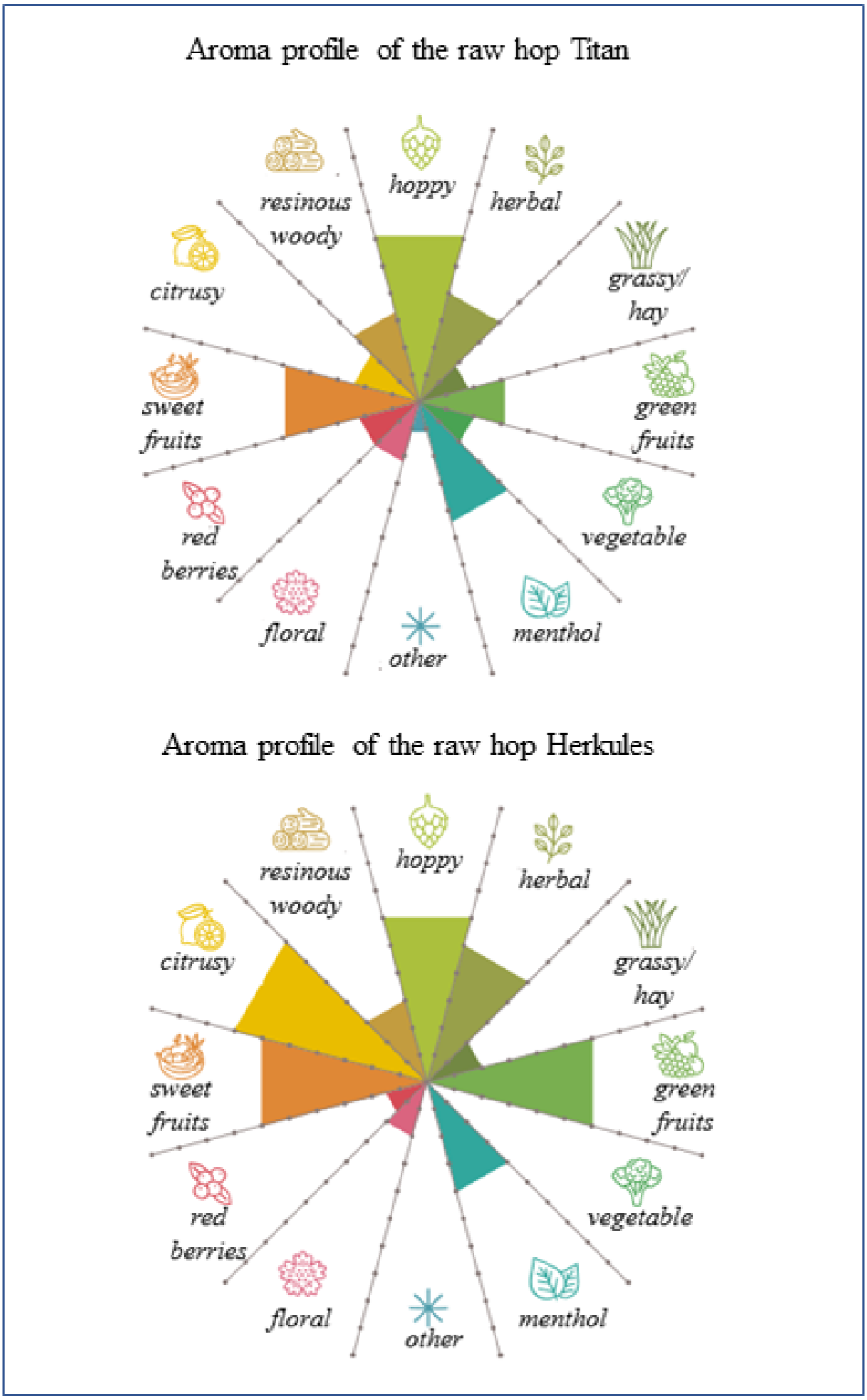


Figure 6.1: Aroma profile of raw hops from Titan and Herkules

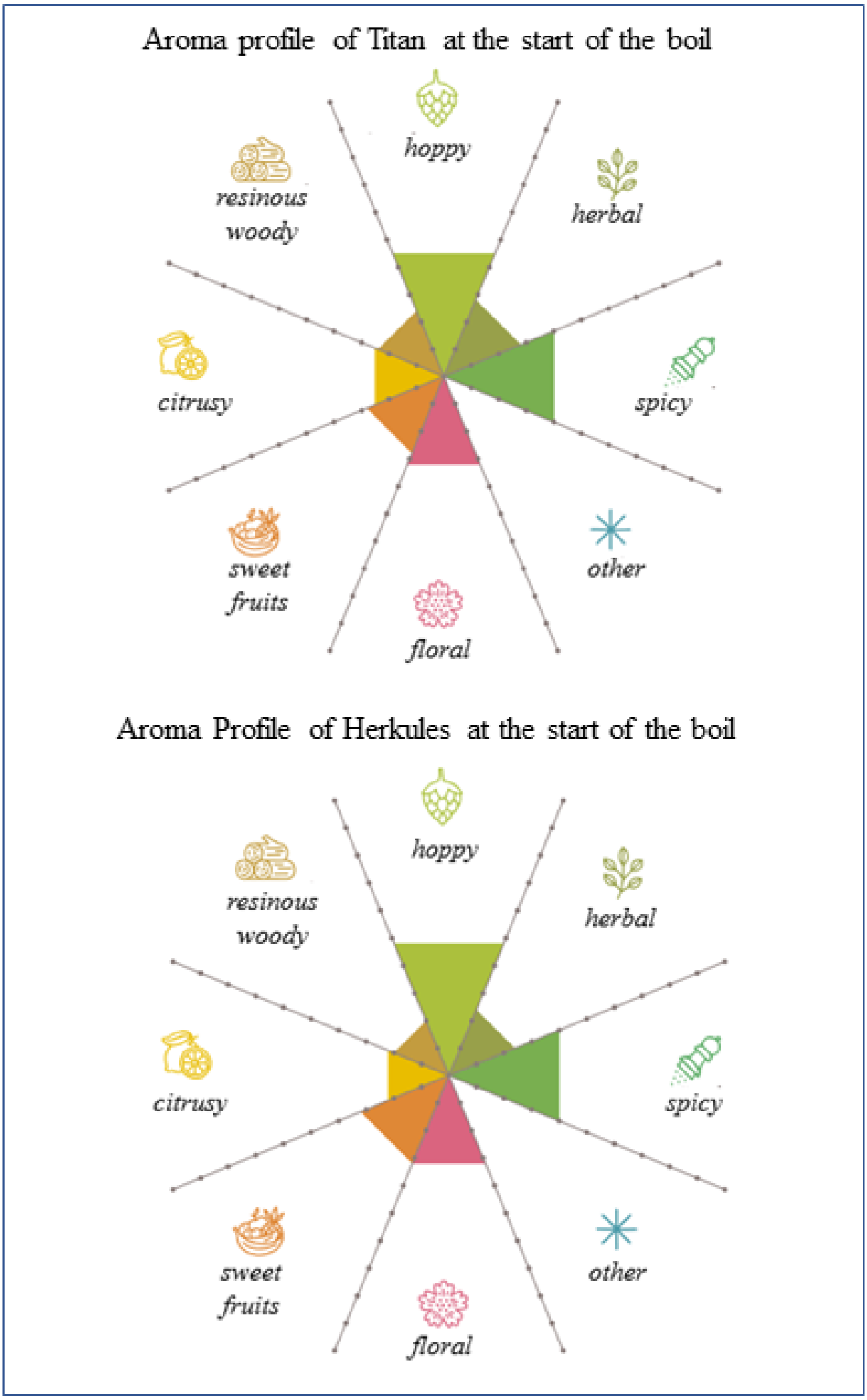


Figure 6.2: Aroma profile of Titan and Herkules at the start of the boil

The chemical data in Table 6.2 shows that Titan has a greater resemblance to its mother Polaris than to its grandmother Herkules. The beta-to-alpha ratio is comparable for the three high alpha varieties. The oil composition is a snapshot and refers to samples from the 2022 biogenesis test at the Stadelhof/Hallertau site. Exogenous factors such as environmental conditions and terroir effects can play a major role determining these values. The content of linalool, which is an indicator substance for excellent classic hop aromas, is relatively high in Titan, with 15 mg/100 g, while the two esters geranyl acetate and geranyl isobutyrate, which are almost non-existent in Hercules, are even higher in Titan than they are in Polaris. Both are broken down into geraniol during fermentation, which is soluble in beer, where it contributes fresh, rose-like aromas. The non-terpenoid esters in the three varieties, which have low molecular weights and are also soluble in beer, contribute fruity aromas. Finally, the total polyphenol content, assayed according to EBC-7.14, are very similar in the three varieties.

Table 6.1: Origin and agronomic characteristics of the new high-alpha variety Titan

Pedigree	Polaris x (Herkules x Hüll high-alpha breeding line)
Resistances / Tolerances	Improved resistance or tolerance to many diseases and pests
Low Input	Reduced need for pesticides, water, and nitrogen fertilizers
High Output	High yields, alpha acid values, and oil content
Stress and Climate Tolerance	Excellent and stable in terms of both yields and alpha acids
Maturation	Medium late (one week earlier than Hercules)

Brewing quality and aroma in beer

When breeding a new high-alpha variety, a high-quality bitterness is one of the most important selection criteria. For Titan, it had to be comparable to that of such bitter varieties as Herkules and Magnum, before it could be considered as a substitute for them. Otherwise, breweries around the world would not accept it, in spite of its superior agronomic characteristics.

The hop research center, therefore, attached particular importance to assessments of the variety’s bitterness during brewing trials and developed a special tasting scheme for the purpose. Determining the bitterness quality was developed by the hop research center. With the support from the German brewing industry, several standardized batches were brewed, each with just a single bitter hop variety, and the taste-tested by a panel of 37 experts. From these sensory trails, Herkules emerged as the optimal reference variety for assessing the bitter quality of Titan.

Next, three test breweries at Weihenstephan (TUM), St. Johann, brewed the same batches with just Titan; and the results were compared to the brews with Herkules. In the judgement of the experts, the quality and intensity of the bitterness from Titan were rated comparable to those of Herkules. The bitterness unfolds its full effect upfront and then gradually recedes without leaving any unpleasant or broad flavors in the finish. Likewise, the tasting panels also rated the aroma quality of Titan as subtle, classic, and typically hoppy even though Titan was added as a single dose only at the start of the boil (Figure 6.2). Subsequent large-scale brewing trials, conducted in breweries of various sizes and assessed in sensory evaluations, confirmed the judgments of the initial tasting group. Therefore, the market introduction of Titan as an all-round variety is now being accelerated as a long-term contribution to more sustainability agriculture and beer making.

Environmental and resource-saving production despite climate change

Given the carefully planned genetic roots of Titan as a hybrid derived from Herkules, Polaris, and select Hüll high-alpha lines, this new variety not only has excellent brewing qualities, but also meets many of the requirements of a modern cultivar (Table 6.2). In particular, the Hüll breeding team deliberately selected individuals that could thrive without irrigation, while minimizing the use of fertilizers and pesticides. This "low input" strategy makes Titan not only highly nutrient-efficient but also highly productive (“high output”), with consistently high yields, alpha acid values, and oil contents even under extremely difficult weather and climatic conditions. Titan’s agronomic prowess could be confirmed in numerous cultivation trials in the Hallertau, in Tettnang, in Spalt, and in the Elbe-Saale region.

Its resistances and tolerances are much improved compared to Hercules, which could be demonstrated in extensive greenhouse, laboratory, and field tests, even when plant protection chemicals were reduced.

Large-scale experimental cultivation carried out on a hectare basis not only supplemented the experiences gained during the original smaller-scale trials, it also provided sufficient harvested material for early commercial brewing trials.

Table 6.2: Chemical data for the components responsible for aroma and bitterness of Titan in freshly harvested samples compared to Herkules and Polaris

Chemical Compounds	Titan	Herkules	Polaris
Total oil (EBC 7.10 in ml/100g)	3.2 (2.6 – 4.0)	1.8 (1.2 – 2.4)	3.40 (2.8 – 4.2)
Bitter substances (EBC 7.7)			
Alpha acids (%)	17.5 (14.0 – 20.0)	16.0 (12.7 -17.5)	18.5 (16.5 -20.5)
Beta acids (%)	4.9 (4.0 -5.5)	4.8 (3.8 – 5.3)	5.5 (5.0 -6.0)
Ratio beta/alpha ß/α	0.28	0.30	0,30
Cohumulone (as a % of alpha acids)	22 (20 – 24)	36 (33 - 38)	23 (21 -25)
Xanthohumol (%)	0.54 (0.45 – 0.60)	0.80 (0.60 – 0.95)	0.80 (0.60 -0.95)
Select mono-and sesquiterpenes (mg/100 g)			
Myrcene	1254	583	927
ß-Pinene	45	28	44
ß-Ocimene	41	33	62
ß-Caryophyllene	143	135	317
Humulene	362	273	499
ß-Farnesene	<1	1	1
ß-Eudesmene (ß-Selinene)	5	8	19
α-Eudesmene (α-Selinene)	8	11	27
α-Cadinene	36	31	101
Monoterpene alcohols and esters (mg/100 g)			
Linalool	15	8	14
α-Terpineol	<1	<1	<1
Geraniol	5	7	8
Geranyl acid methyl ester	4	4	4
Geranyl Acetate	29	0	14
Geranyl iso-butrate	34	2	15
Non-terpenoid esters (water soluble) (mg/100 g)			
Isobutyl propionate	9	5	7

Chemical Compounds	Titan	Herkules	Polaris
Isobutyl iso-butrate	9	12	15
2-Methylbutyl acetate	8	1	16
Methylhexanoat	1	2	1
2-Methylbutyl propionate	11	10	11
3-Methylbutyl-isobutyrate = Isoamyl isobutyrate	11	6	13
2-Methylbutyl-isobutyrate	24	42	42
Heptane acid methyl esters	25	10	16
Capryl acid methyl esters = Oktane acid methyl esters	48	14	76
Pelargonic acid methyl esters = Nonanonic methyl esters	10	8	16
Total Polyphenols (EBC 7.14)	**4.4**	**3.8**	**4.0**

Another milestone in the direction of environmentally friendly, climate-stable production of quality hops

The release of Titan represents another milestone in the hop and brewing industries advancing the goals of climate adaptation, environmental and resource protection, complying with tightening fertilizer regulations, and securing supplies for the future. It is a viable alternative to what has been the world's most important high-alpha variety, Herkules.

Availability

The Gesellschaft für Hopfenforschung (GfH) (*Society for Hop Research, e.V.*) registered Titan with the European Plant Variety Office in December 2021, and licenses for the cultivation of Titan can now be purchased from the GfH. The acreage planted with Titan is expected to expand to about 100 ha in 2023 and yield enough hops for breweries and other interested parties to obtain trial samples from the GfH and the hop trade for integrating the new variety into their recipes.

Thanks

The authors would like to thank all hop growers, hop processors and distributors, and brewers for their valuable support during the development of Titan. Their cultivation trials and brewing trials have amounted to a significant contribution to testing this new Hüll high-alpha variety in a short time. Our special thanks go to Prof. Dr.-Ing. Thomas Becker and the TUM research brewery, led by Christoph Neugrodda, for the numerous test brews with Titan.

6.4 Further work on the *Verticillium* problem in hops — Molecular detection of *Verticillium* directly from the bine using real-time PCR techniques

Sponsor:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung (*Bavarian State Research Center for Agriculture, Institute for Plant Production and Plant Breeding)* AG Züchtungsforschung Hopfen (IPZ 5c) (*AG Hop Breeding Research Group*)
Financing:	Erzeugergemeinschaft HVG e. G. *(HVG Hop Producer Group)*
Project Management:	Dr. S. Gresset
Team:	AG Züchtungsforschung Hopfen (*AG Hop Breeding Research Group*): P. Hager, R. Enders, A. Lutz, J. Kneidl
Collaboration:	AG Pflanzenschutz im Hopfenbau (*Plant Protection in Hop Cultivation*): S. Euringer, K. Lutz, Dr. S. Radišek, Slovenian Institute of Hop Research and Brewing, Slovenia
Duration:	Since 2008 to October 31, 2023

Objective

In addition to phytosanitary and other measures, detecting *Verticillium nonalfalfae* is crucially important for producing healthy seedlings. This requires laboratory tests because young hop plants do not exhibit visual symptoms of *Verticillium* even if they are infected. Starting in 2013, therefore, seedlings have been examined for the fungus using a highly sensitive real-time PCR-based detection method, which ensures that only wilt-free hops are used for propagation.

Method

Based on research by Maurer et al. (2013) a very reliable and sensitive molecular detection technique for *Verticillium* directly from the hop bines is now available. We are constantly working on optimizing this test system. The aim is not only to test for *V. nonalfalfae* in general in one PCR run, but also to simultaneously differentiate between mild and lethal strains of *V. nonalfalfae*. This is now possible using a multiplex PCR analysis.

Verticillium investigations

Every year, about 500 plants are tested for *Verticillium*. This corresponds to about 2,000 PCR reactions. Because we cannot be certain that the wilt fungus is distributed homogeneously in the test material, 2 to 3 samples are collected from every plant. The DNA is then extracted separately from each sample and analyzed undiluted and diluted at a ratio of 1:10, using real-time PCR. Whenever a test result is inconclusive, the PCR test is repeated. The following materials were examined this year:

- Material from the LfL's breeding hop garden in Stadelhof, as well as from commercial trial sites (row and large plot trial cultivation in the Hallertau, Tettnang, Spalt, and Elbe-Saale) to ensure freedom from *Verticillium*.

- Various samples from the commercial hop gardens in the Hallertau to study the spread of *Verticillium* infections (lethal strains).
- Mother plants selected for propagation by the GfH to ensure a supply of wilt-free rhizomes.
- Mother plants intended for propagation to ensure that hop growers receive *Verticillium*-free seedlings.
- Samples from test sites to verify visual ratings. These investigations were conducted in cooperation with S. Euringer and K. Lutz of IPZ 5b and are related to remedial measures in *Verticillium*-infested soils and to ensure the *Verticillium*-free state of bine chaff, as well as the detection of the fungus in other plants (such as cover crops and weeds).

Results

The 92 samples of inspected planting material for breeding were not infected with *Verticillium* nor could the fungus be detected in any of the 212 inspected GfH mother plants intended for contract propagation. However, the results of the qPCR analysis also confirm that the spread of aggressive (lethal) *Verticillium* strains is increasing. The lethal form of the fungus was detected in 122 of 175 hop bines collected in commercial hop yards. Mild strains were found in only 8 samples.

Outlook

In order to record all future incidences of *Verticillium* strains in the Hallertau, the reaction conditions and primers/probes used must be continuously verified and improved.

Further Reading

EPPO Bulletin (2020) PM 7/78 (2) *Verticillium nonalfalfae* and *V. dahliae*: 50 (3): 462-476.

Guček, T., Stajner, N., Radišek, S. (2015): Quantification and detection of *Verticillium albo-atrum* in hop (Humulus lupulus) with real-time PCR. Hop Bulletin 22, 26-39.

Maurer, K.A., Radišek, S., Berg, G., Seefelder, S. (2013): Real-time PCR assay to detect *Verticillium albo-atrum* and *V. dahliae* in hops: development and comparison with a standard PCR method. Journal of Plant Diseases and Protection, 120 (3), 105–114.

Seigner, E, Haugg, B, Hager, P., Enders, R., Kneidl, J. & Lutz, A. (2017): Verticillium wilt on hops: Real-time PCR and meristem culture – essential tools to produce healthy planting material. Proceeding of the Scientific-Technical Commission of the International Hop Growers´ Convention, Austria, 20-23.

Weller, S.A., Elphinstone, J.G., Smith, N.C., Boonham, N., and Stead, D.E. (2000): Detection of Ralstonia solanacearum strains with a quantitative, multiplex, real-time, fluorogenic PCR (TaqMan) assay. Appl Environ Microbiol. 66(7), 2853-8.

7 Hop Quality and Analysis

Bureau Director (RD) Dr. Klaus Kammhuber, Dipl.-Chemist

7.1 Overview

The Working Group IPZ 5d conducts all analytical investigations within Section IPZ 5 Hops. This work is used to support tests requested by other working groups, especially in the area of hop breeding. Hops are mainly grown because of their valuable compounds. Therefore, hop cultivation and research is not possible without hop analytics.

Hops have three groups of valuable ingredients. In order of importance, these are bitter substances, essential oils, and polyphenols (Figure 7.1)

Figure 7.1: Valuable compounds in hops

Alpha acids are considered the primary quality feature of hops since they are a measure of the bitter potential. In addition, the amounts of hops added to beer are based on their alpha acid content. Currently, the international average amount of alpha acids added to beer is about 4.5 to 5 g per 100 l. Alpha acids are also increasingly important in setting hop prices. Hop growers are either paid directly by the weight of alpha acids (in kilograms), or there are additional clauses in hop contracts for surcharges and discounts if shipments are outside an agreed-upon "neutral" alpha acid range.

Hops were discovered as raw materials for brewing in the Middle Ages. Because of their antimicrobial properties, they also increased a beer's shelf life. Today, the main function of hops is to give beers their characteristic fine bitterness and pleasant, fine aroma. In addition, hops have many other positive properties (Figure 7.2).

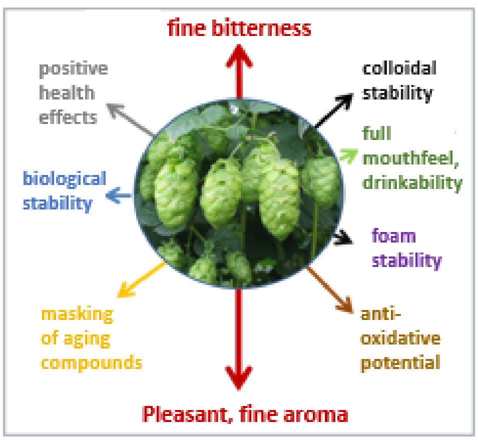


Figure 7.2: The many functions of hops in beer

7.2 Which requirements should hops meet in the future?

Hops are grown almost exclusively for brewing beer. Some 95% is used in breweries and only 5% in other applications. There are now efforts underway to find additional uses for the plant (Figure 7.3).

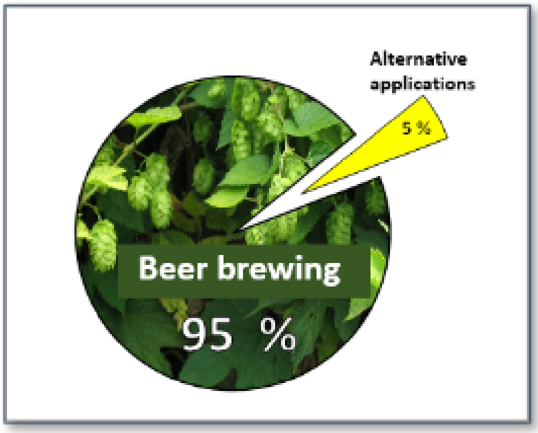


Figure 7.3: Uses for hops

7.2.1 Requirement for the brewing industry

With regard to the use of hops in the brewing industry, there are many different philosophies. Some breweries are interested only in cheap alpha acids, while others select hops deliberately according to variety and cultivation terroir (Figure 7.4). Yet others rank somewhere in between these two views.

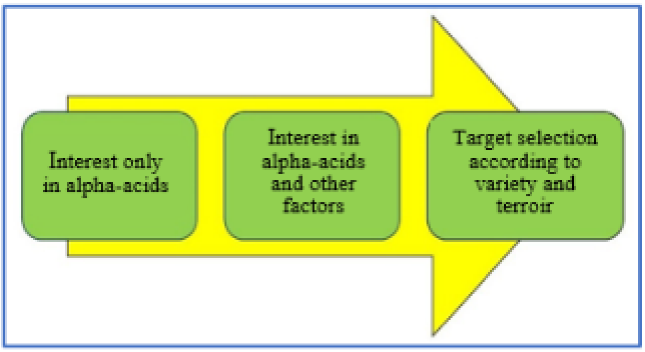


Figure 7.4: Different philosophies regarding the use of hops

However, there is agreement that the development of varieties with the highest possible amounts of alpha acids and the most stable alpha acid yields from year to year are important breeding objectives. Climate change will also be the biggest future problem for hop cultivation. A low cohumulone value relative to the overall alpha acid content is no longer considered important, even though in beer, a low proportion of cohumulone is beneficial for foam stability. For so-called downstream products and applications outside of beer making, high-alpha varieties with large portions of cohumulone are even desirable.

Hop oils should produce classic aroma profiles in beer. Polyphenols, on the other hand, have not been considered of great importance in the brewing industry, even though they also contribute to the sensory profile of beer by affecting its mouthfeel, for instance. In addition, polyphenols have many health benefits (see Chapter 7.3.2).

7.2.1.1 **Special requirements of craft brewers**

In the US, the craft brewing movement was a huge success. The share of craft breweries in total beer sales is around 14%. Globally, 2.5% craft brewers consume 20% of the global hop crop. In Germany, however, where traditional beer styles are preferred, the craft brewer scene has not been able to establish itself as strongly.

Craft brewers prefer hops with fruity and floral aromas that do not correspond to classic hop aromas. These hops are sometimes referred to as "special flavor hops."

7.2.1.2 **Dry hopping is experiencing a renaissance**

Craft brewers rediscovered the classic technique of dry-hopping, that is, of adding hops to cold beer. This process was already well known in the nineteenth century and is now being revived. It is a form of cold extraction, whereby hops are added to the finished beer in the bright, lagering, or conditioning tank; and the dosages are calculated based on the hop oil content, not on the amounts of alpha acids. Beer is a polar solvent; and the average beer contains roughly 92% water and 5% ethanol. This means that the compounds released by the hops in the cold area are primarily polar (Figure 7.5).

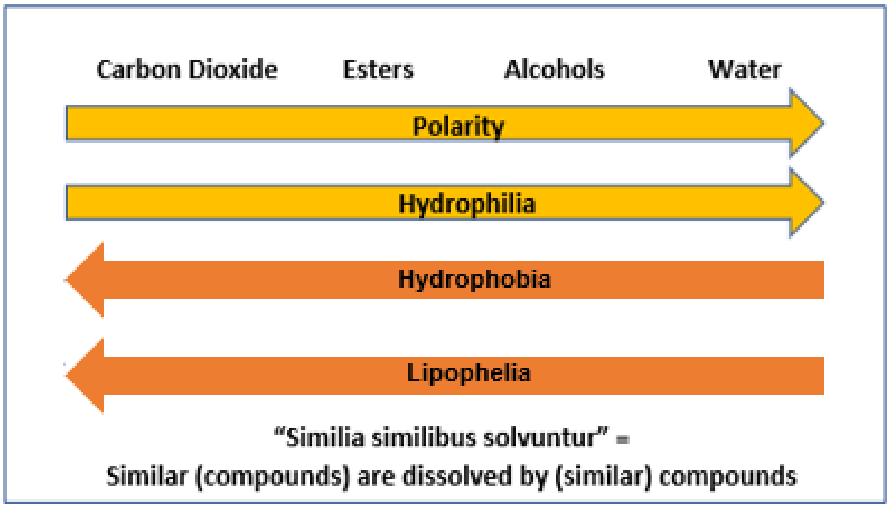


Figure 7.5: The solubility behavior of hop compounds is based on polarity

Alpha acids dissolve only minimally in wort or beer unless they are isomerized. On the other hand, especially low molecular esters and terpene alcohols are easily transferred. This is why dry-hopped beers have fruity and floral aromas. Traces of non-polar substances such as myrcene are dissolved, too.

The group of polyphenols is also easily soluble because of their polarity. Unfortunately, undesirable substances such as nitrate also transfer entirely into cold beer. The average nitrate content of hops is around 0.7%. However, the nitrate threshold of 50 mg/l for drinking water does not apply to beer. Pesticides tend to be non-polar and thus not very soluble in water. In cold-hopped beers, therefore, there is no measurable increase in concentrations of pesticide residues compared to conventional beers.

7.2.2 Alternative uses of hops

In alternative applications, the entire hop plant, not just the cones, can be used. The inner, wooden parts of the hop bine, for instance, are known as shives or shoves. They have excellent insulation properties and mechanical strength, which makes them well suited as a material for insulation. They can also be turned into molded parts for such applications as automotive door panels. To date, however, no such applications exist on a large scale.

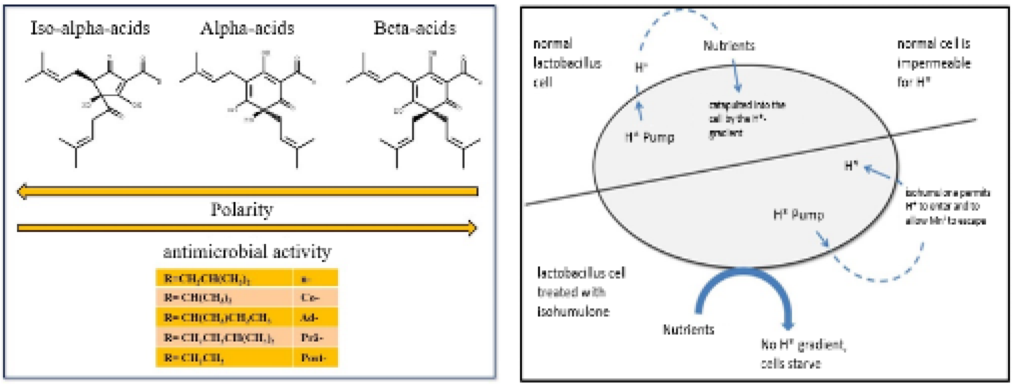


Figure 7.6: Sequence of antimicrobial activity of iso-alpha acids, alpha acids, and beta acids, as well as their effectiveness

As for cones, the antimicrobial properties of their bitter acids are of special interest for alternative uses. Even in catalytic quantities (0.001 to 0.1% by weight), they reveal their antimicrobial and preservative effectiveness, in ascending strength from iso-alpha acids, to alpha acids, to beta acids (Figure 7.6).

The more non-polar a molecule is, the greater is its antimicrobial effectiveness. Hop bitter substances destroy the pH gradient on the cell membranes of gram-positive bacteria, which prevents the bacteria from absorbing nutrients. This causes them to die.

Iso-alpha acids inhibit inflammatory processes and have positive effects on fat and sugar metabolisms. In beer, they even protect against *Helicobacter pylori*, a type of bacterium that can trigger stomach cancer. Beta acids are effective against the growth of gram-positive bacteria such as listeria and clostridia; and they can inhibit the tuberculosis-causing pathogen *Mycobacterium tuberculosis*. Because of these properties, hop bitter substances can be used as natural biocides wherever bacteria must be kept in check. In the sugar and ethanol industries, beta acids have already become a successful substitute for formalin. Some applications based on the antimicrobial activity of hops are listed below.

- Beta acids control gram-positive bacteria (clostridia, listeria, the tuberculosis pathogen mycobacterium tuberculosis)
- Use as a preservative in the food industry (fish, meat products, dairy products)
- Sanitation of biogenic waste (sewage sludge, compost)
- Elimination of mold infestations
- Smell and hygiene improvement of litter
- Control of allergens
- Use as an antibiotic in animal nutrition
- Biological control of bacteria in the sugar and ethanol industry (formalin replacement)

A greater demand of hops in these applications is certainly conceivable in the future. Therefore, it is also a breeding goal in Hüll to increase the beta acid content. Currently the beta acid record is a content of roughly 20%. There is even a breeding line that produces only beta and no alpha acids. This variety (Relax) is used in the production of tea.

Hops are also interesting in the areas of health, wellness, dietary supplements, and functional foods because they contain large amounts of polyphenolic substances. In the 2021 annual report, polyphenols were dealt with in great detail, which is why they are presented in a shorter form in this annual report.

7.3 Hop polyphenols

Polyphenols are secondary plant compounds that are synthesized by plants as defenses against diseases and pests, as growth regulators and as coloring agents. Because of their antioxidant properties and their ability to scavenge free radicals, they have many health benefits. Figure 7.7 shows the simplest polyphenol hydroquinone and its oxidation to p-benzoquinone. Since polyphenols themselves can be oxidized very easily, they have an antioxidant or reductive potential.

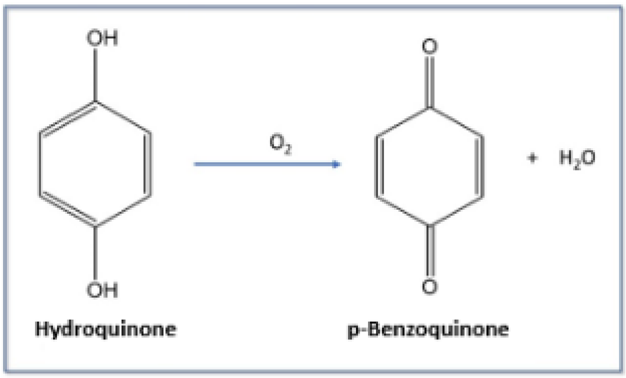


Figure 7.7: Oxidation of hydroquinone to p-benzoquinone

Cancer, atherosclerosis, Alzheimer's, and Parkinson's are examples of diseases that are based on oxidative processes. Because of their polarity, polyphenols are transferred easily into beer and their importance for the sensory system is currently underestimated but could become more important in the future. The polyphenols in hops can be classified as follows (Figure 7.8).

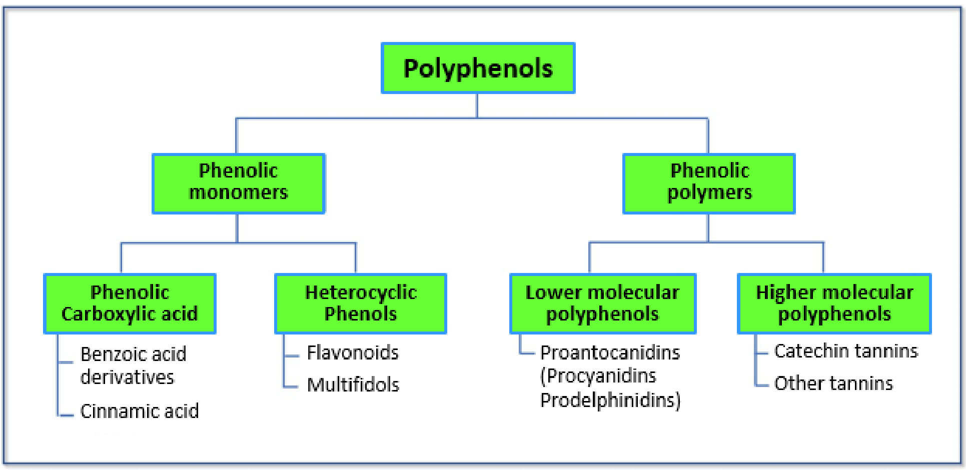


Figure. 7.8: Classification of polyphenols

Table 7.1 shows the order of magnitude in which polyphenols are present in hops.

Table. 7.1: Phenolic substances in hops

Substances and Substance Groups	Concentrations
Phenolic Carboxylic acid	
1) Benzoic acid derivatives	< 0.01 %
2) Cinnamic acid	0.01 – 0.03 %
Flavonoids	
3) Xanthohumol (Chalcone)	0.20 – 1.70 %
4) 8,6-Prenylnaringenin	< 0.01 %
5) Quercetin glycoside	0.05 – 0.23 %
6) Kaempferol glycoside	0.02 – 0.24 %
7) Catechin und Epicatechin	0.03 – 0.30 %
8) Acylphloroglucinol derivates (Multifidols)	0.05 – 0.20 %
Higher molecular substances	
9) Oligomeric Proanthocyanidins	0.30 – 1.64 %
10) Catechin and tannins	2.00 – 7.00 %

7.3.1 Isolation, identification, and analysis of multifidols in hops

This research project was funded by the Scientific Station for Breweries Munich e.V. for the years 2020 and 2021 with €10,000. Out of self-interest, samples from the 2021 harvest were also analyzed.

Quercetin and kaempferol glycosides, as well as multifidols are present in hops in relatively high concentrations. These are easily soluble in water because of their polarity. They have low taste thresholds. Table 7.2 shows the taste threshold values of these compounds according to Dr. M. Biendl and S. Cocuzza (Hardharze, Hopfenrundschau International, 2016/2017, 60-68).

Table 7.2: Flavor threshold values of low-molecular polyphenols in hops and the percentage of beers in which these are exceeded

Low molecular weight polyphenols	Taste threshold value in mg/l	Percentage of beer over the taste threshold
Quercetin-3-glucoside	0.9	86
Kaempferol-3-glucoside	0.5	95
Kaempferol-3-(malonyl) hexoside	2.7	1
Co-Multifidol glucoside	1.8	54

The multifidol glucosides are also pharmacologically interesting because they have anti-inflammatory properties (Bohr, G., Gerhäuser, C., Knauft, J., Zapp, J., Becker, H.: "Anti-inflammatory Acylphloroglucinol Derivatives from Hops (Humulus lupulus), J Nat Prod 2005, 68, 1545-1548).

The sample preparation and the analysis method with HPLC are described in great detail in the 2021 annual report and will therefore not be repeated here.

Figure 7.9 shows the results of important hop varieties from the 2019, 2020 and 2021 crop years. The varieties have very different levels. Herkules has the highest co-multifidol glucoside content and Hersbrucker Spät the lowest. The variety differences are easily reproducible over the three harvest years, which says that the multifidols are genetically determined for the specific variety. However, there is no correlation to the alpha acid levels. Some varieties with high alpha acid levels like Hall. Magnum or Polaris have a rather low co-multifidol glucoside content. Other grades such as low alpha acid sapphire have high levels of co-multifidol glucoside.

If the multifidols are not one of the main components of the hops, even with up to 0.2%, they can certainly contribute to the harmony of the bitterness. The role of the accompanying bitter substances has not yet been scientifically clarified.

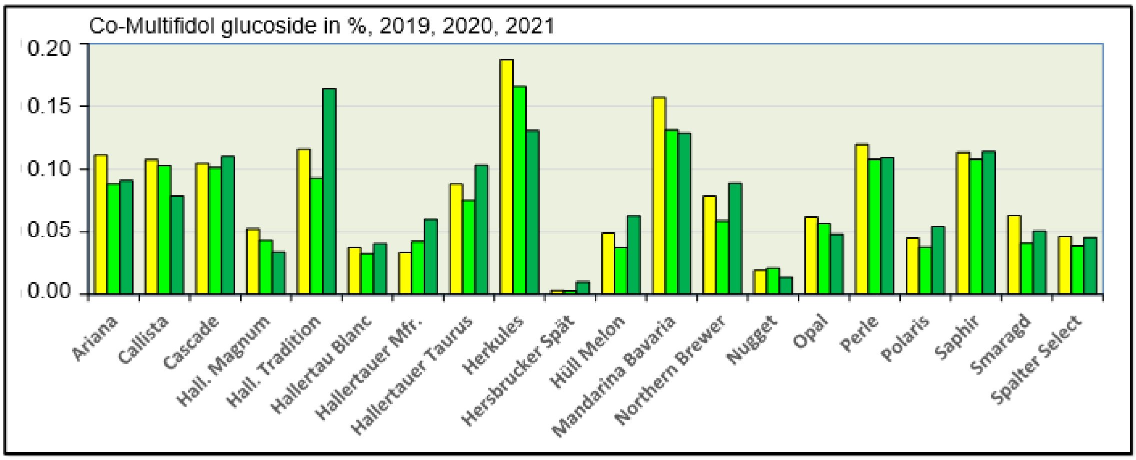


Figure 7.9: Co-multifidol glucoside levels in important hop varieties from crop years 2019, 2020, and 2021

7.3.2 The importance of polyphenols for beer and health

The importance of polyphenols for beer is discussed rather controversially in the literature. However, many references state that low-molecular polyphenols should be rated positively because they contribute to the full-bodied character of beer. However, there is no debate that polyphenols contribute antioxidant potential to beer. Higher molecular weight polyphenols combine with proteins via hydrogen bonds, causing turbidity (Figure 7.10). Therefore, higher molecular weight polyphenols are not desirable and are removed with filter aids, such as PVPP (polyvinylpolypyrrolidone).

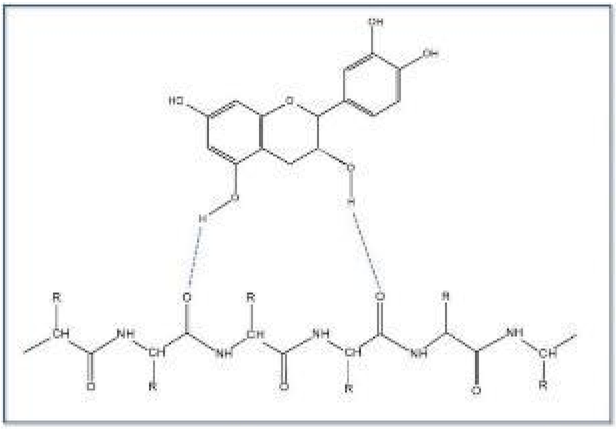


Figure 7.10: Polyphenol-protein complex

The literature on polyphenols and health is almost infinite and highlights the following properties.

• Polyphenols act as antioxidants in the body

• Certain polyphenols such as catechins prevent tooth decay

• Polyphenols protect against heart attacks and cancer

• Flavonoids prevent cell oxidation

• Polyphenols ensure good intestinal flora

There is a clear consensus that humans should eat a diet that is very high in polyphenols. This means it should include plenty of fruit and vegetables. Compared to other fruits, hops are very rich in polyphenols.

Of all the hop polyphenols, however, xanthohumol has received the most public attention in recent years, and scientific work on tis substance has exploded. The health-promoting effects of xanthohumol have also been proven by the EFSA (European Food Security Authority), which regulates health claims. Therefore, xanthohumol can also be marketed for applications in dietary supplements and functional foods. Extensive information about the history of xanthohumol and its effects can be found on the homepage of T.A. XAN Development S.A.M. (https://www.xan.com). Xanthohumol has many beneficial effects (Figure 7.11), but its most important one is its anti-carcinogenic properties.

During the brewing process, the prenylated flavonoids are constantly being transformed (Figure 7.11). Xanthohumol is isomerized to iso-xanthohumol during wort boiling and demethylxanthohumol to 8- and 6-prenylnaringenin. This is why desmethylxanthohumol is not found in beer and the concentrations of prenylated naringenins are significantly higher in beer than in hops.

8-prenylnaringenin is one of the strongest phytoestrogens found anywhere in the plant kingdom. The estrogenic effect is due to the fact that 8-prenylnaringenin has a structure similar to that of the female sex hormone 17-ß-estradiol.

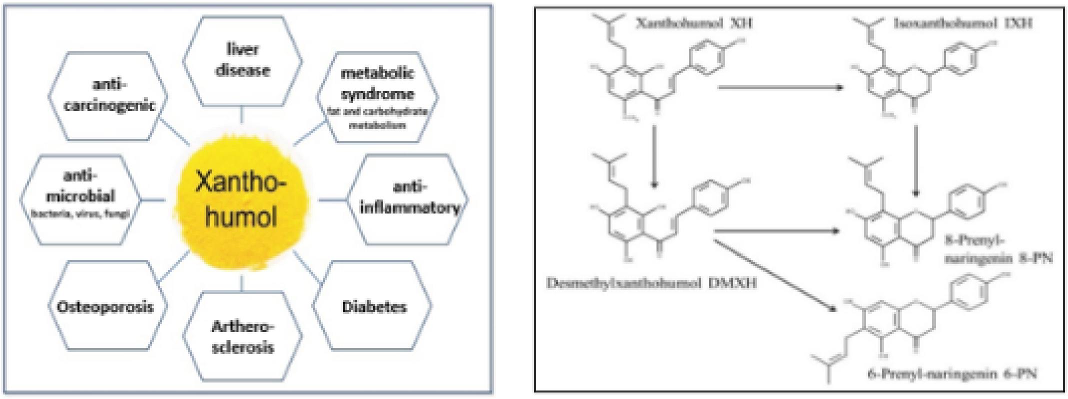


Figure 7.11: Effects of xanthohumol and transformations in the brewing process

Multifidol glucosides have anti-inflammatory properties, which are briefly discussed here. The starting point for inflammation is arachidonic acid, which is found everywhere in the tissue. After tissue is injured, prostagladin G2 is formed initially through the participation of the enzyme cyclooxygenase. This is followed by the formation of prostagladin H2 through oxidation (Figure 7.12). An entire cascade of different prostagladins can be derived from prostagladin H2. These trigger the various defense reactions of the body, including inflammatory processes.

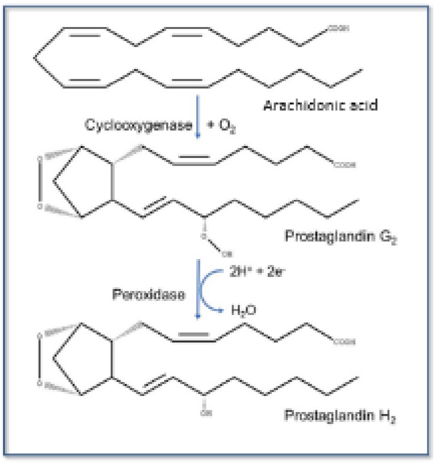


Figure 7.12: Arachidonic acid as a starting point for prostagladin G2 and H2

The action of many well-known painkillers is based on blocking cyclooxygenase. Among them are among other:

- Acetylsalicylic acid (aspirin)
- Ibuprofen
- Naproxen
- Diclofenac (Voltaren)

The co-multifidol glucoside in hops is also able to inhibit cyclooxygenase.

7.4 The essential oils of hops

With the rise of the craft brew movement, essential oils have gained in importance. Figure 7.13 shows a systematic classification of these oils. The literature lists about 300 to 400 oil components. Of these, the Hüll laboratory has verified the existence of 143 such substances.

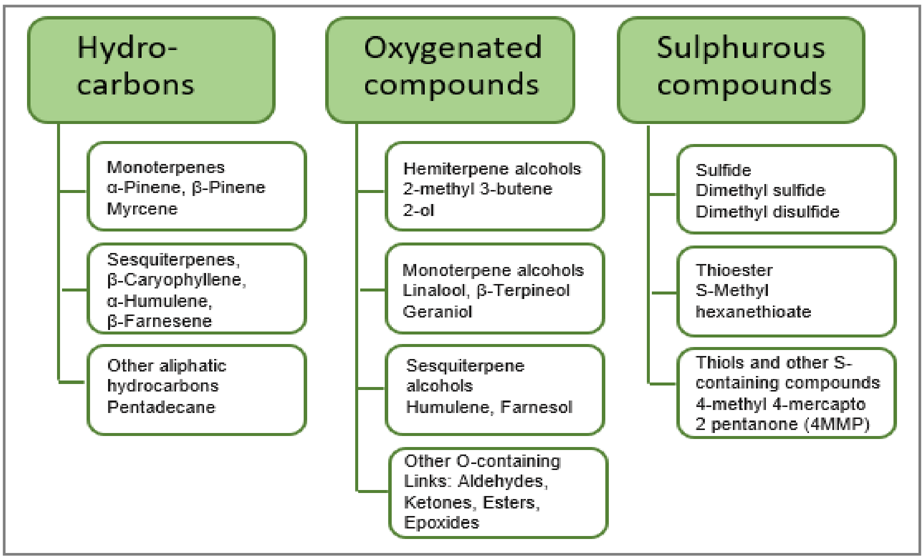


Figure 7.13: Systematic classification of essential hop oils

The Hüll laboratory is interested in the following three questions regarding essential oils:

- Which oil components are important for distinguishing between types?
- Which substances determine the aroma of the hops?
- Which substances are transferred into beer?

Sesquiterpenes such as ß-ocimene, ß-caryophyllene, aromadendrons, humulene, ß-farnesene, α-selinene, ß-selinene, ß/γ-cadinene, and 3,7-selinadiene are particularly valuable for distinguishing between varieties, although these substances have nothing to do with aroma contributions because they are non-polar and thus do not migrate into beer. Hop aromas are primarily derived from myrcene, linalool, and polyfunctional thiols such as 4-mercapto-4-methyl-2-pentanone (4-MMP). As shown in Section 7.2.1.2, polar substances are readily transferred into beer. These are terpene alcohols, low molecular weight esters, and polyfunctional thiols.

7.5 World hop portfolio (2021 crop)

Every year, essential oils from the world hop portfolio are analyzed using gas chromatography. Likewise, bitter substances are analyzed using HPLC. Table 7.3 shows the results for the 2021 crop year. It can serve as an aid to assigning unknown hop varieties to a specific variety type.

The constituents of hop can be using DNA analysis, although many external, so-called exogenous factors also play a role in the expression of the morphological appearance and the constituents (metabolome) (Figure 7.14).

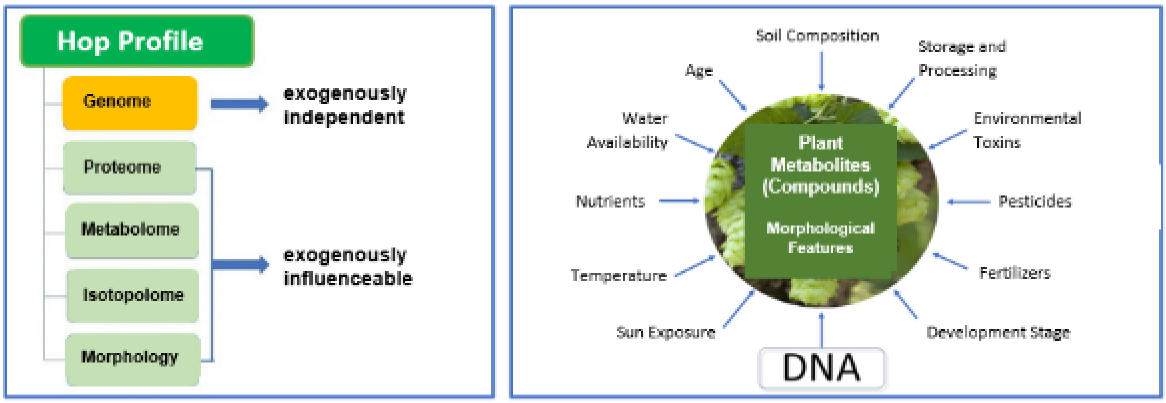


Figure 7.14: Hop morphology and metabolome are characterized by many exogenous factors

Table 7.2: World Hop Portfolio (Harvest 2021)

Variety	Myr-cene	2-Methyl-butyl-isobutyrat	Methyl-isohep-tanoat	ß-Oci-mene	Lina-lool	Aroma-dend-reen	Unde-canone	Hu mu-lene	ß-Far-ne-sene	γ-Muu-rolene	ß-Seli-nene	α-Seli-nene	ß/γ-Ca-dinene	3,7-Seli-nadiene	Gera-niol	α-a-cids	ß-acids	ß/α	Co-humo--lone	Co-lupu-lone
Admiral	13864	2260	1	306	90	0	18	691	0	22	2	5	16	0	1	16.7	4.8	0.29	37.4	73.7
Agnus	2847	241	0	49	17	0	11	280	0	22	5	9	16	0	6	11.3	5.2	0.46	31.5	55.4
Ahil	12177	1349	149	29	41	0	38	310	103	18	6	12	16	1	19	8.8	3.5	0.40	36.6	81.0
Alliance	5168	542	0	14	39	0	17	614	0	22	2	4	19	0	0	6.3	2.4	0.38	32.5	57.3
Ariana	14849	1288	272	444	43	0	35	668	0	24	18	39	21	2	2	9.7	4.4	0.45	37.4	64.1
Atlas	14443	2259	145	61	54	0	5	325	131	18	6	13	17	1	36	7.8	3.6	0.46	41.5	78.3
Backa	13856	2008	3	114	84	0	21	510	30	23	1	4	22	0	2	8.7	2.8	0.32	37.4	71.8
Belgisch Spalter	4294	518	2	96	41	10	30	377	0	26	21	49	13	77	1	7.1	2.9	0.41	24.6	47.6
Blisk	10551	1106	151	39	64	0	4	379	115	22	5	10	21	0	19	10.2	3.7	0.37	33.5	65.3
Bor	7394	583	7	568	23	0	24	658	0	18	2	4	20	0	5	10.9	3.2	0.29	23.3	49.1
Bramling Cross)	13288	766	0	38	82	0	36	647	0	16	7	16	15	0	1	4.6	2.6	0.57	42.2	62.6
Braustern	4507	501	2	339	15	0	16	497	0	22	2	3	18	0	1	12.1	4.7	0.38	27.7	55.1
Brewers Gold	6596	803	103	183	33	0	5	392	0	20	5	9	18	0	17	8.9	4.0	0.45	38.1	64.0
Bullion	10431	834	100	222	29	0	13	474	3	19	3	7	17	1	2	9.7	3.4	0.35	38.2	67.1
Callista	15138	940	210	40	110	0	36	673	7	28	28	61	24	0	1	5.3	5.6	1.05	28.8	44.5
Cascade	18378	1390	177	115	65	0	16	469	87	21	8	18	17	0	9	6.4	4.3	0.67	35.5	55.0
Challenger	9115	1198	4	334	54	0	38	602	0	22	30	71	17	2	0	5.5	4.2	0.76	26.3	42.7
Chang bei 1	9299	261	15	14	59	0	43	486	9	31	15	34	25	35	2	5.4	3.5	0.64	35.2	51.6
Chang bei 2	9458	15	18	26	67	0	54	490	13	23	11	24	20	37	1	5.2	3.2	0.60	30.7	46.7
Chinook	4203	752	70	46	18	0	7	415	0	74	9	19	54	38	10	10.2	3.2	0.32	31.7	54.3
Columbus	6414	841	62	44	27	0	2	385	0	65	9	17	46	31	3	13.2	5.4	0.41	35.2	70.3
Comet	4639	244	45	180	25	0	8	16	0	6	27	62	4	29	3	11.2	4.1	0.37	36.8	75.9
Crystal	10089	404	9	250	69	34	12	478	3	31	26	59	18	84	1	5.5	4.4	0.80	26.1	44.3
Density	9336	701	4	62	66	0	29	634	0	18	2	4	17	0	1	5.0	2.7	0.53	39.1	62.9
Early Choice	4198	488	1	302	16	0	13	515	0	18	32	76	14	0	2	4.4	1.7	0.40	31.2	66.4

Variety	Myr-cene	2-Methyl-butyl-isobutyrat	Methyl-isohep-tanoat	ß-Oci-mene	Lina-lool	Aroma-dend-reen	Unde-canone	Hu mu-lene	ß-Far-ne-sene	γ-Muu-rolene	ß-Seli-nene	α-Seli-nene	ß/γ-Ca-dinene	3,7-Seli-nadiene	Gera-niol	α-a-cids	ß-acids	ß/α	Co-humo--lone	Co-lupu-lone
Eastwell Golding	5527	496	1	109	32	0	19	612	0	20	2	5	18	0	1	7.6	2.7	0.36	30.3	55.1
Emerald	4614	287	26	161	17	0	28	654	0	18	2	3	15	0	1	8.8	3.8	0.43	31.6	53.4
Estera	4991	619	0	99	42	0	17	312	24	20	2	4	21	0	1	5.2	2.8	0.55	29.1	54.1
Galena	14678	2325	398	1192	22	0	21	524	0	23	5	11	21	2	2	8.1	5.7	0.70	38.5	63.6
Ging Dao Do Hua	8056	1698	1	12	42	0	21	558	0	79	40	85	61	1	7	6.2	4.5	0.73	51.9	66.1
Golden Star	10339	1453	0	13	37	0	15	583	0	78	39	83	58	0	5	6.3	4.2	0.66	52.2	66.4
Granit	6571	624	9	178	10	0	65	481	0	17	6	12	13	0	2	11.0	3.3	0.30	29.3	55.9
Hallertau Blanc	59211	4912	770	236	177	0	49	234	5	32	438	988	32	1	11	10.1	4.3	0.42	27.7	45.1
Hallertauer Gold	13679	950	136	98	80	0	32	679	0	20	4	8	18	0	1	7.8	4.0	0.51	26.3	48.4
Hallertauer Magnum	10959	696	234	182	24	0	17	661	0	18	2	4	16	0	1	15.4	5.8	0.38	25.7	48.9
Hallertauer Merkur	3976	555	88	61	39	0	19	595	0	24	2	4	22	0	1	13.4	4.4	0.33	15.6	38.0
Hallertauer Mfr.	2984	354	8	21	52	0	23	592	0	29	2	4	24	0	2	4.1	4.8	1.17	18.1	34.4
Hallertauer Taurus	12871	682	123	117	94	0	37	638	0	23	46	102	23	0	3	16.6	3.8	0.23	20.7	42.3
Hallertauer Tradition	7536	825	35	76	71	0	26	663	0	21	1	3	20	0	0	7.5	2.9	0.39	24.1	46.5
Harmony	7172	345	22	136	64	0	45	574	0	22	52	112	22	0	4	11.4	5.1	0.45	20.1	40.8
Herkules	11468	1123	255	540	26	0	26	668	0	19	2	3	17	0	9	17.2	4.6	0.27	30.5	60.5
Hersbrucker Pure	5763	551	17	123	56	7	31	523	0	23	11	26	18	45	2	4.6	2.6	0.57	23.9	41.6
Hersbrucker Spät	6304	246	24	49	53	37	28	498	0	30	21	47	18	86	1	4.3	4.9	1.14	18.8	31.9
Huell Melon	26831	3747	33	311	54	0	50	428	171	41	137	288	40	99	11	8.5	6.5	0.77	31.4	48.1
Hüller Anfang	4075	493	29	17	47	0	18	621	0	26	2	4	21	0	0	4.5	4.7	1.03	24.6	42.8
Hüller Aroma	5331	488	4	11	68	0	24	647	0	26	2	4	25	0	0	5.1	3.7	0.72	33.7	51.2
Hüller Fortschritt	5889	367	24	16	68	0	24	658	0	22	2	4	22	0	0	4.7	4.4	0.93	31.0	48.3
Hüller Start	4061	294	1	63	26	0	30	637	0	26	2	4	23	0	1	3.9	3.4	0.87	30.6	46.1
Kirin 1	10767	1593	1	25	42	0	17	538	0	76	32	69	61	0	6	6.1	4.5	0.73	54.6	69.6
Kirin 2	10193	1663	1	18	38	0	15	553	0	86	41	85	66	0	6	6.9	4.9	0.71	52.8	66.6
Kitamidori	5192	130	34	141	11	0	11	323	12	26	2	4	22	0	1	11.3	3.1	0.28	24.4	38.0
Kumir	5783	501	4	216	47	0	28	631	0	20	2	4	19	0	1	10.8	4.1	0.38	20.5	44.9

Variety	Myr-cene	2-Methyl-butyl-isobutyrat	Methyl-isohep-tanoat	ß-Oci-mene	Lina-lool	Aroma-dend-reen	Unde-canone	Hu mu-lene	ß-Far-ne-sene	γ-Muu-rolene	ß-Seli-nene	α-Seli-nene	ß/γ-Ca-dinene	3,7-Seli-nadiene	Gera-niol	α-a-cids	ß-acids	ß/α	Co-humo--lone	Co-lupu-lone
Late Cluster	18962	1947	184	273	79	12	37	310	28	108	39	83	65	109	7	7.2	3.8	0.53	28.4	48.9
Lubelsky	7947	82	11	41	45	0	41	438	76	18	6	14	18	0	3	8.8	4.8	0.55	29.1	48.1
Mandarina Bavaria	20637	2393	53	111	66	0	29	656	3	34	67	33	32	0	15	10.0	4.0	0.40	33.6	62.6
Mt. Hood	4805	322	77	50	33	0	18	540	0	31	2	4	25	0	2	5.7	4.6	0.80	22.6	43.5
Neoplanta	3893	460	1	197	12	0	13	286	12	20	2	4	21	0	1	7.4	2.8	0.37	38.2	75.9
Neptun	4740	522	164	50	40	0	8	465	0	24	1	3	21	0	1	16.7	4.4	0.26	23.4	51.8
Northdown	4583	509	4	232	30	0	13	507	0	19	2	4	18	0	1	9.3	4.6	0.49	25.7	48.5
Northern Brewer	4495	670	4	321	19	0	25	560	0	20	1	3	19	0	2	9.5	4.3	0.45	23.5	41.8
Nugget	5411	299	6	98	28	0	15	423	0	15	8	17	11	0	0	11.1	3.5	0.32	31.8	56.9
Opal	7167	575	53	272	90	0	29	550	0	22	2	1	18	2	4	6.4	3.9	0.60	19.3	36.8
Orion	4122	545	16	95	42	0	23	476	0	23	1	3	22	0	1	9.2	3.7	0.40	33.6	62.5
Perle	4979	532	4	283	16	0	18	565	0	19	1	3	15	0	1	9.4	3.7	0.39	33.0	57.2
Polaris	7515	514	92	310	13	0	16	472	0	20	1	3	20	0	1	18.1	3.8	0.21	25.8	57.1
Premiant	4760	534	17	196	49	0	31	568	0	20	1	3	15	0	1	7.9	3.8	0.48	22.7	45.2
Progress	23639	2146	301	417	70	12	37	445	0	99	36	77	66	83	6	11.2	4.8	0.42	34.1	63.0
Record	6462	242	18	19	60	0	25	644	0	21	2	4	21	0	0	5.4	6.2	1.15	24.9	41.8
Relax	9940	552	226	26	87	0	35	693	0	28	25	56	23	1	3	3.2	7.6	2.35	19.4	33.3
Rottenburger	9585	230	1	15	72	0	33	676	0	22	3	7	19	0	0	5.2	5.5	1.05	32.6	45.0
Rubin	5552	532	132	150	25	0	11	513	0	26	45	93	24	0	11	14.9	3.7	0.25	27.4	55.5
Saazer	10696	16	16	58	75	0	77	546	176	23	2	4	20	0	6	4.5	3.9	0.88	21.9	39.8
Saphir	9516	546	67	165	58	4	76	516	0	22	9	20	18	34	1	6.4	4.7	0.73	25.6	44.5
Serebrianker	5338	345	3	92	47	0	15	430	5	24	23	47	21	0	5	3.5	5.3	1.53	24.6	43.7
Sladek	5399	428	7	181	43	0	28	627	0	22	2	4	19	0	1	11.6	3.8	0.33	18.9	41.3
Smaragd	10198	251	64	84	77	0	32	636	0	23	2	0	22	1	4	7.4	2.5	0.34	21.6	37.5
Sorachi Ace	10753	642	5	237	24	0	26	637	5	24	2	4	24	1	3	12.8	4.7	0.37	31.4	58.6
Spalter	10496	9	10	70	95	0	51	548	186	22	2	3	22	0	10	3.8	5.5	1.47	23.2	38.6
Spalter Select	22061	988	52	100	165	13	40	478	182	23	16	38	14	75	2	7.5	3.2	0.43	27.8	49.5

Variety	Myr-cene	2-Methyl-butyl-isobutyrat	Methyl-isohep-tanoat	ß-Oci-mene	Lina-lool	Aroma-dend-reen	Unde-canone	Hu mu-lene	ß-Far-ne-sene	γ-Muu-rolene	ß-Seli-nene	α-Seli-nene	ß/γ-Ca-dinene	3,7-Seli-nadiene	Gera-niol	α-a-cids	ß-acids	ß/α	Co-humo--lone	Co-lupu-lone
Strisselspalter	6141	176	21	66	62	38	29	472	0	31	24	54	13	95	1	4.7	4.5	0.98	19.8	36.0
Talisman	8925	742	5	476	18	0	19	554	0	20	1	3	18	0	0	10.9	3.8	0.35	27.2	50.3
Target	10507	1265	3	180	76	0	51	455	0	42	6	11	35	17	1	11.0	4.2	0.38	35.7	68.1
Tettnanger	7290	54	12	60	71	0	59	490	99	26	2	4	20	0	11	4.4	4.2	0.96	22.1	38.9
Viking	12230	586	45	332	37	53	49	467	95	22	26	59	19	1	2	8.9	4.2	0.47	23.9	45.3
Vojvodina	11076	983	4	296	24	0	30	545	5	17	1	3	15	0	4	7.5	2.6	0.34	34.2	67.1
WFG	10804	20	9	57	90	0	55	642	122	22	3	7	22	0	8	5.9	4.3	0.72	21.8	41.1
Willamette	5389	605	4	44	41	0	10	280	19	21	2	5	22	0	2	3.9	2.8	0.71	34.2	53.3
Xantia	12800	1007	66	578	24	0	22	377	100	22	32	72	20	1	3	15.3	4.4	0.29	31.4	68.3
Yeoman	6062	822	71	209	25	0	19	528	0	19	31	70	22	0	6	13.8	4.2	0.30	27.3	58.6
Zatecki	5606	619	1	167	49	0	18	318	14	19	2	5	18	0	2	5.5	2.7	0.49	29.0	51.2
Zenith	8207	579	4	229	58	0	33	627	0	23	61	138	22	0	1	11.0	2.9	0.27	30.2	60.5
Zeus	6137	668	70	29	24	0	2	381	0	62	8	17	44	29	2	14.5	4.2	0.29	33.5	70.5
Zitic	6719	46	23	132	27	0	51	644	0	21	2	4	23	0	11	10.1	4.3	0.42	21.7	43.9

Essential oils = relative values, ß-caryophyllene = 100, α - and ß-acids in %, analogues in % of α - or ß-acids

7.6 Quality assurance in alpha acid analysis for hop delivery contracts

7.6.1 Chain analyses for the 2022 harvest

Starting in 2000 hop supply contracts also have included an agreement specifying that the α-acid content of a delivery batch should be taken into account and can modify the agreed-upon price up or down if the α-acid content is outside the stipulated, so-called neutral range. The working group for hop analysis (IPZ 5d) specifies precisely how hop samples are to be processed (sample division, storage), which laboratories can carry out the follow-up tests, and which tolerance ranges are permitted for the analyses. In 2022, once again, the working group had the task of organizing and evaluating chain analyzes to ensure the quality of the α-acid analyses. That year, the following laboratories took part in the chain of tests.

- Hallertauer Hopfenveredelungsgesellschaft (HHV), Werk Au/Hallertau
  (Hop Processing Society [Hopsteiner], Au/Hallertau plant)
- Hopfenveredlung St. Johann GmbH & Co. KG, St. Johann
  (Hop processing St. Johann GmbH & Co. KG, St. Johann)
- Hallertauer Hopfenveredelungsgesellschaft (HHV), Werk Mainburg
  (Hop Processing Society [Hopsteiner], Mainburg plant)
- Hallertauer Hopfenverwertungsgenossenschaft (HVG), Mainburg
  (Hallertauer Hop Processing Cooperative, Mainburg),
- AGROLAB Boden- und Pflanzenberatungsdienst GmbH, Leinefelde
  (AGROLAB Soil and Plant Advisory Service, Leinefelde)
- Bayerische Landesanstalt für Landwirtschaft, (LfL) Arbeitsbereich Hopfen, Hüll
  (Bavarian State Research Center for Agriculture, Hop Group, Hüll)
- BayWa AG Tettnang

The chain tests started on September 6 and ended on November 4, 2022, by which time the majority of the hop batches had been examined in the laboratories. The chain tests were carried out nine times (9 weeks). The sample material was kindly provided by Hopfenring Hallertau. Each sample was only taken from a single bale to ensure the greatest possible homogeneity. On Mondays, the samples were pulverized using a hammer mill in Hüll. Next, they are divided by a sample divider (Figure 7.15), then vacuum-packed, and taken to the individual laboratories. One sample per day was analyzed during subsequent weekdays. The analyses results were returned to Hüll a week later and evaluated there. A total of 35 samples were analyzed in 2022.

Figure 7.15: Sample divider and hammer mill

The evaluations were passed on to the individual laboratories as quickly as possible. Figure 7.16 shows an evaluation as an example of what a proficiency test should ideally look like. Note that the numbering of the laboratories (1-7) does not correspond to the list above.

Nr. 25: SGD (October 19, 2022)

Laboratory	Measured Value		Mean	S	cvr
1	3.48	3.44	3.46	0.028	0.8
2	3.41	3.40	3.41	0.007	0.2
3	3.53	3.53	3.53	0.000	0.0
4	3.54	3.46	3.50	0.057	1.6
5	3.36	3.41	3.39	0.035	1.0
6	3.51	3.51	3.51	0.000	0.0
7	3.39	3.46	3.43	0.049	1.4

mean	3.46
sr	0.033
sL	0.051
sR	0.061
Vkr	0.96
vkR	1.76
r	0.09
R	0.17
Min	3.36
Max	3.54

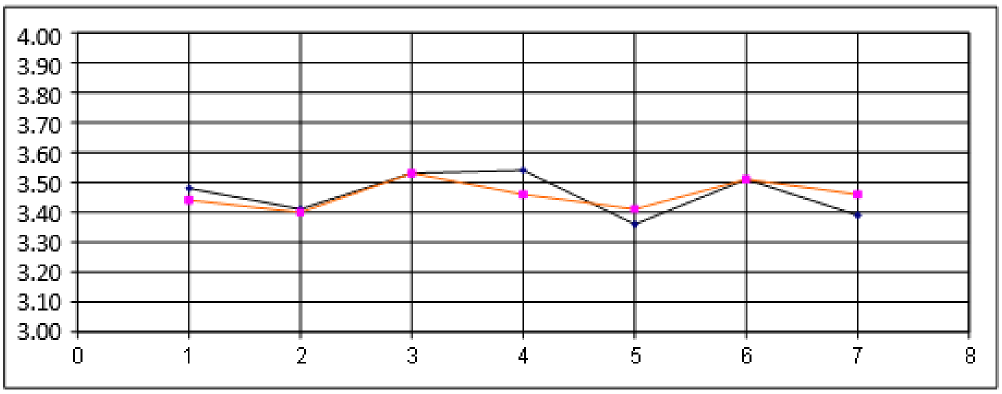


Figure 7.16: Evaluation of a set of chain analyses as an example

The outlier tests are calculated in accordance with DIN ISO 5725. The Cochran test was used within the laboratories and the Grubbs test between the laboratories.

$$\text{Cochran:} \quad C = \frac{s_{max}^2}{\sum s_i^2}$$

Formula 7-1

With 8 laboratories and a duplicate determination, C must be smaller than **0.794** at α = 1% and C smaller than **0.680** at α= 5%, otherwise a sample is considered an outlier.

$$\text{Grubbs:} \quad G = \frac{|x_{max} - \bar{x}|}{s}$$

Formula 7-2

With 8 laboratories and a duplicate determination, G must be smaller than **2.274** for α = 1% and G smaller than 2.126 for α = 5%, a sample is considered an outlier.

The outliers for 2022 are compiled in Table 7.4.

Table 7.4: Outliers in 2022

	Cochran		Grubbs	
Sample	α = 0.01	α = 0.05	α = 0.01	α = 0.05
1				Laboratory 3
9		Laboratory 4		
10		Laboratory 4		
22		Laboratory 7		
Total:	**0**	**3**	**0**	**1**

The tolerance limit $d_{crit.}$, which indicates the difference within which measurements cannot be distinguished, is calculated using formula 7-3, where r is the repeatability and R is the reproducibility (Formula 7-4).

$$d_{krit.} = |x_1 - x_2|_{krit.} = \sqrt{R^2 - \frac{r^2}{2}}$$

Formula 7-3

$$r = s_r * 2.8 \rightarrow R = s_R * 2.8$$

Formula 7-4

Starting in 2013 there are 5 alpha classes with new tolerance limits. Table 7.5 shows the new classification and the exceedances in 2022.

Table 7.5: Updated alpha acid classes and tolerance limits, as well as their limits transgressions in 2022

	< 5.0 %	5.0 % - 8.0 %	8.1 % - 11.0 %	11.1 % - 14 %	> 14.0 %
Critical Range	+/-0.3 0.6	+/-0.4 0.8	+/-0.5 1.0	+/-0.6 1.2	+/- 0.7 1.4
Transgressions in 2022	0	0	0	0	0

In 2022, there were no transgressions of permitted tolerance limits.

In Figure 7.17, all analysis results for each laboratory are compiled as relative deviations from the mean (= 100%), differentiated according to α-acid contents <5%, >=5% and <10%, and >=10%. This graph shows if a laboratory has a tendency to generate values that are too high or too low.

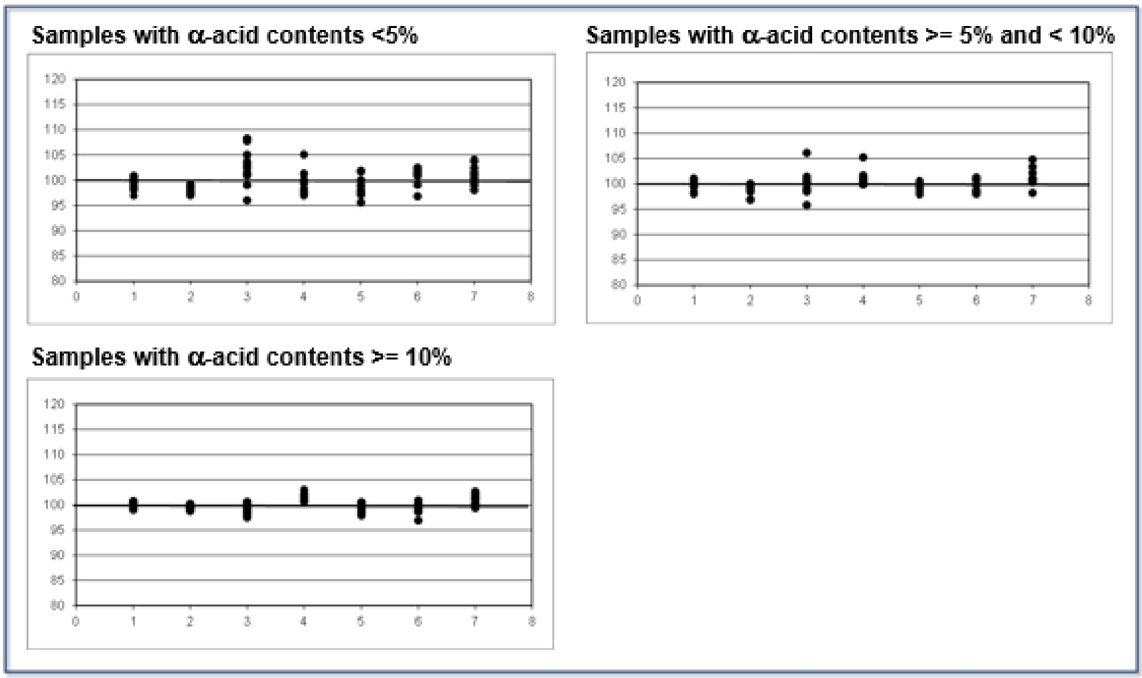


Figure 7.17: Laboratory analyses results relative to the mean

The Hüll laboratory is number 5. In 2022, the general α-acid content was very low, which is why there were more samples with lower α-acid contents (below 5%).

7.6.2 Evaluation of controls

Since 2005, control tests have been conducted in addition to the chain tests. The IPZ 5d working group evaluates these and forwards them to the laboratories involved, as well as to the hop growers' and hop trade association. The first laboratory selects three samples per week, which are then analyzed by three different laboratories in accordance with AHA specifications. The initial examination value applies if the mean value of the follow-up examinations and the initial examination value are within the tolerance limits (Table 7.5). Table 7.6 shows the results for the year 2022. The initial test value could not be confirmed in just one case (yellow marking). Starting with the 2020 harvest, the BayWa Tettnang laboratory has also been a follow-up laboratory.

Table 7.6: Control evaluation in 2022

Sample name	Initial test laboratory	Initial test value	Follow-up tests			Average	Results confirmed
			1	2	3		
31199 HTR	Agrolab	5.9	5.9	5.9	6.0	5.92	yes
31149 HAL	Agrolab	3.7	3.7	3.7	3.7	3.71	yes
30419 NBR	Agrolab	5.4	5.1	5.2	5.2	5.18	yes
1 TET Batch No. 18200	BayWa	2.7	2.1	2.1	2.2	2.13	no
12 HTR Batch No. 34601	BayWa	4.5	4.3	4.4	4.4	4.37	yes
52 HMG Batch No. 2329058	BayWa	11.8	11.9	12.1	12.1	12.04	yes
HHTU, KW 38 - 31687	HVG Mainburg	14.3	14.1	14.1	14.3	14.19	yes
HHMG, KW 38 - 31326	HVG Mainburg	11.0	10.7	10.9	11.3	10.97	yes
HHTR, KW 38 -31334	HVG Mainburg	3.7	3.5	3.7	3.8	3.66	yes
KW 39-PER, Agrolab N0. 36845	HV St. Johann	3.5	3.2	3.3	3.4	3.31	yes
KW 39-HMG, Agrolab No. 35187	HV St. Johann	9.7	9.4	9.6	9.9	9.62	yes
KW 39-HKS, Agrolab No. 35973	HV St. Johann	13.1	13.0	13.1	13.3	13.14	yes
KW 40-HKS 1	HHV Au	15.6	15.3	15.4	15.9	15.54	yes
KW 40-HKS 2	HHV Au	13.6	13.5	13.8	13.9	13.72	yes
KW 40-HKS 3	HHV Au	14.2	14.3	14.4	14.5	14.41	yes
Sample 1, 40786 HMG	Agrolab	10.5	10.3	10.3	10.4	10.33	yes
Sample 2, 40662 CAL	Agrolab	3.0	2.0	3.0	3.1	2.99	yes
Sample 3, 40754 HKS	Agrolab	16.9	16.9	17.0	17.2	17.02	yes
560, Variety HKS, Batch No. 42812	BayWa	16.2	15.5	15.7	16.2	15.79	yes
485, Variety HTR, Batch No. 35141	BayWa	5.2	5.0	5.1	5.2	5.10	yes
644, Variety HAL, Batch No. 28242	BayWa	3.7	3.5	3.5	3.6	3.55	yes
HPLA, KW 43- 39903	HVG Mainburg	18.8	18.7	19.1	19.3	19.03	yes
HHKS, KW 43- 40251	HVG Mainburg	17.9	18.0	18.2	18.3	18.17	yes
HHMG, KW 43- 39391	HVG Mainburg	10.7	10.7	10.7	11.0	10.79	yes
KW 44 - 41066, NUG	HV St. Johann	9.4	9.2	9.2	9.4	9.28	yes
KW 44 – 39922, HKS	HV St. Johann	13.3	12.8	13.0	13.2	12.99	yes
KW 44 -41048, HTU	HV St. Johann	14.0	13.9	14.0	14.2	14.02	yes
KW 45 - HMG	HHV Au	11.3	11.2	11.5	11.6	11.43	yes
KW 45 - HKS	HHV Au	14.2	14.1	14.2	14.7	14.33	yes
KW 45 - PLA	HHV Au	16.6	16.1	16.4	16.6	16.37	ja

7.6.3 Follow-up surveys for the 2022 harvest

The laboratory in Hüll has been involved as a follow-up laboratory since 2019. It evaluates the results. Starting with the 2020 harvest, the BayWa laboratory in Tettnang was also approved as a testing laboratory (Table 7.7).

Table 7.7: Workflow for follow-up laboratories

Initial test laboratory	Follow-up test laboratories		
HHV Au HHV Mainburg	HVG Mainburg	HV St. Johann	LfL Hüll
HV St. Johann	HVG Mainburg	HHV Mainburg	LfL Hüll
HVG Mainburg	HV St. Johann	HHV Mainburg	LfL Hüll
AGROLAB	HV St. Johann	HHV Au	LfL Hüll
BayWa Tettnang	HV St. Johann	HHV Au	LfL Hüll

The evaluation of the follow-up examination is sent to the initial examination laboratory as a LfL follow-up examination report within three working days after receipt of the follow-up examination results, which immediately initiates forwarding to the client of the follow-up examination. In 2022 there were a total of 42 follow-up examinations. Only in a single case was the initial test value not confirmed. Table 7.8 shows the follow-up results in ascending chronological order. There were many follow-up examinations, especially for the Herkules variety and for the St. Johann hop refinement.

Table 7.8: Follow-up tests in 2022

Sample Name	Initial test laboratory	Initial test results	Follow-up tests			Mean	Results con-firmed
			1	2	3		
Sample 31638, Variety DE H HTR	HV St. Johann	7.1	6.9	7.0	7.2	7.03	yes
Sample 30651, Variety DE H HTR	HV St. Johann	6.0	5.7	5.7	5.9	5.77	yes
Variety HPLA, Analysis No. Agrolab 33016, Analysis No. HVG 1623/24	HVG Mainburg	14.7	14.5	14.6	14.9	14.67	yes
Agrolab- Analysis No. 6827, Batch No, 2633779, Variety HKS	HHV Au	14.8	14.5	14.6	15.0	14.68	yes
Sample 34219, Variety DEH HKS	HV St. Johann	14.9	14.9	15.0	15.3	15.07	yes
Sample 33491, Variety DEH HKS	HV St. Johann	15.3	15.3	15.3	15.7	15.43	yes
Sample 36608, Variety HHKS	HV St. Johann	14.3	14.1	14.1	14.3	14.17	yes
Sample 36650, Variety HHKS	HV St. Johann	14.5	14.8	14.9	15.0	14.90	yes
Sample 39553, Variety DEH HKS	HV St. Johann	13.7	13.7	13.7	14.1	13.82	yes
Sample 40119, Variety DEH HKS	HV St. Johann	15.4	15.5	15.7	16.0	15.74	yes

Sample Name	Initial test laboratory	Initial test results	Follow-up tests			Mean	Results con-firmed
			1	2	3		
Analysis No.. 37707, Variety PLA	Agrolab	16.5	15.9	16.1	16.4	16.13	yes
Sample 37380, Variety DEH HKS	HV St. Johann	15.5	15.2	15.4	16.0	15.54	yes
Sample 35047, Variety DEH HKS	HV St. Johann	16.2	16.1	16.2	16.6	16.30	yes
Sample 33414, Variety DEH HKS	HV St. Johann	16.7	16.8	16.8	17.2	16.95	yes
Agrolab-Analysis No. 37370, Batch No. 2562321, Variety HKS	HHV Au	10.8	10.5	10.6	11.0	10.69	yes
Sample 40611, DE HKS	HV St. Johann	17.1	16.7	16.8	17.2	16.90	yes
Sample 39462, DE HKS	HV St. Johann	14.0	13.8	13.8	14.2	13.94	yes
Analysis No. Agrolab 40546, Analysis No. HVG 47/4718, Variety HKS HKS	HVG Mainburg	13.3	13.2	13.4	13.4	13.33	yes
Sample 38713, Variety DEH HKS	HV St. Johann	16.1	15.8	16.1	16.4	16.10	yes
Sample 39235, Variety DEH HKS	HV St. Johann	15.6	15.3	15.6	16.0	15.64	yes
Sample 39483, Variety DEH HKS	HV St. Johann	16.1	16.0	16.3	16.8	16.35	yes
Sample 40091, Variety DEH HKS	HV St. Johann	15.6	15.2	15.7	15.8	15.56	yes
Sample 33590, Variety DEH HKS	HV St. Johann	16.0	15.4	15.8	16.2	15.80	yes
Sample 34327, Variety DEH HKS	HV St. Johann	14.7	14.3	14.6	14.9	14.80	yes
Sample 35206, Variety DEH HKS	HV St. Johann	15.6	15.5	15.7	16.0	15.74	yes
Sample 35942, Variety DEH HKS	HV St. Johann	15.0	14.9	15.0	15.4	15.11	yes
Sample 36261, Variety DEH HKS	HV St. Johann	14.5	14.2	14.6	14.7	14.48	yes
Sample 36718, Variety DEH HKS	HV St. Johann	16.0	15.4	15.7	16.3	15.80	yes
Sample 37407, Variety DEH HKS	HV St. Johann	15.3	14.6	15.0	15.2	14.93	yes
Sample 37011, Variety DEH HKS	HV St. Johann	15.5	15.5	15.5	16.0	15.67	yes
Sample 37449, Variety DEH HKS	HV St. Johann	15.9	16.0	16.3	16.6	16.30	yes
Sample 38164, Variety DE HKS	HV St. Johann	15.3	15.0	15.1	15.5	15.20	yes
Sample 38655, Variety DE HKS	HV St. Johann	15.0	14.9	15.0	15.5	15.12	yes

Sample Name	Initial test laboratory	Initial test results	Follow-up tests			Mean	Results con-firmed
			1	2	3		
Sample 39100, Variety DE HKS	HV St. Johann	15.9	15.9	16.0	16.5	16.15	yes
Sample 39534, Variety DEH HKS	HV. St. Johann	16.3	16.4	16.5	16.8	16.56	yes
Sample 40118, Variety DEH HKS	HV St. Johann	15.5	15.5	15.7	16.1	15.77	yes
Sample 40169, Variety DEH HKS	HV St. Johann	15.3	15.1	15.1	15.4	15.21	yes
Sample 40042, Variety HKS	Agrolab	13.3	13.4	13.5	13.5	13.46	yes
Sample 39384, Variety DEH HKS	HV St. Johann	16.3	15.9	16.3	16.7	16.29	yes
Sample 36130, Variety DEH HKS	HV St. Johann	13.6	13.4	13.5	14.3	13.73	yes
Sample 36137, Variety DEH HKS	HV St. Johann	15.2	15.5	15.6	16.0	15.71	yes
Sample 38166, Variety DEH HKS	HV St. Johann	13.8	14.1	14.5	14.8	14.45	no

The results of the control and follow-up examinations are published annually in July or August in the Hopfenrundschau. Table 7.9 shows the number of follow-up examinations and complaints from 2019 - 2022.

Table 7.9: Number of follow-up examinations and complaints from 2019 – 2022

Follow-up exams	Number	Complaints
2019	47	1
2020	42	1
2021	33	0
2022	42	1

7.7 Studies of the biogenesis of bitter substances and oils from new breeding strains

With newer breeding lines, extensive biogenesis tests on the essential oils and bitter substances are carried out every year in order to obtain information on optimal harvest dates. Table 7.10 shows the harvest times, whereby slight shifts in the harvest dates are possible from one year to the next.

Table 7.10: Harvest times of the biogenesis experiments

T0	T1	T2	T3	T4	T5	T6
August 16	August 21	August 28	Sept. 4	Sept. 11	Sept. 18	Sept. 25
☐	☐	☐	☐	☐	☐	☐

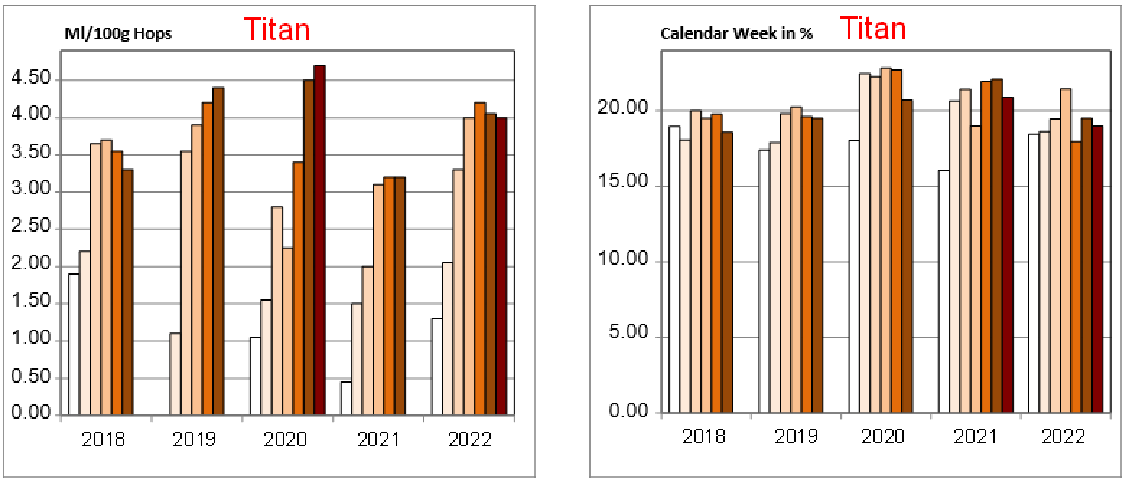


Figure 7.18: Biogenesis of oils and bitter substances in the Titan variety at the Stadelhof site

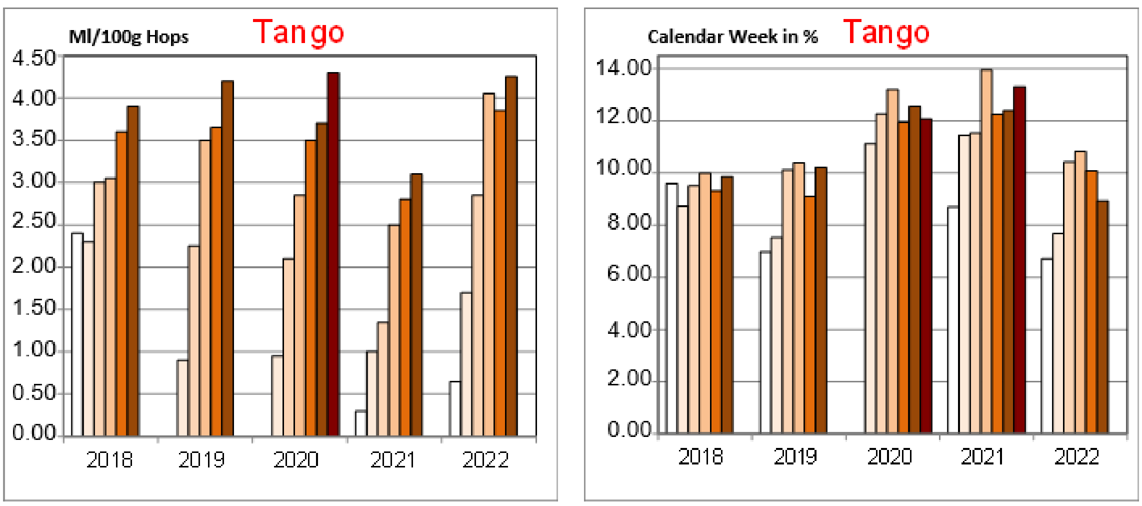


Figure 7.19: Biogenesis of oils and bitter substances in Tango at the Stadelhof site

Figure 7.18 and Figure 7.19 clearly show that the oil content is significantly more dependent on the timing of the harvest than is the content of bitter substances. For a distinct aroma, therefore, it is advisable to schedule the harvest later. The new Tango variety has a very high oil content (2.4 - 4.0 ml/100 g hops) relative to its alpha-acid content (7.5 - 11.0%). The climatic conditions also seem to have different effects on these values. In dry and hot years, the oil concentration even increases. The year 2021 was ideal for the α-acid content. This year had record α-acid results but the oil content was lower. In the dry, hot year 2022, α–acid levels were very low, but oil contents, relatively high.

The illustration also shows that the α-acid decline in Titan in 2022 was only minimal. With Tango it was slightly larger, but still smaller than that of many other varieties. This shows the stability of the two new Hüll varieties in relation to climate fluctuations.

7.8 Development of NIRS calibrations based on conductometer and HPLC data with the new near infrared reflectance spectroscopy device

The laboratory in Hüll acquired a new NIRS device in the spring of 2017 (Figure 7.20). It was financed entirely by the Society for Hop Research.

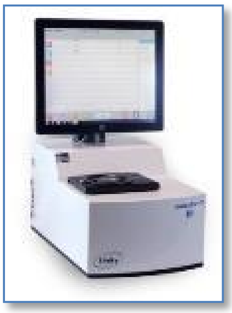


Figure 7.20: NIRS device from Unity Scientific

The device is compatible with devices installed at AQU in Freising. Old calibrations by the Foss device could be adapted to the new device by simple mathematical transformation.

However, work has started on the development of a new, proprietary calibration system for this device based on conductometer and HPLC data. The calibrations are expanded and validated every year with the samples from the chain tests. Figure 7.21 shows the correlations of the individual parameters between laboratory values and NIRS values.

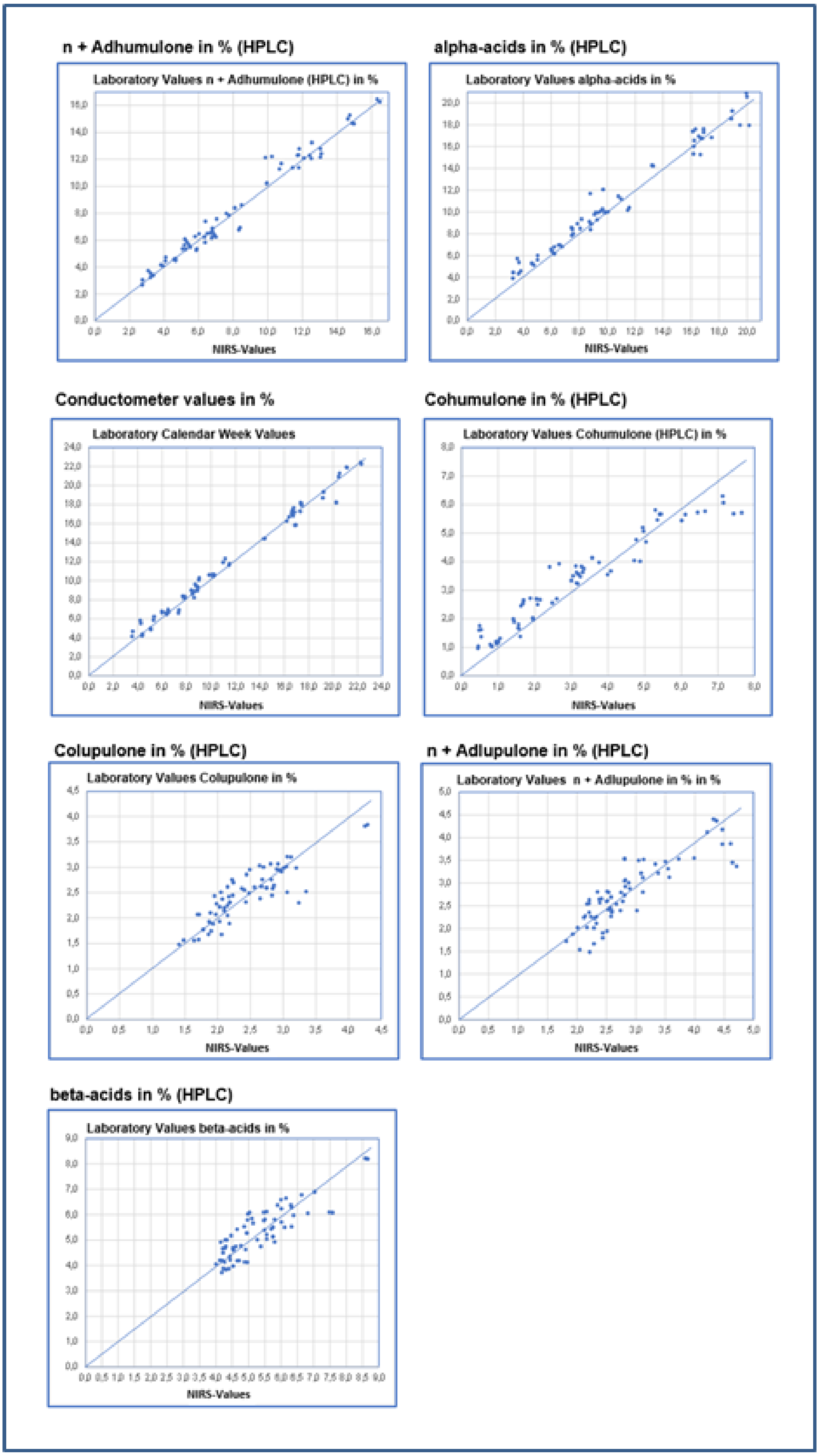


Figure 7.21: Correlations between laboratory values and NIRS values

Table 7.11 shows the statistical parameter used to evaluate the precision of calibrations. Bias indicates the systematic deviation between NIRS values and laboratory values. SEP refers to the Standard Error Prediction, which is the standard error between NIRS values and the values of the validation samples. SEP is calculated using Formula 7-5, while the random error SEP(C) is calculated using Formula 7-5. R^2 indicates the confidence in the values between NIRS values and laboratory values. The higher R^2 is, the better is the correlation.

$$SEP = \sqrt{\frac{\Sigma(y_i - \hat{y}_i)^2}{n-1}}$$

Formula 7-5

$$SEP(C) = \sqrt{SEP^2 - Bias^2}$$

Formula 7-1

Table 7.11: Statistical parameters for evaluation the precision of the NIRS method

Method	Bias	SEP	SEP(C)	R^2
Conductometer values	- 0.316	0.716	0.643	0.987
Cohumulone (HPLC)	- 0.188	0.667	0.630	0.924
n + Adhumulone (HPLC)	- 0.112	0.629	0.619	0.973
alpha-acids (HPLC)	- 0.417	0.929	0.830	0.977
Colupulone (HPLC)	- 0.022	0.291	0.290	0.743
n + Adlupulone (HPLC)	- 0.088	0.395	0.385	0.731
beta-acids	- 0.015	0.557	0.557	0.717

Especially the conductometer values and the HPLC values for alpha acids correlate well with the NIRS values. The NIRS method seems to be less suitable for the determination of ß-acid values. For hop breeding, the near infrared spectroscopy method seems valuable because it allows for the measurement of many sample values per day and because it does not require the use of solvents, which are difficult to dispose of. As an evaluation method for hop delivery contracts, however, the NIRS method is still too imprecise. This is why conductometric titration is still needed for this purpose.

7.9 Alpha-acid stability of the new Hüll cultivars in relation to year-to-year fluctuations

By now, data on alpha acid exists even for the recently-bred Hüll varieties. These were collected from 2012 to 2021. They can be conveniently visualized by way of a Box-Plot representation. Figure 7.22 illustrates this type of representation.

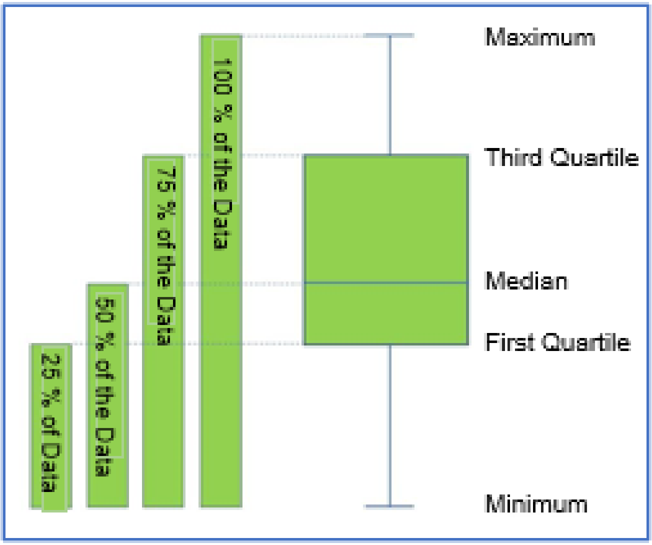


Figure 7.22: Explanation of a box plot display

Figures 7.23 and 7.24 show Box-Plot evaluations of official AHA results. The illustrations clearly show that the more recent Hüll cultivars are much more stable with fewer year-over-year fluctuations than, for instance, Perle and Northern Brewer.

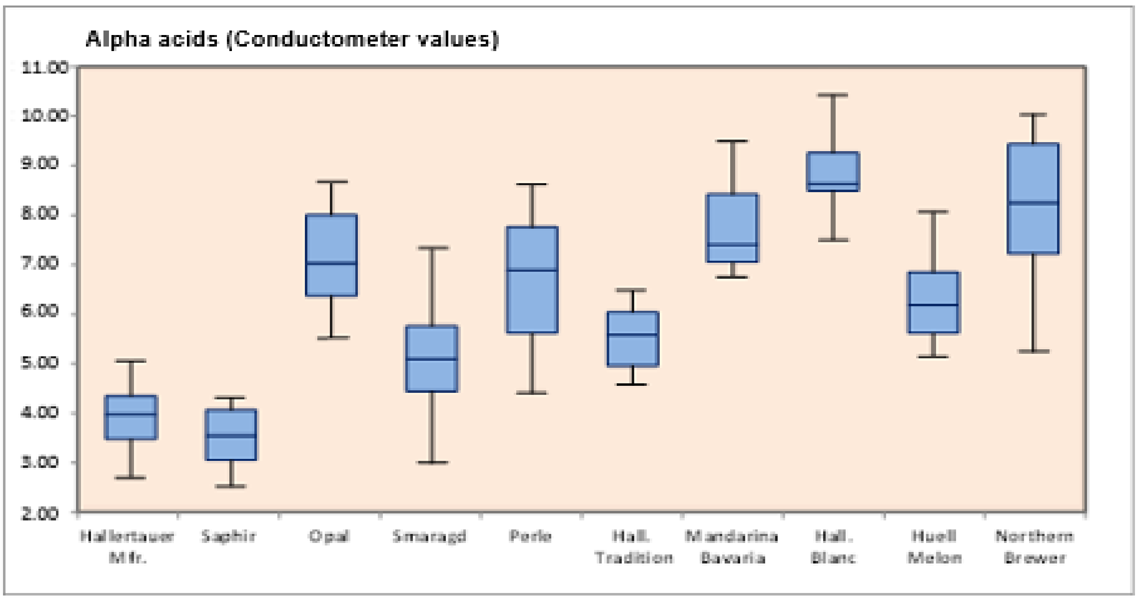


Figure 7.23: Box-Plot evaluation of aroma varieties

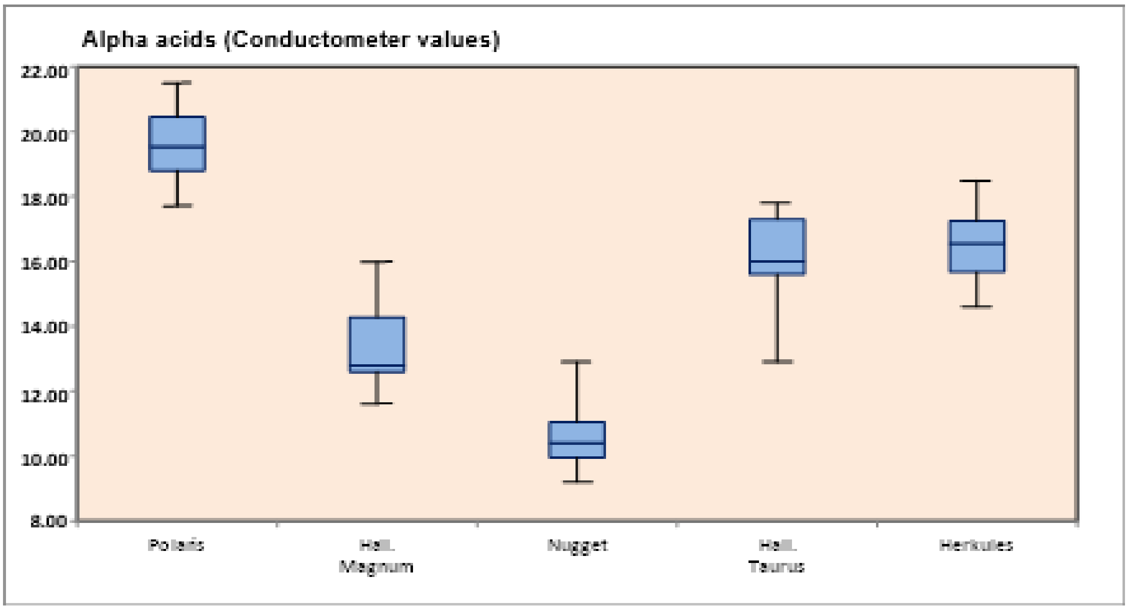


Figure 7.24: Box-Plot evaluation of bitter varieties

7.10 Tests for the determination of alkaloids in Lupines

Tests for the determination of alkaloids in Lupines were carried out for working group IPZ 1b Günther Schweizer. The initial steps involved the selection of an appropriate method to prepare samples, as well as a GC method for the analytics. Figure 7.25 shows the alkaloids that need to be analyzed. The main alkaloid is lupinin. It is desirable that the concentration of alkaloids in lupines be as small as possible because alkaloids are poisonous. When the lupine project is approved, a larger number of alkaloid determinations will be conducted in 2023.

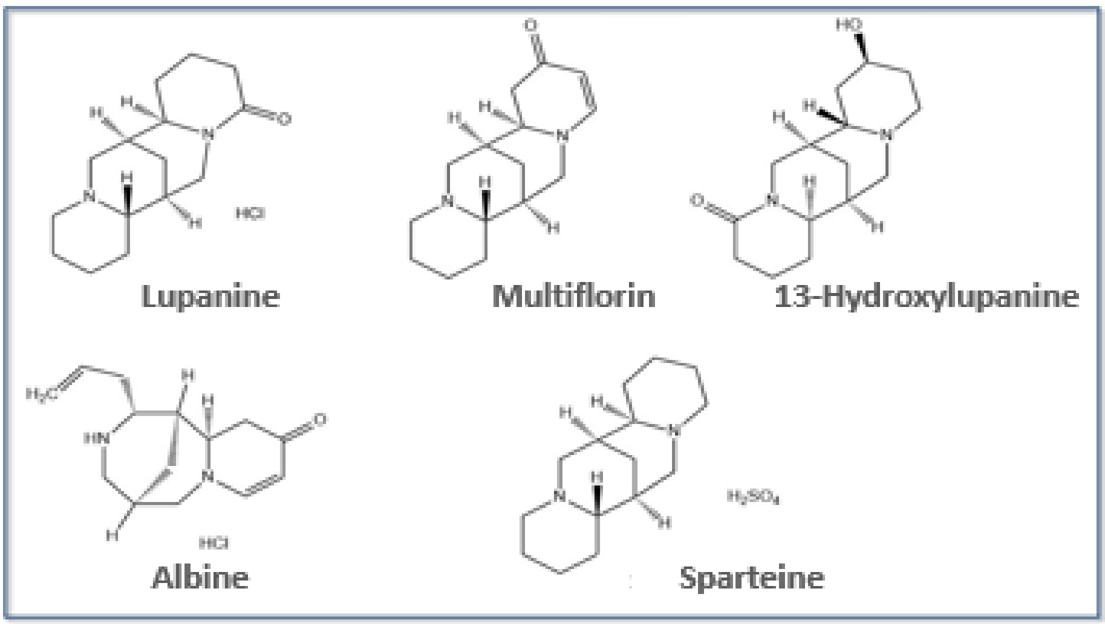


Figure 7.25: Alkaloids in Lupines

7.11 **Verification of varietal authenticity in 2022**

The working group IPZ 5d is mandated by the food control authorities to verify the authenticity of different varieties. In 2022, the group conducted 14 variety tests for the district offices of the food control authorities. There were no problem issues.

8 Ecological Issues in Hop Production

Dr. Florian Weihrauch, Dipl.-Biol.

The task of this working group is to conduct applied research, as well as to update the state of knowledge regarding environmentally friendly and organic hop production. This includes diagnoses, observations, and monitoring of the occurrence of hop pests and their enemies, while considering the progression of climate change and the resulting effects on affected biocoenoses. It also involves the development and evaluation of biological and other eco-compatible crop protection methods. This working group is mainly supported by research funds for ecological issues in hop cultivation.

8.1 Minimizing the use of copper-containing crop protection agents in organic and ecologically integrated hop cultivation

Sponsor:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Hopfenökologie (IPZ 5e) *(Bavarian State Research Center for Agriculture, Institute for Plant Production and Plant Breeding, AG Hop Ecology [IPZ 5e])*
Financing:	Erzeugergemeinschaft Hopfen HVG e. G. *(HVG Hop Producer Group)*
Project Management:	Dr. F. Weihrauch
Team:	Dr. F. Weihrauch, S. Kaindl, K. Kaindl, M. Obermaier, A. Baumgartner, M. Felsl
Collaboration:	Betrieb (*Hop Farm*) Robert Drexler, Riedhof Forschungsinstitut für Biologischen Landbau *(The Research Institute of Organic Agriculture)* (FiBL), Frick Boku Wien, IFA-Tulln Institut für Umweltbiotechnologie *(University of Natural Resources and Life Sciences, Institute of Environmental Biotechnology)*
Duration:	March 1, 2014 to December 31, 2022

Objectives

Based on environmental and toxicological assessments, plant protection products containing copper should no longer be used. At the EU level, this active ingredient has received an unfavorable classification in recent years (listing in Appendix I). Thus, it is now permitted to be used in crop protection only as an exceptional, short-term remedy. A new extension of the approval of copper was granted in December 2018, although only for a maximum "grace period" not exceeding seven years, until January 31, 2026. During this period, pesticides containing copper should disappear entirely from the market as soon as there are equivalent or better active ingredients available; and the member countries are, therefore, obligated to work intensely on concepts that allow for the further reduction of the amount of copper in use.

However, organic farms still cannot do without copper as an active ingredient, regardless of the crops they cultivate. First, a four-year test program, lasting from 2010 to 2013, and initiated by the Federal Organic Farming Program (BÖLN) investigated the extent to which copper quantities in hop cultivation could be reduced without incurring losses. As a result, the currently permissible application rate for hops of 4.0 kg Cu/ha/year was reduced to 3.0 kg Cu/ha/year. After the successful completion of that first project, this follow-up project has the task of critically examining the effects of the new 3.0 kg Cu/ha/year rule, which has now been implemented. It is also tasked to investigate if further reductions in the use of copper are possible.

Approach and results

In 2022, this work was assigned to a bachelor thesis (S. Kaindl, TUM, Depar5tment of Ecological Agriculture and Cultivation). For this study, 14 test sections had been created in 2021. All copper variants were based on the product Funguran progress, which is the currently approved copper-based crop protection preparation. The variants consisted of different application rates with different mixing partners as synergists, some of which were also tested as solo variants. The trial was again carried out using the susceptible variety Herkules at the Riedhof site. All treatments were planned with six applications, as is customary in practice, whereby the variants that received just 1 kg of pure copper per ha were treated only twice with 0.5 kg each, on the dates of the two middle applications. The results for 2022 were published separately by Susanne Kaindl as part of her bachelor thesis.

8.2 Further developments of cultivation-specific strategies for ecological applications of plant protection preparations using category-specific networks — category hops

Sponsor:	Bund Ökologische Lebensmittelwirtschaft (BÖLW e.V.) *Organic Food Production Alliance (BÖLW e.V.) and* Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Hopfenökologie (IPZ 5e) *Bavarian State Research Center for Agriculture, Institute for Plant Production and Plant Breeding, AG Hop Ecology (IPZ 5e)*
Financing:	Bundesanstalt für Landwirtschaft und Ernährung (BLE) (*Federal Office for Agriculture and Food*) über Bundesprogramm Ökologischer Landbau und andere Formen nachhaltiger Landwirtschaft (*Federal Organic Farming Program including other forms of sustainable agriculture*) (BÖLN-Projekt 2815OE095)
Project Management:	Dr. F. Weihrauch
Team:	Dr. F. Weihrauch, M. Obermaier
Collaboration:	Bund Ökologische Lebensmittelwirtschaft (BÖLW e.V.) *Organic Food Production Alliance (BÖLW e.V.)*
Duration:	August 15, 2017 to December 31, 2022 (project extension)

Procedure and objective

The overall research project has set up six cultivation networks (arable farming, vegetables, hops, potatoes, fruit, and viticulture) focusing on plant health in organic farming, with department coordinators serving as central contacts. Overall coordination is in the hands of BÖLW; while the hop division is coordinated by IPZ 5e in Hüll. The tasks of the coordinator include building a stable interaction network of a group of commercial farms, giving advice to farms interested in converting, collecting questions about plant health in the respective crops, recording and disseminating news about innovations; learning about research needs; and formulating cultivation strategies for each crop.

Within the organic hop network, communication takes place mainly in two to three meetings per year, which bring together the relevant players. One of the meetings is a special workshop for farms. In addition, there will be at least one information exchange workshop per year for all the cultivation networks. This ensures the overall coordination of the project. From the perspective of the hop division, the key events in 2022 were the hop cultivation day as part of the Bioland week (February 9, 2022) and a round-table about current problems with phytosanitary measures in organic in hop cultivation. The round-table meeting took place in Hüll on April 6, 2022 with 28 participants. There were lively discussions and direct exchanges among commercial growers. In addition, there was a summer excursion of the working group Organic Hops with 43 participants on July 19 and 20 in Tettnang.

The primary objective of this research project is to develop management strategies that rely on phyto-medically active substances in the cultivation system. The expectations of the BLE or BMEL as sponsor clients are focused on progress and innovation. This involves the development of new management or cultivation systems and a coherent cultivation system as the result, in the form of a "strategy paper," that concludes the first part of the research project. It was published at the end of 2022.

Figure 8.1: Group photo of the participants in the summer excursion of the working group Organic Hops in July 2022 in Tettnang

8.3 Development of a catalog of measures that promote biodiversity in hop growing

Sponsor:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Hopfenökologie (IPZ 5e) *(Bavarian State Research Center for Agriculture, Institute for Plant Production and Plant Breeding, AG Hop Ecology)*
Financing:	Erzeugergemeinschaft Hopfen HVG e.G. *(HVG Hop Producer Group)*
Project Management:	Dr. F. Weihrauch
Team:	Dr. F. Weihrauch, Dr. I. Lusebrink, M. Obermaier, A. Baumgartner, M. Felsl, K. Kaindl, S. Kaindl
Collaboration:	Interessengemeinschaft Niederlauterbach (IGN) e.V. *(Interest Group Niederlauterbach)* AELF Pfaffenhofen, FZ Agrarökologie *(Centre of Expertise for Agroecology)* Landesbund für Vogelschutz, KG Pfaffenhofen, UNB am Landratsamt Pfaffenhofen *(The State Association for Bird Protection in Bavaria eV, UNB* (Unteren Naturschutzbehörde; *Nature Protection Office*) *at the district office of Pfaffenhofen)*
Duration:	March 1, 2018 to December 31, 2023 (Project extension)

Background and objectives

The concept of biodiversity is on everyone's mind and the Bavarian state government declared 2019 and 2020 as 'years of biodiversity.' At the beginning of 2018, the EG HVG, together with the LfL, began to initiate measures to stop the loss of species and to promote biodiversity in and around hop cultivation. This includes, for example, the evaluation of possible measures, the creation of a working concept, the formulation of individual topics and solutions, the initiation and application for follow-up projects, and the coordination of the implementation of new hop cultivation practices. At the same time, the goal of the project is not to interfere with the productivity of valuable arable land or hop gardens, but to stop the cultivation in marginal, unproductive, or environmentally critical areas, and to redesignate them as protected wild spaces.

Method

The first step was to set up a cooperating network of as many associations, organizations, and facilities as possible to come together for a joint and constructive approach and solutions. In addition to the LfL and TUM (*Technical University Munich*), the BBV (*Bavarian Farmers Association*), the AELF Pfaffenhofen (*specialist center for agroecology*), the LBV (Landesbund für Vogelschutz in Bayern e.V; *Bavarian state association for the protection of birds*), UNB (Unteren Naturschutzbehörde; *Nature Protection Office*) at the Pfaffenhofen district office, the IGN (Interessen Gemeinschaft Qualitätshopfen; *Interest Group for Quality Hops*) in Niederlauterbach and all organizations headquartered in the Haus des Hopfens (*House of Hops* in Wolnzach) have been involved to date.

Concept of the 'Biodiversity Panorama Eichelberg'

The most significant step thus far in the project resulted from the constructive collaboration with IGN Niederlauterbach. Within the landscape of the traditional hop-growing village of Eichelberg, on the edge of the Ilm Valley, there is an almost contiguous 85-ha basin, most of which belongs to and is managed by three IGN farms. Of this area, 34 ha (40%) are planted with hops, 28 ha (33%) is arable land, and the rest is divided into wooded areas, grasslands, flowering meadows, as well as other special-use or no-function spaces. Thanks to the small number of committed landowners and farmers who are interested in biodiversity, the panorama in Eichelberg offers exceptional opportunities to develop an example for demonstrating how hop growing and biodiversity do not have to be mutually exclusive but can coexist without problems. In the fall of 2020, a preliminary action plan with an outline of planned measures was introduced (Figure 8.3).

Implementation of these measures started in the spring of 2021. The focus of the initial work was the creation of new living and hibernation areas for beneficial insects such as predatory mites (Figure 8.2). As a first step, these structures were ‘inoculated’ in the spring of 2022 with predatory mites from viticulture. To determine the extent to which the promotion of beneficial organisms contributes to the biological control of spider mites, four hop gardens in Eichelberg were each divided in half — one part managed conventionally with acaricide and one part managed with beneficial insects instead of acaricide. The development of the spider mite infestation in these areas will be observed and investigated every year.

Figure 8.2: Planting of Parthenocissus quinquefolia*, a deciduous, woody, tendril-climbing vine commonly called Virginia creeper or woodbine, on anchor ropes in Eichelberg*

A further part of this project involves public relations. For this purpose, a 2.5 km long, circular public foot path entitled “Hops and Biodiversity” is currently under development in Eichelberg. It will have 16 explanatory information poster boards, each with a different topic, along the way. These include "The woodlark," "Untouched soil areas," "Spider mite control with beneficial insects," and "Myrmeleontidae,” predatory insect larvae that feed on ants and other insects (Figure 8.3). The text for these posters was created under the leadership of the IPZ 5e working group in cooperation with the AELF IN-PAF, the UNB district office, and the LBV. The final installation of the poster boards is planned for April 2023.

Figure 8.3: Draft of the information board about Myrmeleontidae on the “Hops and Biodiversity” trail in Eichelberg (in German only)

8.4 Development of techniques for deploying predatory mites

Sponsor: Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Hopfenökologie (IPZ 5e)
Bavarian State Research Center for Agriculture, Institute for Plant Production and Plant Breeding, AG Hop Ecology (IPZ 5e)

Financing: Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Hopfenökologie (IPZ 5e)
Bavarian State Research Center for Agriculture, Institute for Plant Production and Plant Breeding, AG Hop Ecology (IPZ 5e)

Project Management: Dr. F. Weihrauch

Team: Dr. I. Lusebrink, M. Obermaier, A. Baumgartner, M. Felsl, K. Lutz

Collaboration: Betrieb Blüml GbR, Dürnwind
Koppert Biological Systems

Duration: May 2021 to October 2023

Objective and background

The largest European producer of beneficial insects, Koppert Biological Systems in the Netherlands, is interested in a pilot project in the Hallertau for testing and improving techniques for the release of predatory mites in hops. The aim is the development of an uncomplicated application technique of predatory mites that can help in the control of the common spider mite *Tetranychus urticae*. In terms of costs and personnel requirements, any new technique should not differ significantly from existing acaricide applications. In the 2021 season, initial tests were carried out with a specially designed device, which is mounted on the rear of a tractor and designed to distribute predatory mites unto the hop plants via six blow tubes at three height levels. This construction, however, failed to deposit large amounts of the beneficial insects into the hops. Instead, it deposited it into the furrow. Therefore, a modified design was tested in 2022. It was used to treat freshly emerged hop plants very early in their vegetation period, at the beginning of May, once close to the ground using two blow tubes (Figure 8.4).

Figure 8.4: Modified construction of a device by Koppert for the early application of predatory mites close to the ground in hop gardens in Dürnwind on May 2, 2022

Based on experience by the Hop Research Center during many years of trials, a mixture of two predatory mites, *Neoseiulus californicus* and *Phytoseiulus persimilis*, was used, which proved to be effective once about 100,000 of such mites per ha were distributed. As a cheaper variant, a solo treatment with *P. persimilis* (80,000 mites/ha) was also tested for comparison with an untreated control. The control was a sprayed plot (with an application with Spirotetramat) of the test garden, as well as an application on bean leaves (application on May 31, 2023), which had particularly successful in all tests in past years.

In contrast to the previous year, the deployment date was delated until May 2, 2022. Because of the unseasonably cold weather in April, the hop plants were still very small at that time. The application of the predatory mites relied on sawdust as a carrier material deposited without losses straight on the rows of freshly sprouted plants (Figure 8.4).

Results in 2022

At the beginning of the growing season, the spider mite infestation was low and never exceeded 12 individuals or eggs per leaf. Only shortly before harvest time did the number of spider mites increase significantly, just as in the previous year. In the control, the number reached an average of 70 individuals per leaf. Differences among the test variants became discernible only starting in mid-August. As expected, the untreated control had the largest number of spider mites per leaf (Figure 8.5).

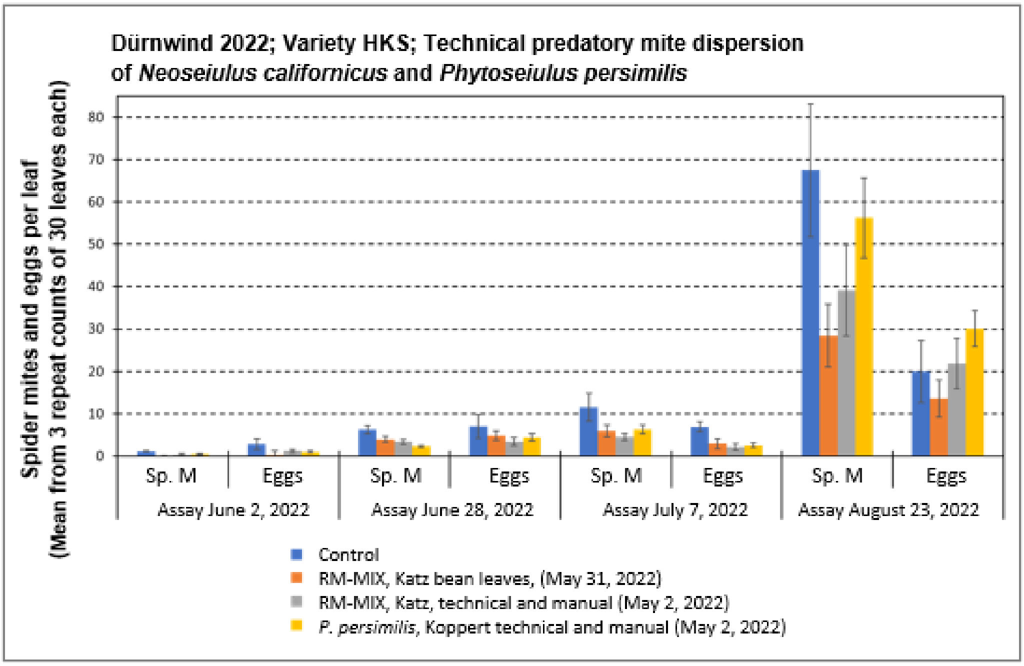


Figure 8.5: Development of the spider mite population with different distribution techniques for predatory mites in the Dürnwind test garden (avg. of all repeats per test plot)

On September 12, 2022, a trial harvest at the end of the season revealed differences in spider mite infestation between the variants by assessing the harvested plants (4 x 10 plants per test segment from one plot; Figure 8.6). Infestation levels are also reflected in the yield or alpha acid content of the crop. The untreated control showed the lowest amount of alpha acids. However, there were no significant difference between the control and plants treated with conventional crop protection measures against two of the predatory mite variants. The significantly better yield of the Koppert mix can also be attributed to small-scale soil differences (Figure 8.7). Regardless, the absence of acaricide applications can be ruled out as a cause of crop damage.

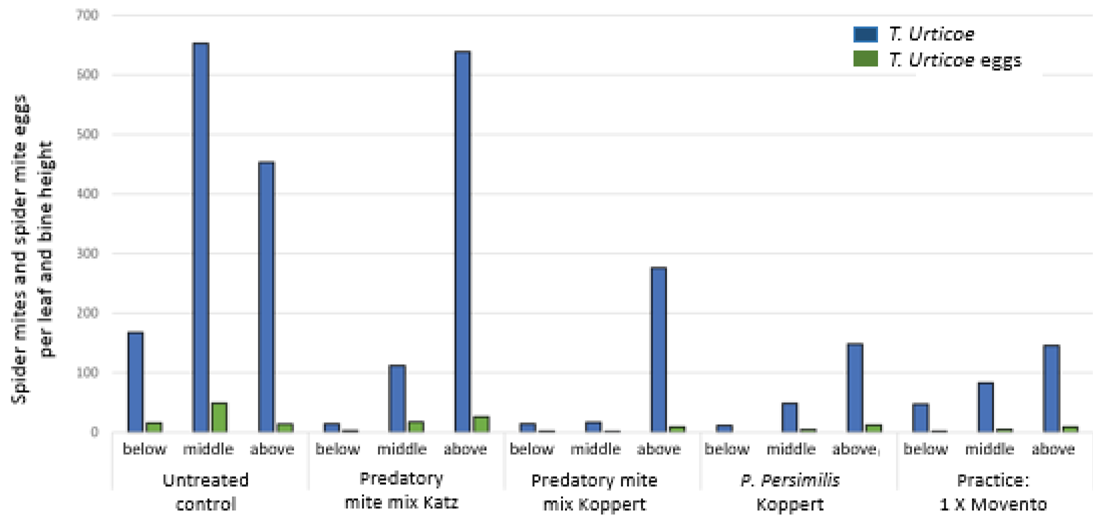


Figure 8.6: Pre-assessment of the plants harvested for the test on September 12, 2022 in Dürnwind. Variants: Untreated control, predatory mite mix from Katz on bean leaves, predatory mite mix from Koppert 1 × technical, P. persimilis *from Koppert 1 × technical, practice - 1 x Movento (Spirotetramat)*

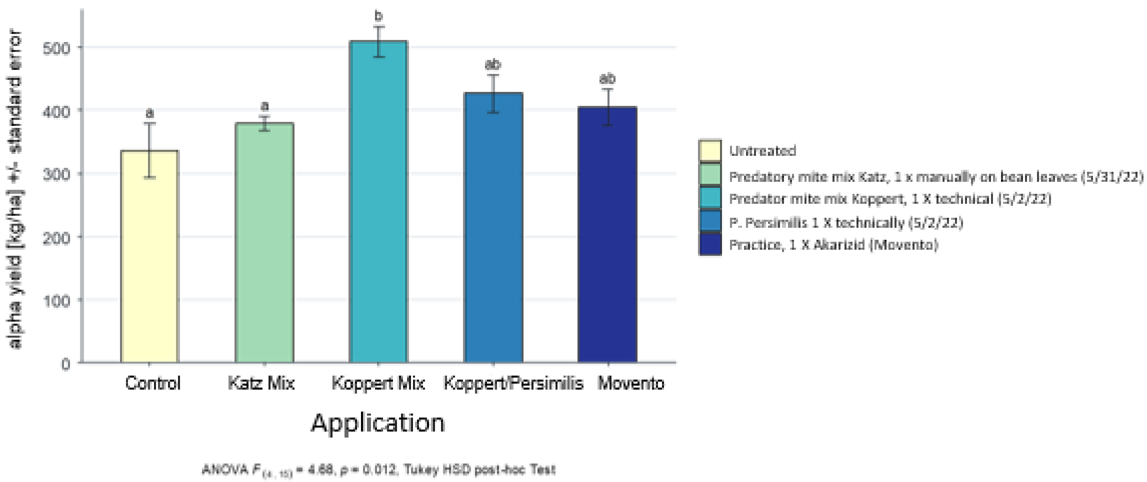


Figure 8.7: Determination of the yield of alpha acids in the test harvest of the predatory mite test on September 12, 2022 (one-factorial ANOVA)

Outlook

For any technical predatory mite application to be competitive with conventional spraying against spider mites, some improvements will still need to be made. In 2023, further trials in commercial plots are in the planning stage, one of them again in Dürnwind. At the very least, these tests thus far have shown that a suitable application of predatory mites can achieve results that are comparable with chemical plant protection.

8.5 Induced resistance to spider mites in hop production

Sponsor:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Hopfenökologie (IPZ 5e) *(Bavarian State Research Center for Agriculture, Institute for Plant Production and Plant Breeding, AG Hop Ecology (IPZ 5e)]*
Financing:	Deutsche Bundesstiftung Umwelt (DBU), Förderinitiative ‘Vermeidung und Verminderung von Pestiziden in der Umwelt’, Förderkennzeichen: AZ 35937/01-34/0) *(German Federal Foundation for the Environment (DBU), Funding initiative 'Avoidance and reduction of pesticides in the environment', funding reference: AZ 35937/01-34/0)*
Project Management:	Dr. F. Weihrauch
Team:	Dr. I. Lusebrink, M. Obermaier, A. Baumgartner, M. Felsl, S. Kaindl, K. Lutz, R. Obster
Collaboration:	20 farms with integrated hop production; Working group IPZ 5d, hop analysis
Duration:	June 2021 to May 2026

Background and Objectives

The common spider mite *Tetranychus urticae* is a polyphagous pest that affects around 90 crops in Germany, including hops. The damage they cause to hops is also referred to as "copper fire." Severely affected leaves dry up and turn gray or copper-brown and eventually fall off. In dry, hot summers, the spider mite can build up very large populations in a short time and then sometimes cause enormous losses in quality and yield.

Observations from various crop protection trials by the Hop Research Center over the last few years show that hop plants that have survived severe spider mite infestations are capable of defending themselves against excessive spider mite infestations in subsequent years. This project will investigate whether and to which extent a one- or two-year heavy common spider mite infestation of hop plants can reduce the susceptibility of the surviving plants to spider mites in subsequent years as a result of "induced resistance.”

Method

For this purpose, field trials were conducted in 31 test hop gardens were carried out with four hop varieties, Hallertauer Tradition (HTR), Spalt Select (SSE), Tettnanger (TET) and Herkules (HKS), (5-10 gardens per variety).

Each experimental garden is divided into two 500 m² plots (Figure 8.8), one of which serves as a control plot with spider mites that develop freely without the use of agents, and one treated at least once with acaricide or other agents to minimize the presence of spider mites as much as possible. In the center of both plots are monitoring areas for collecting leaves regularly from the lower, middle and upper bines during the growing season. These are rated for spider mites and their predators. If there is a sufficient level of infestation, the trial plots are harvested at the end of the season (one to three plots per variety of the most interesting gardens). Then, the yields per hectare, alpha acid contents, and weights, as well as the cone quality are examined for possible differences between the control and commercial plots. In 2022, all test gardens were rated four to five times and two test harvests per variety were carried out in the Hallertau and one in Tettnang.

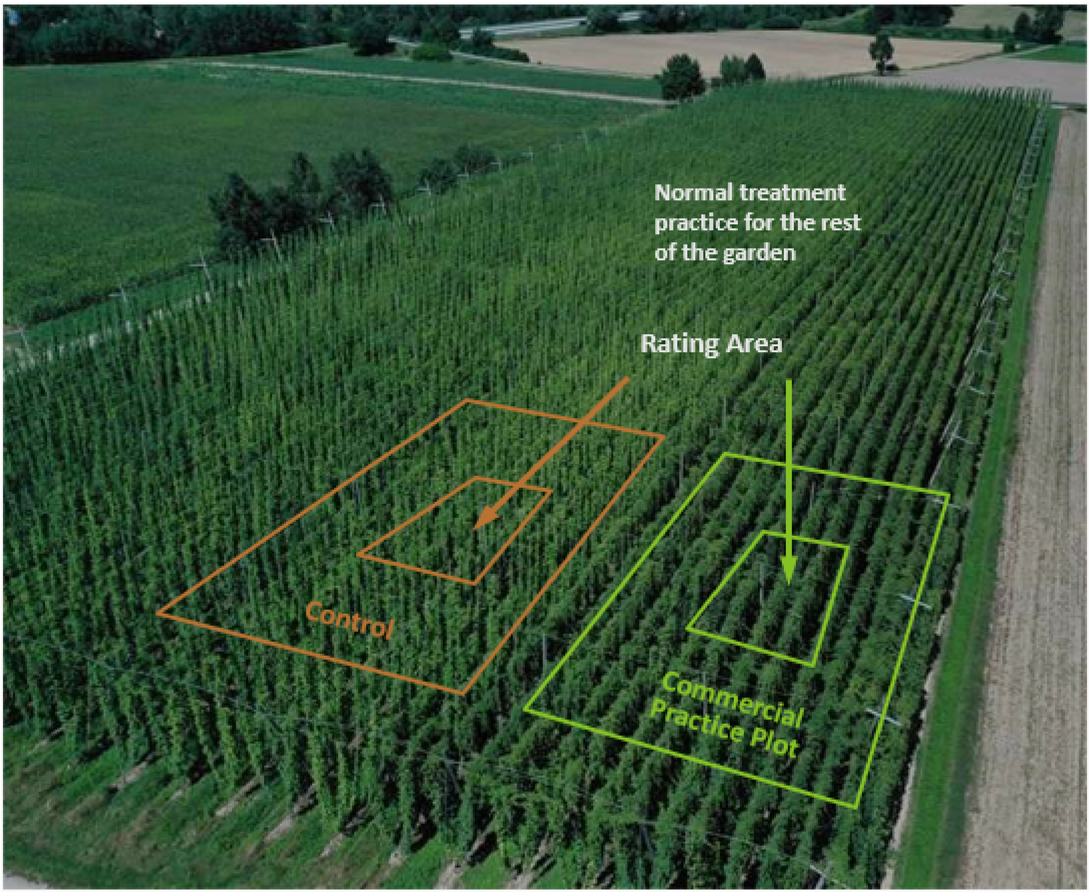


Figure 8.8: Field test setup: control plot (shown in copper) and commercial practice plot (green) with scoring area

Results

While there was little spider mite infestation in 2021, the first project year, because of the damp weather with only a few hot days in midsummer, 2022 was an ideal year for the spider mite because of the persistent drought and heat, when the pest was able to multiply quickly. It even reached an infestation index of around 4 by the end of the season in the control plots of the HKS test gardens (see table). Nevertheless, neither the yield per hectare nor the alpha acid content of HKS was affected by the heavy infestation. This was different in the HTR trial gardens which were less infected than the HKS plots, but the yield of the control plot was significantly lower than that of the commercial practice plot. The same was true with the two SSE experimental yards, whereby the second SSE test yard showed no adverse effects from spider mite infestation. There were also no differences between the control and commercial practice plots with Tettnang hops. Whenever there was a significant difference in alpha acid content, the control plots always had higher values because a spider mite infestation tends to promote alpha acid production. None of the plots were entirely free of spider mites with the result that the quality of the cones suffered from the strong spider mite pressure.

Table 8.1: Results of the trial harvests 2021 und 2022 (controls and regular commercial plots)

Year	Variety	Plot	**Infestation Index (BI) Mean per 30 leaves**										**Trial Harvest Results**					
			Rating 1†		**Rating 2**		**Rating 3**		**Rating 4**		**Rating 5**		**Yield** [dt/ha]		**Alpha acids** [%]		**Alpha yield** [kg/ha]	
			CW	BI	CW	BI	CW	BI	CW	BI	CW	BI	MW ± SF		**MW ± SF**		**MW ± SF**	
2021	HTR	Control	25	2.05	28	2.37	31	2.67	35	2.44	-	-	25.02 ± 2.25	n.s.	6.98 ± 0.11	n.s.	174.81 ± 16.69	n.s.
		Regular	25	1.40	28	0.90	31	0.20	35	0.43	-	-	24.32 ± 1.13		6.89 ± 0.06		167.65 ± 8.13	
	SSE	Control	25	0.05	28	0.30	30	0.73	36	1.53	-	-	17.20 ± 0.36	n.s.	6.50 ± 0.14	n.s.	**111.75 ± 3.50**	**
		Regular	25	0.10	28	0.40	30	0.20	36	0.62	-	-	13.67 ± 0.88		6.15 ± 0.26		83.82 ± 4.89	
	TET	Control	26	0.20	29	0.13	32	0.50	36	0.67	-	-	21.72 ± 1.30	n.s.	5.60 ± 0.11	n.s.	121.99 ± 9.48	n.s.
		Regular	26	0.50	29	0.40	32	0.53	36	0.90	-	-	21.32 ± 1.47		5.33 ± 0.15		113.80 ± 9.81	
	HKS	Control	25	0.15	28	0.27	30	0.60	37	2.60	-	-	31.09 ± 1.34	n.s.	20.76 ± 0.12	n.s.	645.90 ± 30.71	n.s.
		Regular	25	0.00	28	0.27	30	0.04	37	0.90	-	-	26.88 ± 2.24		20.73 ± 0.09		557.40 ± 46.74	
2022	HTR 1	Control	23	0.30	27	1.43	29	2.37	32	2.37	35	1.23	9.32 ± 0.27		6.74 ± 0.17	*	62.76 ± 1.38	
		Regular	23	0.25	27	0.83	29	0.97	32	0.23	35	0.77	**16.48 ± 0.61**	***	5.65 ± 0.33		**92.51 ± 2.84**	***
	HTR 2	Control	23	0.25	27	1.37	29	2.34	32	2.13	-	-	13.57 ± 0.78		**8.50 ± 0.14**	**	115.61 ± 8.38	
		Regular	23	0.15	27	1.17	29	1.27	32	1.60	-	-	**17.64 ± 0.17**	*	7.71 ± 0.15		135.97 ± 3.23	n.s.
	SSE 1	Control	24	0.00	27	0.63	29	1.07	32	1.30	36	2.50	7.65 ± 0.43		2.79 ± 0.28		21.42 ± 2.48	
		Regular	24	0.05	27	0.90	29	0.87	32	0.63	36	2.23	**9.95 ± 0.65**	*	3.07 ± 0.25	n.s.	**30.45 ± 2.62**	*
	SSE 2	Control	24	0.30	27	1.03	29	1.50	32	0.97	36	2.03	19.20 ± 1.13	n.s.	3.48 ± 0.19	n.s.	67.34 ± 7.32	n.s.
		Regular	24	0.15	27	0.27	29	0.53	32	0.00	36	0.13	16.82 ± 0.98		3.42 ± 0.12		57.32 ± 3.26	
	TET	Control	25	0.57	-	-	31	2.50	34	3.00	35	2.43	13.88 ± 2.64		**5.15 ± 0.06**	*	71.51 ± 13.67	
		Regular	25	1.07	-	-	31	2.27	34	2.43	35	1.53	16.06 ± 0.74	n.s.	4.69 ± 0.11		75.19 ± 3.57	n.s.
	HKS 1	Control	23	0.60	27	1.37	29	2.00	32	1.20	36	3.87	18.77 ± 1.23	n.s.	17.71 ± 0.19	n.s.	332.61 ± 21.14	n.s.
		Regular	23	0.80	27	1.13	29	0.80	32	0.23	36	1.07	17.17 ± 0.85		16.97 ± 0.42		291.38 ± 16.03	
	HKS 2	Control	24	0.60	27	0.73	29	0.87	32	1.73	36	4.13	30.16 ± 1.67		18.43 ± 0.16		555.12 ± 26.84	
		Regular	24	0.30	27	0.70	29	1.20	32	0.43	36	2.03	33.09 ± 0.92	n.s.	18.72 ± 0.25	n.s.	619.53 ± 20.23	n.s.

Abbreviations: KW = calendar week; MW = average value; SF = standard error: *** $p < 0.001$, ** $p < 0.01$, *$p < 0.05$; n.s. = not significant (*t*- Test or Wilcoxon test); †In assessment 1, leaves were only collected from the lower and middle bine height (mean value per 20 leaves); dt = German Dezitonne = 100 kg; ha = hectare.

9 Publications and Technical Information

9.1 Public relations overview

	Number		Number
Working group meetings	4	LfL-Publications	3
Education, training, and further education	3	Memberships	40
Attendance at seminars	1	Posters	4
Internal events	9	Internships	5
Seminars, symposiums, specialist conferences, workshops	9	Grower information events	3
Specialist information	6	Radio and TV broadcasts	3
Guided tours	29	Publications	36
Expert assessments and opinions	13	Lectures	110
Internet contributions	2	Workshops	1

9.2 Publications

9.2.1 Working group meetings

Date	Event	Location	Target Group
February 23, 2022	Meeting of the commodity Expert Group Minor Uses in Hops	Hüll and online	International crop protection specialists in hop growing: 'Commodity Expert Group Minor Uses in Hops'
March 3, 2022	Discussion: "Green Booklet Hops"	Online	Staff responsible for hops in federal states with hop cultivation
August 26, 2022	Internal test tour	Hüll, Stadelhof, Rohrbach	Hop breeding staff
October 24, 2022	Round table on hops	Wolnzach	Management of various hop organizations

9.2.2 Education, training, and further education

Date	Event	Location	Target Group
May 12, 2022	School day, vocational school Pfaffenhofen	Wolnzach-Hüll	Vocational students in Pfaffenhofen
July 14, 2022	School day, agricultural students PAF	Wolnzach-Hüll	Agricultural students in Pfaffenhofen
August 24, 2022	Test inspection, Spalt	Spalt	Breeders

9.2.3 Attendance at seminars, symposiums, expert conferences, workshops IPZ 2022

Date	Event	Place	Target Group
March 15, 2022	Expert discussion: PS hops	Online	Attendants from the federal government, states, and organizations dealing with PS in hops

9.2.4 Internal events

Date	Title	Place	Event Type
February 17, 2022	New developments/trends in hop kilning	Wolnzach	Online seminar
May 12, 2022	School day, vocational school, Pfaffenhofen	Wolnzach-Hüll	Education, training, further instruction
May 31 to June 1, 2022	G-Hop review	Hüll	Workshop
June 9, 2022	Energy savings in hop kilning	Wolnzach	Online seminar
June 24, 2022	Inauguration of the greenhouse in Hüll	Hüll	
June 26, 2022	Day: Open House Hüll	Hüll	
July 14, 2022	School day, agricultural students PAF	Wolnzach-Hüll	Education, training, further instruction
August 24, 2022	Test inspection Spalt	Spalt	Education, training, further instruction
August 26, 2022	Internal test tour	Hüll, Stadelhof, Rohrbach	Working group meeting

9.2.5 Seminars, symposiums, specialist conferences, workshops IPZ 2022

Date	Event	Place	Target Group
February 9, 2022	PS-technical discussion and exchange of information	Bruckbach	Employees of BayWa Group
February 11, 2022	PS-technical discussion and exchange of information	Online	Employees of the Beiselen company and the private land trade
February 16, 2022	Sampler training, certification	Online via webex	Assistants to the official samplers
February 17, 2022	Founding forum for the promotion of ecological Plant Breeding in Bavaria	Freising	Members of the Forum for the Promotion of Organic Plant Breeding in Bavaria Press
February 17, 2022	Conference re: 50% reduction in plant protection products	Online	Official advice

Date	Event	Place	Target Group
March 22, 2022	Forum for the promotion of ecological plant breeding in Bavaria	Freising und Online	Members of the forum for the promotion of ecological Plant Breeding in Bavaria
July 3, 2022 to July 7, 2022	Meeting of the Scientific and Technical Commission (WTK) of the International Hop Growing Bureau (IHB)	Lugo, Galicia, Spain	International hop research
October 27, 2022	Sixth session of the Forum for the Promotion of Ecological plant breeding in Bavaria	Freising	Value chain organic farming, breeding. agriculture, seed marketing, processing, consumption
Nov. 11, 2022	Advisory Board	Hüll	Hop and brewing industry

9.2.6 Technical Information

Citation
Obster, R., Euringer, S. Maier, J.; Portner, J.: 'Integrierter Pflanzenschutz' (Poster)
Obster, R., Euringer, S.; Kaindl, K.; Baumgartner, A.: 'Der Echte Mehltau im Hopfen' (Poster)
Obster, R., Euringer, S.; Kaindl, K.; Baumgartner, A.; Münsterer, J.: 'Peronospora im Hopfenbau' (Poster)
Portner, J., Stampfl, J.: 'Klimawandel und Hopfenanbau', Schafhof, 31.08.2022, Hopfenrundfahrt, VdH (Poster)
Portner, J.: 'Aktuelle Hopfenbauhinweise und Warndienstmeldungen' (Internet Contribution)
Portner, J.: 'Fortbildungsveranstaltungen der LfL; ' (Internet Contribution)

9.2.7 Guided tours (No. = number of participants)

Date	Name	Subject/Title	Guest(s)	No.
June 6, 2022		Festive inauguration of new test facilities at LfL location in Hüll	Inauguration of Vegetation Hall with Press and Minister of Agriculture	100
May 31, 2022	Euringer, S.	Hop Research Hüll	Doemens International	40
September 26, 2022	Euringer, S.	Hop Research Hüll	SumiAgro and Agro-Kanesho	10
July 28.2022	Euringer, S.; Lutz, A.; Kammhuber, K.; Weihrauch, F.	Hop Research Hüll	Lisa Badum and Leon Eckert, Members of Federal Parliament	4
August 4, 2022	Fuß, S.; Lutz, A.; Münsterer, J.	Production-related measures after hail damage Tango - the new Hüll aroma variety	LfL tour Kelheim	30

Date	Name	Subject/Title	Guest(s)	No.
		Saving energy in hop kilning		
August 2, 2022	Fuß, S.; Lutz, A.; Münsterer, J.	Production-related measures after hail damage Tango - the new Hüll aroma variety. Saving energy in hop kilning	LfL tour, young hop growers	60
September 14, 2022	Kammhuber, K.	Hop Research Center Hüll, Analytics and Assaying	Federal Office of Agriculture and Food (BLE), Mr. Betzold and Mr. Rebmann	2
August 8, 2022	Kammhuber, K.	Hop Research Center Hüll, Hop analytics	Professor Fujiwara Akiko Yoshinaga	2
September 28, 2022	Lutz, A.	Assessment of interesting breeding lines	New Clarus Brewing Company, Dan Carey	2
March 15, 2022	Lutz, A.	Guided tour of the Hüll Hop Research Center Cooperation	Hop Growing Cooperative Austria	3
August 29, 2022	Lutz, A.	Guided tour of the Hüll Hop Research Center	IGN Hop Quality Group	8
July 1, 2022	Lutz, A.	Guided tour of the Hüll Hop Research Center	Hop Producer Group HVG employees, Spalt	10
July 5, 2022	Lutz, A.	Guided tour of the Hüll Hop Research Center	Tams, Federal Plant Variety Office	1
April 19, 2022	Lutz, A.	Guided tour through the hop research center, beer tasting	Doemens Academy International Master Brewers	45
September 13, 2022	Lutz, A.	Guided tour through the hop research center Assessment of hop cones of interesting breeding lines and varieties	AB InBev	10
September 9, 2022	Lutz, A.	Guided tour through the hop research center, beer tasting	German Beer Academy	20
July 20, 2022	Lutz, A.	Guided tour through the hop research center, beer tasting	Women's Association Larsbach	25
October 18, 2022	Lutz, A.	Hop varieties, aroma rating	Schönram Brewery, Brewmaster	2

Date	Name	Subject/Title	Guest(s)	No.
May 12, 2022	Lutz, A.	Hop breeding	Berufsschüler der Landwirtschafts-schule Pfaffenh-ofen	20
May 31, 2022	Lutz, A.	Hop breeding and hop vari-eties for breweries	Doemens Academy brewmaster class	60
August 23, 2022	Lutz, A.	New breeding lines and va-rieties	BayWa Group	12
September 8, 2022	Lutz, A.	New breeding lines and va-rieties	Hop Producer Group HVG em-ployees	10
July 30, 2022	Lutz, A.; König, W.	Hop breeding Guided tour through the hop research center	AB InBev Brazil, Hop breeding	30
June 28, 2022	Lutz, A.; Kammhuber, K.	Guided tour through the hop research center	Brewery students at Technical Uni-versity Munich (TUM)	20
September 14, 2022	Lutz, A.; König, W.	Guided tour through the hop research center	Excursion as part of the Drinktec; BarthHaas Brew-ers Insight	30
October 10, 2022	Lutz, A.; Kneidl J.	Aroma assessment of dif-ferent strains and varieties	Raw materials ex-perts AB InBev	6
October 17, 2022	Lutz, A.; Portner, J.	Breeding and irrigation	Water Administra-tors	25
April 7 2022	Lutz, Anton	Use of different hop varie-ties in breweries; beer tast-ing	Schneider Weisse	3
October 5, 2022	Obster, R.	Hop research center	Nichino delega-tion	4

9.2.8 Expert appraisals and opinions

Date	Staff	Topic	Requested by …
Nov 11, 2022	Weihrauch, F.	Peer review	*Brewing Science* Magazine
Nov. 8, 2022	Satzger, W.; Weiß, J.; Dorfner, G.; Goßner; S.; Saller, J.; Reisenweber: J.; Toews-Mayr, G.; Ippenberger, B.; Gasteiger, R.; Schneider, N.; Münsterer, J.; Fuß, S.	Assessment of the economic situation - regular publication	LfL
Nov. 3, 2022	Obster, R.; Fuß, S.	Statement about growth anomalies caused by the use of Luna Sensation in hop growing	BAYER
October 14, 2022	Weihrauch, F.	Peer review	*Revista Brasileira de Entomología* Magazine
August 24, 2022	Fuß, S.	Official Hop Harvest estimate in the Hallertau growing region 2022	StMELF
July 21, 2022	Euringer, S.; Obster, R.	Opinion on Motion for Art. 53 Kiron	German Hop Growers Association
June 29, 2022	Doleschel, P.; Portner, J.; Lutz, A.; Weihrauch, F.	Answer to the written question from MP Paul Knoblach; hop themes	The Bavarian State Ministry for Food, Agriculture and Forestry (StMELF)
April 11, 2022	Euringer, S.; Obster, R.	Opinion on Motion for Art. 53 Luna Sensation	German Hop Growers Association
February 25, 2022	Weihrauch, F.	Statement about emergency application according to Article 53	Organic Food Production Alliance (BÖLW e.V.)
February 4, 2022	Portner, J.; Fuß, S.	Working hours in hop cultivation for the statutory agricultural accident insurance	Prof. Bahrs
February 3, 2022	Portner, J.; Lutz, A.; Doleschel, P.	Hops in climate change - Report on the situation of Bavarian hop farmers	The Bavarian State Ministry for Food, Agriculture and Forestry (StMELF)
February 1, 2022	Euringer, S.; Obster, R.	Opinion regarding Article 53 Exirel	German Hop Growers Association
January 27, 2022	Portner, J.	Supplementary statement on the report of the Expert Commission on Water Supply in Bavaria	The Bavarian State Ministry for Food, Agriculture and Forestry (StMELF)

9.2.9 Internet Contributions

Author	Title	Target Group
Portner, J.	Current hop growing instructions and warning service messages	Hop growers
Portner, J.	Training events of the LfL	Hop growers

9.2.10 Memberships

Member	Organization (Original names)	Organization (English)
Doleschel, P.	Bayerische Pflanzenzuchtgesellschaft	Bavarian Plant Breeding Society
	DLG e.V., Deutsche Landwirtschafts-Gesellschaft	DLG e.V., German Agricultural Society
	DLG-Ausschuss für Pflanzenzüchtung und Saatgutwesen	DLG Committee for Plant Breeding and Seed Science
	GIL, Gesellschaft für Informatik in der Land-, Forst- und Ernährungswirtschaft e.V.	GIL Society of Computer Science in Agriculture, Forestry and Food Science e.V.
	Gesellschaft für Hopfenforschung	Society for Hop Research
	Gesellschaft für Pflanzenbauwissenschaften e.V.	Society for Plant Cultivation Sciences, e.V.
	Gesellschaft für Pflanzenzüchtung	Society of Plant Breeding
	ISIP e.V. (Informationssystem Integrierte Pflanzenproduktion)	ISIP e.V. (Information System Integrated Plant Production)
	Kartoffelgesundheitsdienst Bayern e.V.	Potato Health Service Bavaria
	LKP	LKP
	Testgremium für Pflanzkartoffeln in Bayern	Test Team for Seed Potatoes in Bavaria
Euringer, S.	AG Pflanzengesundheit in Hopfen	AG Plant Health in Hops
	EU Commodity Expert Group Minor Uses Hops	EU Commodity Expert Group Minor Uses Hops
	Ring junger Hopfenpflanzer e.V.	Young Hop Growers e.V.
Fuß, S.	Prüfungsausschuss für den Ausbildungsberuf Landwirt am Fortbildungsamt Landshut	Board of Examiners for Qualified Agriculturalist at Landshut authority for continuing education
Kammhuber, K.	Arbeitsgruppe für Hopfenanalytik (AHA)	Hop Analytics Working Group (AHA)
	European Brewery Convention (Hopfen-Subkomitee) Analysen-Kommitee	European Brewery Convention (Hops Subcommittee), Analysis committee
	Gesellschaft Deutscher Chemiker (GDCH)	Society of German Chemists (GDCH)
Lutz, K.	Gesellschaft für Hopfenforschung, e.V.	Society for Hop Research, e.V.

Münsterer, J.	Prüfungsausschuss für den Ausbildungsberuf Landwirt am Fortbildungsamt Landshut	Board of Examiners for Qualified Agriculturalist at Landshut authority for continuing education
Portner, J.	AG Nachhaltigkeit im Hopfenbau	WG Sustainability in Hop Production
	EU Commodity Expert Group Minor Uses Hops	EU Commodity Expert Group Minor Uses Hops
	JKI - Fachbeirat Geräte-Anerkennungsverfahren zur Beurteilung von Pflanzenschutzgeräten	JKI Advisory Committee ─ equipment approval procedure for assessing plant production equipment
	Meisterprüfungsausschuss Regierung von Oberbayern für den Ausbildungsberuf Landwirt	Boards of Examiners Lower Bavaria, Upper Bavaria East, Upper Bavaria West, for Qualified Agriculturalist
Seigner, E.	Gesellschaft für Hopfenforschung, e.V.	Society for Hop Research, e.V.
	Gesellschaft für Pflanzenzüchtung, e.V.	The Society for Plant Breeding e.V. (GPZ)
Weihrauch, F.	Arbeitsgemeinschaft Bayerischer Entomologen e.V.	Working Group of Bavarian Entomologists
	British Dragonfly Society	British Dragonfly Society
	Deutsche Gesellschaft für allgemeine und angewandte Entomologie (DGaaE)	German Society for General and Applied Entomology (DGaaE)
	DGaaE, AK Neuropteren	DGaaE, AK Neuroptera
	DgaaE, AK Nutzarthropoden und Entomopathogene Nematoden	DGaaE, Study Group Beneficial Arthropods and Entomopathogenic Nematodes
	DPG, Deutsche Phytomedizinische Gesellschaft	DPG, German Phytomedicinal Society
	DgfO, Deutsche Gesellschaft für Orthopterologie	DGfO, German Society of Orthopterology
	EU Commodity Expert Group (CEG) Minor Uses in Hops	EU Commodity Expert Group (CEG) Minor Uses in Hops
	Gesellschaft deutschsprachiger Odonatologen e.V.	Society of German-speaking Odonatologists e.V.
	Gesellschaft für Hopfenforschung e.V.	Society for Hop Research, e.V.
	Münchner Entomologische Gesellschaft e.V.	Munich Entomological Society e.V.
	Rote Liste Arbeitsgruppe der Neuropteren Deutschlands	Red List Working Group Germany's Neuroptera
	Rote-Liste-Arbeitsgruppen der Libellen und Neuropteren Bayerns	Red List Working Groups Bavaria's Dragonflies and Neuroptera
	Chairman der Wissenschaftlich-Technische Kommission des Internationalen Hopfenbaubüros	Chairman of the Scientific and Technical Commission (WTK) of the International Hop Growers' Convention (IHB)
	Worldwide Dragonfly Society	Worldwide Dragonfly Society

9.2.11 LfL Publications

Name(s)	Working Group	LfL-Publication	Title
Working Group Hop	IPZ 5	LfL-Information	Jahresbericht 2021 – Specialty Crop Hop
Portner, J.	IPZ 5a	LfL-Information	Hopfen 2022 - Grünes Heft *(Green Pamphlet)*
Euringer, S.	IPZ 5b	LfL-Information	Hopfen 2022 - Grünes Heft *(Green Pamphlet)* Pflanzenschutz *(Plant Protection)*

9.2.12 Posters

Author(s)	Title	Event/Location	Organizer
Obster, R.	Integrated crop protection	Day of Open Door	LfL
Obster, R.	Powdery mildew in hops	Day of Open Door	LfL
Obster, R.	Downy mildew in hop growing	Day of Open Door	LfL
Portner, J.	Climate change and hop cultivation	Hop Tour, Schafhof	VdH

9.2.13 Internships

Date	Supervisor	Theme	Type
March 9, 2022 – February 3, 2023	Kammhuber, K.	Hop research	Student at Vocational High School Scheyern
November 7, 2022 – July 15, 2022	Euringer, S. (Lutz, K.; Lutz, A.)	Hop research	Student at Gymnasium Wolnzach
October 31, 2022 – April 11, 2022	Kammhuber, K.	Hop research	Student at Gymnasium Wolnzach
March 21, 2022 – July 29, 2022	Euringer, S. (Lutz, K.; Lutz, A.)	Hop research	Student at Vocational High School Scheyern
March 21, 2022 – July 29, 2022	Euringer, S.; (Lutz, K.; Lutz, A:)	Hop research	Student at Vocational High School Scheyern

9.2.14 Hop Grower Information Events

Date	Event	Place	Target Group
April 6, 2022	Round table on crop protection in organic hops	Hüll	Organic hop growers and consultants
February 17, 2022	LfL-Hop Grower Meeting	Online	Hop Growers
February 14, 2022	LfL-Hop Grower Meeting	Online	Hop Growers

9.2.15 Radio and TV

Broadcast Date	People	Title	Series	Channel
August 22, 2022	Doleschel, P.	Opportunities and potential of plant breeding for more climate and drought resistance	BR2/ARD Alpha Talk of the Day	BR

Broadcast Date	People	Title	Series	Channel
September 28, 2022	Lutz, A.; König W.	Get-together at the Hüll Hop Research Center Part 1	Miteinander (Together)	INTV
October 5, 2022	Lutz, A.; König, W.	Get-together in the Hop Research Center Part 2	Miteinander (Together)	INTV

9.2.16 Publications

Publications
Fuß, S. (2022): Pflanzenstandsbericht April 2022. Hopfen-Rundschau, 73. Jahrgang Ausgabe 05/2022, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 166
Fuß, S. (2022): Pflanzenstandsbericht August 2022. Hopfen-Rundschau, 73. Jahrgang Ausgabe 09/2022, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 326
Fuß, S. (2022): Pflanzenstandsbericht Juli 2022. Hopfen-Rundschau, 73. Jahrgang Ausgabe 08/2022, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 276 - 277
Fuß, S. (2022): Pflanzenstandsbericht Juni 2022. Hopfen-Rundschau, 73. Jahrgang Ausgabe 07/2022, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 234
Fuß, S. (2022): Pflanzenstandsbericht Mai 2022. Hopfen-Rundschau, 73. Jahrgang Ausgabe 06/2022, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 201
Gruppe, A., Potel, S.; Schmitz, O.; Tröger, E.-J.; Weihrauch, F.; Werno, A. (2022): Provisorische Rote Liste und Gesamtartenliste der Netzflüglerartigen (Kamelhalsfliegen, Schlammfliegen und Netzflügler im engeren Sinn oder Hafte; Neuropterida: Raphidioptera, Megaloptera, Neuroptera) Deutschlands. Naturschutz und Biologische Vielfalt, 70 (5), Rote Liste gefährdeter Tiere, Pflanzen u. Pilze Deutschlands, Band 5: Wirbellose Tiere (Teil 3), Hrsg.: Bundesamt für Naturschutz, 435 - 462
Kammhuber, K. (2022): Die Multifidole - Interessante Hopfeninhaltsstoffe, die zum Geschmack beitragen und wertvoll für die Gesundheit sind. Hopfenrundschau International, Jahresausgabe 2022/2023, Hopfenrundschau International, Hrsg.: Verband Deutscher Hopfenpflanzer, 22 - 26
Kammhuber, K. (2022): Ergebnisse von Kontroll- und Nachuntersuchungen für Alphaverträge der Ernte 2021. Hopfen-Rundschau, Rundschau 08 - 73. Jahrgang, Hopfen Rundschau, Hrsg.: Verband Deutscher Hopfenpflanzer, 284 - 287
Krönauer, C., Weiß, F. (2022): Bericht zum CBCVd-Monitoring 2022. Hopfen-Rundschau, 12/2022, 73. Jahrgang, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 445 - 446
Lutz, K. (2022): Forschungs- und Innovationsprojekt zur Verticillium-Welke im Hopfen. Hopfenrundschau International, 2022/2023, Hrsg.: Verband deutscher Hopfenpflanzer e.V., 140 - 142
Lutz, K. (2022): Gesundes Pflanzgut - ein wichtiger Baustein für einen erfolgreichen Hopfenanbau. Hopfenrundschau International, 2022/2023, Hrsg.: Verb. deutscher Hopfenpflanzer e.V., 138 - 139
Lutz, K. (2022): Welke-Sanierung und Zwischenfruchtanbau: Ein Widerspruch? Hopfen-Rundschau, 73. Jahrgang, 09/2022, Hrsg.: Verband deutscher Hopfenpflanzer e.V., 328 - 329
Lutz, K., Euringer, S. (2022): Sanieren lohnt sich! Hopfen-Rundschau, 73. Jahrgang, 04/2022, Hrsg.: Verband Deutscher Hopfenpflanzer e.V.
Münsterer, J. (2022): Optimierung der Hopfentrocknung durch den Einsatz von Wärmebildtechnik. Hopfenrundschau International, 2022/2023, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 68 - 71
Obermaier, M. (2022): Kann Hopfen einen pflanzeneigenen Schutz gegen die Gemeine Spinnmilbe aufbauen? BrauIndustrie, 107 (1), 16 - 19

Publications
Obster, R. (2022): Fehlaromen durch den Einsatz von Schwefelpräparaten zum Schutz des Hopfens gegen den Echten Mehltau. LfL-Kooperation. Jahresbericht Sonderkultur Hopfen, Hrsg.: Bayerische Landesanstalt für Landwirtschaft (LfL)
Obster, R. (2022): Pflanzenschutztagung. Hopfen-Rundschau
Obster, R., Baumgarnter, A.; Euringer, S. (2022): Erdbeeren als Zeigerpflanzen für den Echten Mehltau. Jahresbericht Sonderkultur Hopfen
Obster, R., Baumgarnter, A.; Euringer, S.; Kaindl, K. (2022): Tastversuch zur Bekämpfung der Gemeinen Spinnmilbe (Tetranychus urticae) bei frühem Befallsbeginn, Juni, Hopfen-Rundschau, 198 - 200
Obster, R., Euringer, S.; Fuß, S.; Kaindl, K. (2022): Hopfenputzen: Herbizideinsatz vermindern durch Essig? LfL-Kooperation. Jahresbericht Sonderkultur Hopfen, Hrsg.: Bayerische Landesanstalt für Landwirtschaft (LfL)
Obster, R., Euringer, S.; Kaindl, K. (2022): Monitoring der im FJ 2021 verstärkt aufgetreten Virosen. LfL-Kooperation. LfL-Jahresbericht Sonderkultur Hopfen, Hrsg.: Bayerische Landesanstalt für Landwirtschaft (LfL)
Obster, R., Euringer, S.; Stampfl, J. (2022): Pflanzenschutztagung. Hopfenrundschau International, 14 - 15
Portner, J. (2022): Bekämpfung von Peronospora-Sekundärinfektionen. Hopfen-Rundschau, 73. Jahrgang Ausgabe 06/2022, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 196
Portner, J. (2022): Kostenfreie Rücknahme von Pflanzenschutz-Verpackungen PAMIRA 2022. Hopfen-Rundschau, 73. Jahrgang Ausgabe 08/2022, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 288
Portner, J. (2022): Rebenhäckselausbringung im Herbst planen! Hopfen-Rundschau, 73. Jahrgang Ausgabe 08/2022, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 289
Portner, J. (2022): Rebenhäckseluntersuchung als zusätzliche Anforderung in den "Roten Gebieten"! Hopfen-Rundschau, 73. Jahrgang Ausgabe 08/2022, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 290
Portner, J. (2022): Zwischenfruchteinsaat im Hopfen planen. Hopfen-Rundschau, 73. Jahrgang Ausgabe 06/2022, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 197
Portner, J. (2022): Übermittlung von Angaben im Hopfensektor. Hopfen-Rundschau, 73. Jahrgang Ausgabe 05/2022, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 160 - 161
Portner, J., Brummer, A. (2022): Nmin-Untersuchung 2022 und endgültige Nmin-Werte in Bayern. Hopfen-Rundschau, 73. Jahrgang Ausgabe 05/2022, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 162 - 164
Weihrauch, F. (2022): Biodiversität - Hopfenbau und Förderung der Artenvielfalt: Passt das überhaupt zusammen? BrauIndustrie, 107 (8), Hrsg.: Verlag W. Sachon, 30 - 32
Weihrauch, F. (2022): Biodiversitätskulisse Eichelberg: Ökonomischer Hopfenbau und Biodiversität – passt das überhaupt zusammen? Hopfenrundschau International, 2022/2023, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 42 - 46
Weihrauch, F. (2022): Die Wissenschaftlich-Technische Kommission des Internationalen Hopfenbaubüros IHB traf sich im Juli 2022 in Lugo, Spanien. Hopfenrundschau International, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 62 - 64
Weihrauch, F. (2022): Internationales Hopfenbaubüro (IHB): Die IHB-Sortenliste wurde wieder aktualisiert. Hopfen-Rundschau, 73 (01), Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 14 - 23
Weihrauch, F. (2022): Kupferminimierung - Auf der Suche nach Alternativen zum Kupfereinsatz im ökologischen Hopfenbau. BrauIndustrie, 107 (4), 20 - 21

Publications
Weihrauch, F., Obermaier M.; Pillatzke J.; Eschweiler J. (2022): Evaluation of a technical solution for the application of predatory mites in hops. Proceedings of the Scientific-Technical Commission, IHGC, 2022, Lugo, Galicia, Spain, 03-07 July 2022, Hrsg.: Scientific-Technical Commission of the International Hop Growers' Convention, 26 - 29
Weihrauch, F., Obermaier, M. (2022): Systemic Acquired Resistance of hop plants against spider mites - a keystone of future plant protection in hops? Proceedings of the Scientific-Technical Commission, IHGC, 2022, Lugo, Galicia, Spain, 03-07 July 2022, Hrsg.: Scientific-Technical Commission of the International Hop Growers' Convention, 55 - 57

9.2.17 Lectures

Place/Date	Speakers	Subject/Title	Organizer	Target Group
Wolnzach/ online February 2, 2022	Doleschel, P.	Moderation of LfL hop grower meeting - Part 1	LfL	Hop growers
Wolnzach/ online February 17, 2022	Doleschel, P.	Moderation of LfL hop grower meeting - Part 2	LfL	Hop growers
March 17, 2022	Euringer, S.	Planters' Association Tettnang Spring Meeting	LTZ (Agriculture Technology Center)	Farmers
March 24, 2022	Euringer, S.	Technical Scientific Committee of the GfH	Gesellschaft für Hopfenforschung e.V. (GfH) *(Society for Hop Research, e.V.)*	Society for Hop Research Board of Directors
June 2, 2022	Euringer, S.	Discussion of plant protection reduction through breeding	LfL	LfL Employees
June 2, 2022	Euringer, S.	HVG Supervisory Board Meeting	HVG (Hop Sales Cooperative)	HVG Supervisory Board
June 21, 2022	Euringer, S.	JKI Plots of limited economic use (Lückenindikation)	Julius Kühn-Institute (JKI)	JKI Employees
Lugo, Galizien July 5, 2022	Euringer, S.	Leaf wall area in hops	International Hop Growers' Convention	International hop scientists
September 1, 2022	Euringer, S.	Leaf wall area	Hop Growers Association	Representatives from nat'l approval authorities, the int'l crop protection industry, and the German hop economy
September 1, 2022	Euringer, S.	Podium Discussion	Hop Growers Association	Representatives from nat'l approval

Place/Date	Speakers	Subject/Title	Organizer	Target Group
				authorities, the int’l crop protection industry, and the German hop economy
October 11, 2022	Euringer, S.	Plant Health and Disease Prevention	AELF Pfaffenhofen Centre of Expertise for Agroecology	Master class
December 7, 2022	Euringer, S.; Krönauer C.; Lutz, K.; Weiß, F.	HVG Board Meeting	Hopfenverwertungsgenossenschaft (HVG) *(Hop Sales Collaborative)*	Supervisory Board HVG
February 16, 2022	Euringer, S.; Obster, R.	DB Hops BW	LTZ (Agriculture Technology Center) Augustenberg	LTZ Employees
February 17, 2022	Euringer, S.; Weiß, F.	CBCVd updates	LfL	Farmers
March 9, 2022	Euringer, S.; Weiß, F.	Development of the LWA-model in hops	LfL	BASF
March 23, 2022	Euringer, S., Weiß, F.	Development of the LWA-model in hops	LfL	BAYER
Zalec April 12, 2022	Euringer, S.; Weiß, F.	CBCVd-Workshop Zalec	IHPS Slovenian Institute of Hop Research and Brewing	Scientists and students from Slovenia and Germany
April 21, 2022	Euringer, S.; Weiß, F.	Plant Health Working Group	LfL	Members and Advisors to AG Plant Health
October 11, 2022	Euringer, S.; Krönauer, C.; Weiß, F.	Meeting of the Plant Health working group	LfL	Members of the Plant Health Working Group
Online February 8, 2022	Euringer, S.; Lutz, K.	Field phytosanitation in hop gardens	Hop Growers Association Elbe-Saale	Hop growers from Elbe-Saale
January 18, 2022	Euringer, S.; Obster, R.	Plant protection discussion on hops with BASF	LfL	BASF employees
March 1, 2022	Euringer, S.; Obster, R.	Integrated crop protection in hop growing	Haus des Hopfens *(House of Hops)*	LKP Hop Ring Advisor
March 15, 2022	Euringer, S.; Obster, R.	Expert discussion on hops with the Federal Ministry of Food and Agriculture (BMEL)	Haus des Hopfens (*House of Hops*)	Employees of BMEL and Association of German Hop Growers

Place/Date	Speakers	Subject/Title	Organizer	Target Group
March 25, 2022	Euringer, S.; Obster, R.	PCA-damage in hops	Barth	Employees of Barth and Association of German hop growers
July 11, 2022	Euringer, S.; Obster, R.	Presentation of LWA BASF	LfL	BASF Employees
November 21, 2022	Euringer, S.; Obster, R.	Plant protection expert discussion Bundesinstitut für Risikobewertung (BfR; German Federal Risk Assessment Institute)	LfL	Employees of BfR and Association of German Hop Growers
March 14, 2022	Euringer, S.; Obster, R.; Kaindl, K.; Fuss, S.	Discussion about internal test syringe prototype	LfL	Employees of BfR and Association of German Hop Growers
January 19, 2022	Euringer, S.; Obster, R.; Weiß, F.; Lutz, K.	LWA in hop growing (internal)	LfL	Employees of BfR and Association of German Hop Growers
November 7, 2022	Euringer, S.; Obstler, R.	Crop Protection Discussion about hops with FMC	LfL	Employees of FMC Corp. and Association of German Hop Growers
Online, February 22, 2022	Fuß, S.	Basic seminar: "Irrigation"	LfL	Hop growers
Kollersdorf, August 8, 2022	Fuß, S.	Production-related measures after heavy hail damage	LfL	Hop growers; Young Hop Growers ring
Kollersdorf, August 8, 2022	Fuß, S.	Production-related measures after heavy hail damage	LfL	Hop growers in the district of Freising
Kollersdorf, August 4, 2022	Fuß, S.	Production-related measures after heavy hail damage	LfL	Hop growers VlF Kelheim
Wolnzach, March 24, 2022	Kammhuber, K.	The Multifidole – interesting, tasty hop compounds	Gesellschaft für Hopfenforschung e.V. (GfH) *(Society for Hop Research, e.V.)*	Brewers and hop specialists
Wolnzach, March 24, 2022	Kammhuber, K.; Portner, J.; Euringer, S.; Lutz, A.; Weihrauch, F.	Experimental and research activities of the Hops IPZ 5 working group	Gesellschaft für Hopfenforschung e.V. (GfH) *(Society for Hop Research, e.V.)*	Members of the Society for Hop Research, e.V.

Place/Date	Speakers	Subject/Title	Organizer	Target Group
Wolnzach-Hüll, November 24, 2022	Lusebrink, I.; Weihrauch. F.	Ecological questions of hop cultivation working group	Gesellschaft für Hopfenforschung e.V. (GfH) *(Society for Hop Research, e.V.)*	Board of the Society for Hop Research, e.V.
Wolnzach, February 14, 2022	Lutz, A.	New Hüll varieties for more sustainability	LfL	Hop growers
Stuttgart, February 16, 2022	Lutz, A.	New Hüll varieties for more sustainability	The Bavarian State Ministry for Food, Agricuture and Forestry (StMELF) Baden-Württemberg	Ministry of Food, Rural Areas and Consumer Protection Hop growers Tettnang
Hüll, March 17, 2022	Lutz, A.	Hüll hop varieties for more sustainability	HPV Tettnang	Hop Growers Association Tettnang
Wolnzach, March 24, 2022	Lutz, A.	Hop breeding for more sustainability	Gesellschaft für Hopfenforschung e.V. (GfH) *(Society for Hop Research, e.V.)*	Members of the Society for Hop Research, e.V.
Hüll, March 24, 2022	Lutz, A.	New Hüll hop varieties for more sustainability	Institut Romeis	Brewers
Hüll, April 18, 2022	Lutz, A.	Hop breeding for more sustainability	LfL	Prof. B. Sturm and team, Leibnitz Institute for Agricultural Engineering & Bioeconomy Prof. A. Büttner and team, Fraunhofer Institute IVV
Pfaffenhofen, June 22, 2022	Lutz, A.	Rating and results: Hop champion	German Hop Growers Association	Award winners and press representatives
Bendeleben bei Bad Frankenhausen, July 13, 2022	Lutz, A.	New Hüll varieties for more sustainability	HPV Elbe-Saale	Hop growers from the Elbe-Saale hop growing area
Eja, July 30, 2022	Lutz, A.	Hop breeding in times of climate change	Greens Members of Parliament	Policy Makers; PR staff
Hüll, August 17, 2022	Lutz, A.	Everything about the hop harvest	Hopfenring	ISO Companies
Freising, October 20, 2022	Lutz, A.	Hop research and hop breeding, aroma rating	Old Weihenstephaner Brewers Union	Brewing students
Hüll, March 8, 2022	Lutz, A.; König, W., Dr. Gastl, M.	Humulus Lupulus – How our beer has influenced hops	TUM; Bier und Brauhaus	Hobby brewers and beer enthusiasts

Place/Date	Speakers	Subject/Title	Organizer	Target Group
Lugo, Galizien, Spanien, July 6, 2022	Lutz, K.	Thermal Treatment of hop waste - bioassay by using eggplant a indicator plant	International Hop Growers' Convention	International hop scientists
Online, August 2, 2022	Lutz, K.	Thermal Treatment of hop waste	SIHB	Employees of the Slovenian Institute of Hop Research and Brewing
Niederlauterbach, January 24, 2022	Lutz, K.; Euringer, S.	Phytosanitary measures in hop gardens: *Verticillium* wilt	Interest group Niederlauterbach (IGN)	Members of the IGN regulars' table
Hüll, November 24, 2022	Lutz, K.; Euringer, S.	*Verticillium* Wilt in Hops	Gesellschaft für Hopfenforschung e.V. (GfH) *(Society for Hop Research, e.V.)*	Board of the Society for Hop Research, e.V.
Online, February 17, 2022	Münsterer, J.	New developments and trends in hop kilning and conditioning	LfL	Hop growers
Online, June 9, 2022	Münsterer, J.	Energy-efficient measures in hop kilning	LfL	Hop growers
Buch, August 2, 2022	Münsterer, J.	Energy savings in hop kilning, including heat recovery	LfL	Hop growers, Young Hop Growers Ring
Buch, August 4, 2022	Münsterer, J.	Energy savings in hop kilning, including heat recovery	LfL	Hop growers (Landkreis Freising)
Buch, August 4, 2022	Münsterer, J.	Energy savings in hop kilning, including heat recovery	LfL	Hop growers (VlF Kelheim)
Online-Veranstaltung, Februay 9, 2022	Obermaier, M., Weihrauch, F.	Induced resistance to spider mites in hops	Bioland e.V.	Organic hop farms, expert advisers in ecological farming
Hüll, Wolnzach, May 12, 2022	Obster, R.	Integrated crop protection in hop growing	LfL	Vocational students at Pfaffenhofen
Hüll, December 12, 2022	Obster, R., Baumgartner, A.; Euringer, S.; Kaindl, K.	Presentation of test results for the 2022 season	LfL	Farmers
Wolnzach, December 14, 2022	Obster, R., Baumgartner, A.; Euringer, S.; Kaindl, K.	Presentation of test results 2022	LfL	LfL Hop Employees
December 19, 2022	Obster, R., Baumgartner, A.; Euringer, S.; Kaindl, K.	Presentation of test results 2022	LfL	Working Group members

Place/Date	Speakers	Subject/Title	Organizer	Target Group
November 29, 2022	Obster, R., Baumgartner, A.; Kaindl, K; Krönauer, Ch.; Lutz, K.; Euringer, S.; Weiß, F.;	News from the working group IPZ 5b	LfL	Working Group members
February 11, 2022	Obster, R.; Euringer, S.	Crop protection specialist talks to Beiselen	Beiselen	Land trade
June 21, 2022	Obster, R.; Euringer, S.	Chemical control at the top of the pyramid	AELF Pfaffenhofen *(Center of Excellence, Agroecology)*	Master class hops
Straßhof, Schweitenkirchen, September 1, 2022	Obster, R.; Euringer, S.	Current crop protection problems and perspectives in hop cultivation	Hop Growers Association	Well-known representatives of national approval authorities and of the int‘l crop protection industry; participants in the German hop economy
Poperinge, November 8, 2022	Obster, R.; Euringer, S.	Results of the trials in 2022	CEG	Commodity Expert Groups (CEG)
December 12, 2022	Obster, R.; Euringer, S.	Presentation of test results	LfL	Crop protection companies
December 13, 2022	Obster, R.; Euringer, S.	Presentation of test results	LfL	Crop protection companies
November 28, 2022	Obster, R.; Euringer, S.; Fuß, S; Kaindl, K.	Presentation of test results	LfL	Crop protection companies
Online, February 17, 2022	Obster, R.; Euringer, S.; Kaindl, K.; Baumgartner A.	Approval status of crop protection products in 2022	LfL – Hop growers meeting online	Hop growers
Poperinge, November 8, 2022	Obster, R.; Euringer, S.; Lutz, K.; Weiß, F.	Adopting Leaf Wall Area in Hops	CEG	Commodity Expert Groups (CEG)
Pfaffenhofen, October 11, 2022	Obster, R.; Euringer, S; Fuß, S.	What should be considered when selecting/planning pesticides?	AELF Pfaffenhofen *(Center of Excellence, Agroecology)*	Master Class

Place/Date	Speakers	Subject/Title	Organizer	Target Group
January 12, 2022	Obster, R.; Euringer, S.	Plant protection discussion re hops, with SumiAgro	VdH	Employees of SumiAgro
January 19, 2022	Obster, R.; Euringer, S.	Plant protection discussion re hops with FMC	VdH	Employees of FMC
January 20, 2022	Obster, R.; Euringer, S.	Plant protection discussion re hops with BAYER	VdH	Employees of BAYER
January 26, 2022	Obster, R.; Euringer, S.	Plant protection discussion re: hops with Syngenta	VdH	Employees of Syngenta
February 9, 2022	Obster, R.; Euringer, S.	Approval status of crop protection products in 2022	BayWa	Land trade
Digital, February 11, 2022	Obster, R.; Euringer, S.	Aapproval status of crop protection products in 2022	LfL	Warehouses
March 1, 2022	Obster, R.; Euringer, S.	Internal test coordination	LfL	Working Group members
May 12, 2022	Obster, R.; Euringer, S.	Plant protection in hop growing	AELF Pfaffenhofen *(Center of Excellence, Agroecology)*	Vocational students, hops
Wolnzach, March 24, 2022	Portner, J.	Projects and tasks of the hop production technology working group	Gesellschaft für Hopfenforschung e.V. (GfH) *(Society for Hop Research, e.V.)*	Membes and guests of the Society for Hop Research, e.V.
Hüll, April 8, 2022	Portner, J.	Discussion of common research goals for hops	LfL	Representatives from Fraunhofer and Leibniz Institute
Wolnzach, June 2, 2022	Portner, J.	Grant applications for hop research projects	Hop Producer Group (HVG)	Members, Management Board and Supervisory Board of HVG
Aiglsbach, June 8, 2022	Portner, J.	Project presentation "Alpha studies"	Hop Growers Association Hallertau	Advisory Board of the Hallertau Hop Growers' Association
Moosburg a. d. Isar, September 15, 2022	Portner, J.	Expert critique hops	City of Moosburg a. d. Isar	Award winners and guests
Braunschweig, September 28, 2022	Portner, J.	Application safety in crop protection in hops	BVL	Experts from companies, associations,

Place/Date	Speakers	Subject/Title	Organizer	Target Group
				organizations and authorities related to application safety in plant protection
Grub, November 10, 2022	Portner, J.	Climate change and special crops - hops, irrigation ,and more	LfL	Agency management of the AELF and Section 6 of the governments
Hüll, November 28, 2022	Portner, J.	Projects and trials of IPZ 5a 2022 and Outlook 2023	LfL	Employees of IPZ 5
Hüll, November 28, 2022	Portner, J.	Strategy process LfL 2023 - goals and schedule	LfL	Employees of IPZ 5
Wolnzach, December 7, 2022	Portner, J.	Grant application of hop research projects	Hop Producer Group (HVG)	Members of the Management Board and Supervisory Board of HVG
Hüll, December 8, 2022	Portner, J.	Projects and Trials 2022 and Outlook 2023	LfL	Members of the working group "Hops Management"
Wolnzach, March 24, 2022	Portner, J.; Schlagenhaufer, A.	Results from the research projects on nitrogen dynamics, bine chaff	Gesellschaft für Hopfenforschung e.V. (GfH) *(Society for Hop Research, e.V.)*	Members of the GfH Technical Scientific Working Committee
Online, February 23, 2022	Schlagen-haufer, A.; Fuß, S.	Hop cultivation seminar: Effective fertilizer management as part of the current Fertiizer Ordonance	LfL	Hop growers
Online-Tagung, February 9, 2022	Weihrauch. F.; Obermaier, M.	Current projects of Working group IPZ 5e "Ecological issues in hop growing"	Bioland e.V.	Organic hop farms, expert advisers in ecological farming
Wolnzach, March 24, 2022	Weihrauch. F.	Induced resistance to spider mites in hop cultivation	Gesellschaft für Hopfenforschung e.V. (GfH) *(Society for Hop Research, e.V.)*	Technical-scientific committee of the GfH
Lugo, Galizien, Spanien, July 4, 2022	Weihrauch, F.; Obermaier M.; Pillatzke J.; Eschweiler J.	Evaluation of a technical solution for the application of predatory mites in hops	International Hop Growers' Convention	International hop scientists

Place/Date	Speakers	Subject/Title	Organizer	Target Group
Lugo, Galizien, Spanien, July 5, 2022	Weihrauch. F.; Obermaier, M.	Systemic Acquired Resistance of hop plants against spider mites - a keystone of future plant protection in hops?	International Hop Growers' Convention	International hop scientists
Prag, July 26, 2022	Weihrauch. F.	Report on the 2022 Meeting of the Scientific-Technical Commission in Lugo, Galicia, Spain	International Hop Growing Office (IHB)	International hop industry: planters, trade, science
Prag, July 28, 2022	Weihrauch. F.	Brief report of the Scientific-Technical Commission, I.H.G.C.	International Hop Growing Office (IHB)	International hop industry; growers, trade, scientists
Eichelberg, 18.08.2022	Weihrauch. F.	Biodiversity in harmony with hop growing: The concept of 'biodiversity backdrop Eichelberg'	Interest Group: Quality hops Niederlauterbach (IGN)	Hop growers, brewers, assn. staff, trade press
Mainburg, October 20, 2022	Weihrauch. F.	Hop growing: Risk more ecology	Bund Naturschutz, KG Kelheim	Interested citizens, hop farms
Online-Tagung, November 17, 2022	Weihrauch. F.	Copper monitoring in Germany: Hop cultivation	Julius Kühn-Institut (JKI) and Federal Organic Farming Programme (BÖLW)	Scientists, consultants, representatives from the field of organic farming
Aiglsbach, November 29, 2022	Weihrauch. F.	Predatory mites in hops – an important aspect in future crop protection?	Hopfenring e.V	Hop growers, Hopfenring consultants, hop trade
Hüll, June 21, 2022	Weiß, F.; Euringer, S.; Lutz, K.	*Verticillium* and CBCVd in hop growing	AELF PAF	Master Class, hops
Online, February 3, 3033	Weiß, F.; Lutz, K.	Spectral analysis of hops	LfL	Employees of GeoConcept
November 29, 2022	Weiß, F.; Lutz, K., Euringer, S.	Smart farming hops	BayWa AG *(BayWa Group)*	BayWa Hops and Smart Farming Dept.
Hüll, June 29, 2022	Weiß, F.; Lutz, K.; Euringer, S	Training of the AELF and IPS on *Verticillium* and CBCVd	LfL	Inspectors AELF Plant Passport IPS 4c
Hüll, June 30, 2022	Weiß, F.; Lutz, K.; Euringer, S.	1st day of preparation for CBCVd monitoring	LfL	Temp. workers CBCVd monitoring
Hüll, July 1, 2022	Weiß, F.; Lutz, K.; Euringer, S.	2nd day of preparation for CBCVd monitoring	LfL	Temp. workers CBCVd monitoring; buyers

9.2.18 Workshops

Date	Event	Place	Target Group
May 31, 2022 to June 1, 2022	G-hop review	Hüll	Breeding

10 Our Team

The staff working for the State Institute for Agriculture - Institute for Plant Production and Plant Breeding - Hüll / Wolnzach / Freising, in 2022 (AG = working group):

IPZ 5

Coordinator: Director, LfL, Dr. Peter Doleschel

Alexandra Hertwig
Birgit Krenauer

IPZ 5a

AG Hopfenbau, Produktionstechnik

(*Hop Cultivation, Production Technology*)

Managing Director: LD Johann Portner

Elke Fischer
LAR Stefan Fuß
LAR Jakob Münsterer
B.Sc. Andreas Schlagenhaufer

IPZ 5b

AG Pflanzenschutz im Hopfenbau

(*Plant Protection in Hop Cultivation*)

Head: Simon Euringer

Anna Baumgartner
Maria Felsl
Korbinian Kaindl
Christina Krönauer (since July 1, 2022)
Kathrin Lutz
Marlene Mühlbauer
Regina Obster
Johann Weiher
Florian Weiß

IPZ 5c

AG Züchtungsforschung Hopfen

(*Hop Breeding Research*)

Acting Head: LR Anton Lutz

Brigitte Brummer
LTA Renate Enders
CTA Brigitte Forster
CTA Petra Hager
LTA Brigitte Haugg
Maximilian Heindl (until October 31, 2022)
Agr.-Techn. Daniel Ismann
LTA Jutta Kneidl

Katja Merkl
Sonja Ostermeier
Ursula Pflügl
Andreas Roßmeier
Maximilian Schleibinger

IPZ 5d

AG Hopfenqualität und -analytik

(*Hop Quality and Analytics*)

Head: Bureau Director (RD) Dr. Klaus Kammhuber

Sandra Beck (chemical laboratory)
MTLA Magdalena Hainzlmaier
CL Evi Neuhof-Buckl
CTA Silvia Weihrauch
CTA Birgit Wyschkon

IPZ 5e

AG Ökologische Fragen des Hopfenbaus

(*Ecological Issues in Hop Cultivation*)

Head: Dipl.-Biol. Dr. Florian Weihrauch

Dr. Inka Lusebrink (since August 1, 2022)

M.Sc. Maria Obermaier