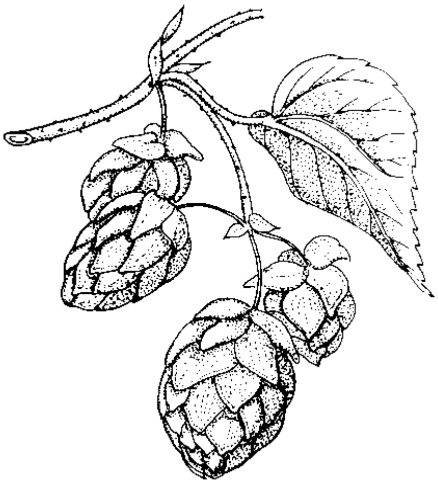
Bayerische Landesanstalt für Landwirtschaft

Gesellschaft für Hopfenforschung e.V.

Annual Report 2014

Special Crop: Hops



Bavarian State Research Center for Agriculture

- Institute for Crop Science and Plant Breeding -

and

Society of Hop Research e.V.

March 2015

LfL-Information

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Edited by:	Institut für Pflanzenbau und Pflanzenzüchtung, Arbeitsbereich Hopfen *(Institute for Crop Science and Plant Breeding, Hops Dept.)* Hüll 5 1/3, 85283 Wolnzach E-mail: Hopfenforschungszentrum@LfL.bayern.de Tel.: +49 84 42/92 57-0
Translated by:	J. Pockrandt (B.Sc.) and M. Eisenberger (B.A. Hons.)
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Foreword

Hops are agricultural products and hop growers face fiercer global competition for the most favourable production conditions than almost any other producer of agricultural products. Prices are set by the market and not by producers. Against this background, it is still, and always has been, essential to have a cutting edge in scientific and production expertise. The hop research performed by the Bavarian State Research Center for Agriculture (LfL) on behalf of the German hop industry guarantees this leading edge. To perform its tasks, it is dependent on significant investments on the part of the state. In return, hop growers remain in a position to react to the demands made by market shifts, climate change, pest range and agricultural regulations. The Hallertau in particular, a self-contained hop-growing area in Bavaria where hops have a considerable economic impact on the entire region, benefits greatly from this situation.

Issues such as automated hop picking, cover-crop management, optimisation of drip irrigation, development of energy-efficient strategies in hop drying, promotion of integrated plant protection, monitoring and forecasting of diseases and pests, establishment of beneficial organisms, neutral testing of plant protective products, minimisation of plant protective dose rates, special cross-breeding with landrace varieties, complex processes in resistance breeding, research programmes on old and new diseases, the use of meristem cultures for eliminating viruses from plant material, monitoring of value-determining components during harvesting, harvesting-time experiments and enhancement of quality analyses could never be addressed if hop research were performed on a purely private basis.

This report will provide you with information on all of these issues and many more. Our research findings are passed on to the experts as quickly as possible via publications, advisory-service documentation, seminars and lectures. The close professional contacts between the staff of the Hop Research Centre and brewers, hop processors, the hop trade and hop growers make the effective and targeted conduct of research projects and practical implementation of their results possible.

The success of hop research stems from the bundling of state and private interests and sharing of interdisciplinary know-how. Hop research has played a major role in preserving the competitiveness of the German hop-growing regions and, given public support, will continue to do so. This is guaranteed by a motivated team of scientists, engineers and experts, whom we would like to thank for their commitment along with all those who support hop research, from research funding organisations, through professional associations and the producer group, to hop growers.

Dr. Michael Möller
Chairman of the Managing Committee
of the Society of Hop Research

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

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1 Research projects and main research areas of the Hops Department

1.1 Current research projects

Development and optimisation of an automatic hop-picking machine (ID: 5381)

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung and Institut für Landtechnik und Tierhaltung *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding and Institute for Agricultural Engineering and Animal Husbandry)*
Financed by:	Bundesanstalt für Landwirtschaft und Ernährung (BLE) *(Federal Agency for Agriculture and Food)*
Project manager:	J. Portner
Project staff:	IPZ 5 and Drs. G. Fröhlich and Z. Gobor from ILT *(Institute for Agricultural Engineering and Animal Husbandry)*
Cooperation:	Fuß Maschinenbau GmbH & Co. KG, Schkölen
Duration:	01.09.2011 – 31.10.2014

Objective

The aim is to automate attachment of the hop bines to the intake arm of the picking machine and thus manage without the largely foreign seasonal workers currently employed for picking purposes without compromising picking quality.

To this end, the stack of 6-7 metre-long hop bines brought in from the field is cut into 0.8-1 metre-long pieces in a cutting machine. A metering device feeds the bine segments uniformly to a newly designed picker comprising three belt pickers arranged in tandem. Any cones remaining on small bunches and bine segments are stripped off in lateral pickers. The harvested hop cones are cleaned in the usual manner.

Results

Various configurations for the future cutting device were tested during the 2011 hop harvest, and preliminary hop picking was filmed with a high-speed camera. The findings were incorporated in the development and design of an automatic hop-picker prototype. In 2012, construction of the prototype was commenced and initial picking trials were performed. Construction of the complete prototype, together with the cleaning unit, was completed in time for the 2013 harvest. In initial trials, the picking quality of the pre-cut bines was compared with that achieved by conventional hop-picking, where the bines are attached manually to the picker intake arm.

Further optimisation measures and tests on the quality of the pre-cut bines were conducted in 2014. Our ILT colleagues also developed and tested a strategy for measuring the stack of hop bines with suitable sensors in order to optimise feed rates and hop-picker efficiency.
More information will be contained in the final report to be completed in April, which will be available on the internet as of May.

Optimisation of drip irrigation in hop growing (ID:4273)

Sponsored by: Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, *(Bavarian Sate Research Center for Agriculture, Institute for Crop Science and Plant Breeding)*

Financed by: Dt. Bundesstiftung Umwelt (DBU) and Erzeugergemeinschaft HVG e.G. *(HVG hop producer group)*

Project manager: Dr. M. Beck

Project staff: T. Graf

Cooperation: Dr. M. Beck, Weihenstephan-Triesdorf University of Applied Sciences
Prof. Urs Schmidhalter, Technical University of Munich/Weihenstephan

Duration: 01.12.2011 – 30.11.2014, extended until 31.12.2015

Objective

Hop yields fluctuate strongly from year to year depending on the weather, making it difficult to satisfy the brewing industry’s need for reliable supplies. For this reason, irrigation systems have so far been established on approx. 15 % of the acreage under hop. While the limiting factor here is water availability, questions have also arisen concerning the extent to which hop irrigation is economically worthwhile and ecologically compatible. The aim of the project is to develop a hop-irrigation management system with which hop yields can be stabilised using scarce water resources and taking economic aspects into account.

The major field-related issues requiring clarification are:

- Drip-hose positioning
- Ideal irrigation time and water volumes
- Irrigation control algorithms

Material and methods

Since the maximum volume of irrigation water supplied in 2012 and 2013 on the basis of an objective control system was only 664 m^3/ha (66 mm), the parameters “water volume” and “irrigation time” were modified in 2014 for the AB150 variant. The aim here was to supply more than 1000 m^3/ha (=100 mm) irrigation water, to which end commencement of irrigation was determined on the basis of a pre-defined water volume and not, as before, as a function of soil moisture (cf. Tab. 1.1).

Tab. 1.1: Irrigation volumes and rainfall in mm

➢		➢ **Sandy soil** ➢ **(Karpfenstein)**	➢ **Clay soil** ➢ **(Attenhofen)**
➢ **Irrigation volume (mm)**	➢ **150 AB**	➢ 144	➢ 139
	➢ **300 AB**	➢ 17	➢ 35
	➢ **600 AB**	➢ 18	➢ 44
	➢ **NB**	➢ 17	➢ 36
	➢ **ZB**	➢ 17	➢ 38
➢ **Natural precipitation (mm)** (1st June – 15th September)		➢ 308	➢ 262

The pre-defined volume was based, among other things, on note swapping with hop farmers, who considered this to be the minimum volume required to produce a positive effect on yield. The numerous trials conducted to date, however, have not yet pointed to such an effect.

Results

Fig. 1.1 shows the averaged hop yields, with standard deviations, at the Karpfenstein sandy-soil location. No statistically significant differences in yields or alpha-acid contents were detected between the six variants (tested by ANOVA, F_{yield}: 0.725, p_{yield} = 0.61, F_{α}: 0.712, p_{α} = 0.62).

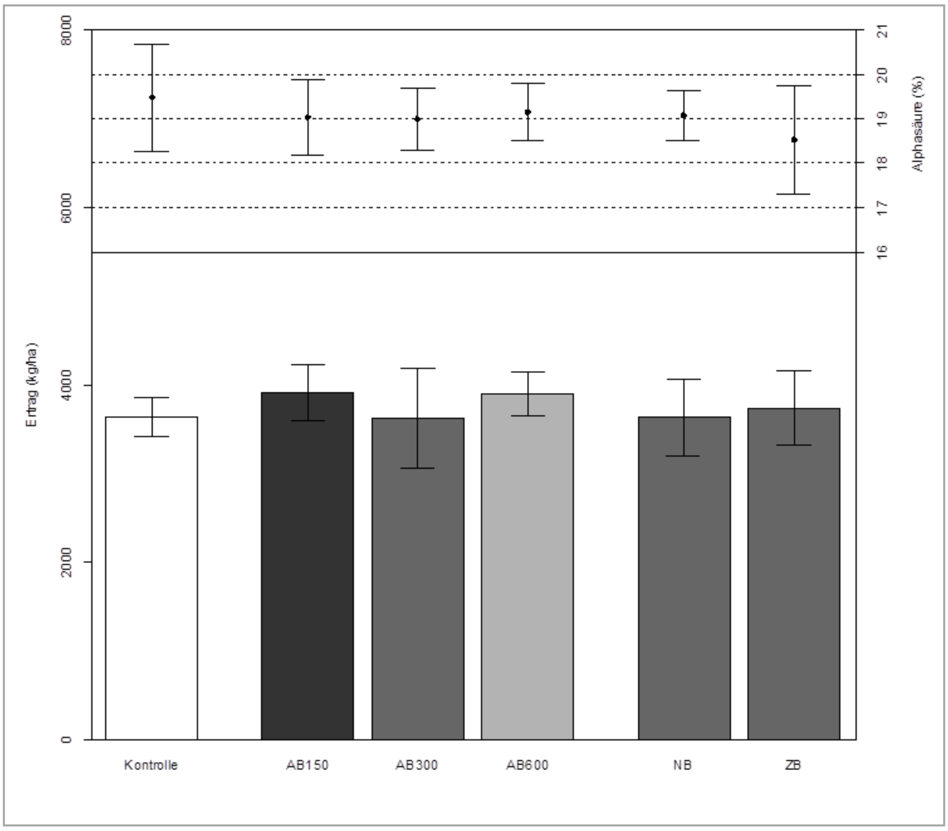

Fig. 1.1: Yield (kg/ha) and α-acid content (%) at the clay-soil location for the various irrigation strategies (control = no irrigation, AB = drip hose on top of the hilled row at soil moisture tensions of 150, 300 and 600 hPa), NB = drip hose buried beside the hilled row, ZB = drip hose buried in the middle of the tractor aisle; NB and ZB were irrigated simultaneously with the AB300 variant); n=6. Neither yields nor α-acid contents showed any significant differences in the ANOVA test (F_{yield}:0.725; p_{yield} = 0.61; F_{α}: 0.712; p_{α} = 0.62).

Fig. 1.2 shows the average hop yields, with standard deviations, and the alpha-acid contents for the six variants at the clay-soil location. Variant AB 600 produced the highest yield. This variant differed statistically in yield (ANOVA and Bonferroni-Holm *posthoc* tests) from the NB and ZB variants, the significance levels being p = 0.03 und p = 0.01, respectively. No significant difference (p = 0.04) in alpha-acid content was detected between the AB150 variant (mean content 19.8 % ± 0.7 %) and the ZB variant (mean content 18.2 % ± 1.3 %).

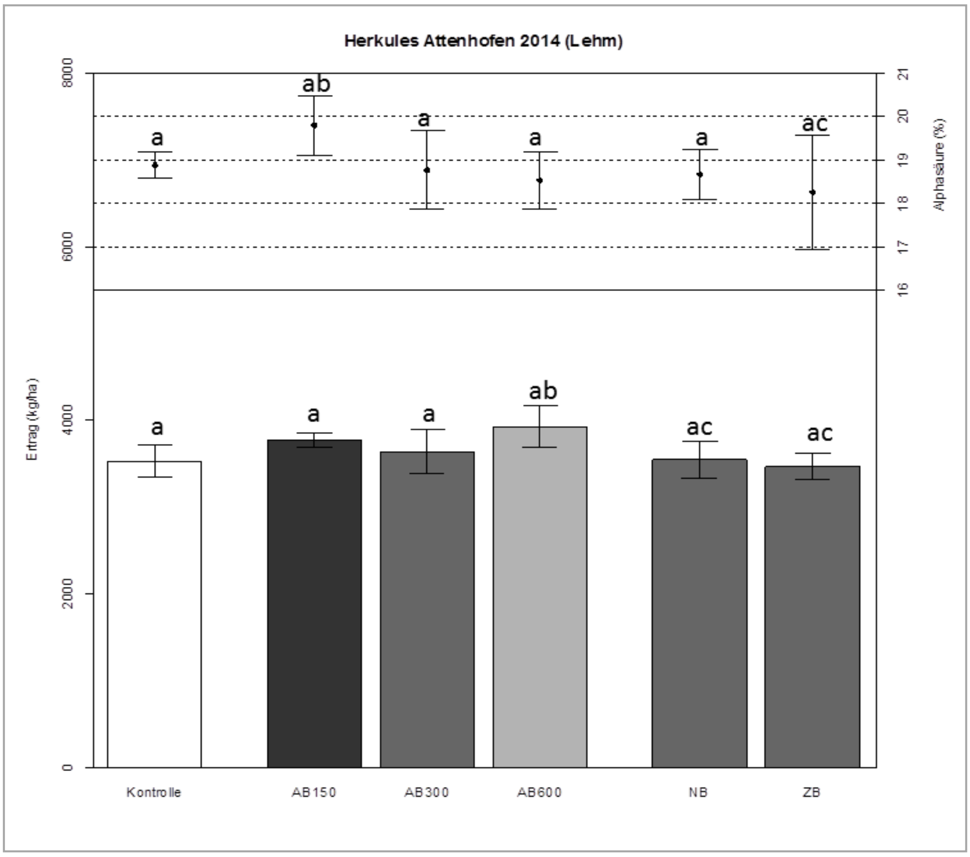

*Fig. 1.2: Yield (kg/ha) and alpha-acid content (%) at the Attenhofen clay-soil location for the various irrigation strategies (control = no irrigation, AB = drip hose on top of the hilled row, with irrigation commencing at soil moisture tensions of 150, 300 and 600 hPa), NB = drip hose buried beside the hilled row, ZB = drip hose buried in the middle of the tractor aisle; NB and ZB were irrigated simultaneously with the AB300 variant); n=6. AB300 and AB600 are based on only five repetitions (n=5) as one plot was excluded in each case due to extremely poor plant growth. Both hop yields and α-acid contents showed significant differences in the ANOVA test (F_{Yield}: 4.215; p_{Yield} = 0.006**; F_{α}: 2.486; p_{α} = 0.05*). The posthoc test with Bonferroni-Holm correction showed significant differences in yield between the AB600 variant and the NB and ZB variants (p = 0.03 and 0.01). AB150 and ZB differed in alpha-acid contents (p = 0.04). No significant differences were detected compared with the non-irrigated control plot.*

Despite the increased volumes of water supplied to the AB150 variants, no statistically significant differences were detected compared with the non-irrigated control plot on account of adequate rainfall (308 mm in Karpfenstein and 262 mm in Attenhofen) during the vegetation period.

Model project: “Demonstration Farms Integrated Plant Protection”, sub-project: “Hop Growing in Bavaria” (ID 5108)

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, *(Bavarian Sate Research Center for Agriculture, Institute for Crop Science and Plant Breeding)*
Financed by:	Bundesministerium für Ernährung und Landwirtschaft (BMEL) über die Bundesanstalt für Landwirtschaft und Ernährung (BLE), *(Federal Ministry of Food and Agriculture (BMEL) and managed by the Federal Institute for Food and Agriculture (BLE))*
Project Manager:	J. Portner
Project staff:	M. Lutz
Cooperation:	Julius Kühn Institute (JKI) Zentralstelle der Länder für EDV-gestützte Entscheidungshilfen und Programme im Pflanzenschutz (ZEPP) 5 demonstration farms (with hop cultivation) in the Hallertau district
Duration:	01.03.2014 – 31.12.2016

Objective

As part of Germany’s National Action Plan for sustainable use of plant protection products, the nation-wide model project “Demonstration Farms Integrated Plant Protection” has been extended to include hop cultivation. In 2014, a “Sub-Project: Hop Growing in Bavaria” was set up in the Hallertau district.

The aim is to minimise the use of chemical plant protection products in hop growing by means of regular crop inspections and intensive consultation. This will involve observing the principles of integrated plant protection and giving preference to the use of non-chemical plant protection measures wherever such measures are available and practicable.

Method

Three demonstration plots, each averaging 1-2 ha in area, were selected on each of five conventional hop farms in the Hallertau district (locations: Geibenstetten, Buch, Einthal, Dietrichsdorf and Mießling). The selected cultivars are HA, HE, HM, HS, HT, PE and SR. Each plot was assessed weekly during the vegetation period and the exact levels of disease and pest infestation determined. During assessment, infection levels in the peripheral areas were measured separately, as well. The staff member in charge of the project based her control recommendations on thresholds, forecasting models and warnings issued by the warning service. Preference was given to the use of non-chemical treatments if these were available as possible alternatives to chemical plant protection products. The assessment data, the time taken to obtain it and the plant protection measures implemented were recorded in a special app or in programs and were sent to the Julius Kühn Institute (JKI) for evaluation.

The following non-chemical measures were implemented in an effort to reduce the use of plant protective products: sensors were used at early development stages in order to target sprays more accurately and prevent spray losses during row treatment. Trico animal repellent, which is based on sheep fat, was used to prevent damage by deer.

The hop plants were stripped by treating them with fertiliser solutions and removing the leaves mechanically by hand or by using defoliation equipment ("garden vac").

To protect against two-spotted spider mites, bines were defoliated manually and given a coating of glue. With some cultivars, the weeds on the hilled rows were removed using defoliation equipment. Couch grass around the outermost poles was dug up manually.

Results

Trico was visibly effective in stopping deer damage. The lower part of plants growing on areas where a "garden vac" had been used for stripping required additional chemical treatment. Manual defoliation required many more man hours/ha than all alternative defoliation methods. Chemical treatment against spider mites was unnecessary in the plot sections where plants had received a coating of glue. As a result of the additional edge-area assessments, spider-mite treatment was more targeted, thus reducing the consumption of plant protection product. The intensive mildew assessments enabled regular identification of numerous infected areas. However, this, in turn, also led to numerous treatments. Some of the hilled rows where weeds had been removed mechanically required subsequent chemical treatment.

No conclusions can be drawn as yet concerning possible savings in plant protection agents.

Release and establishment of predatory-mites for sustainable spider-mite control in hop farming

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Pflanzenschutz Hopfen, *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Plant Protection)*
Financed by:	Bundesanstalt für Landwirtschaft und Ernährung (BLE) *(Federal Agency for Agriculture and Food,* Bundesprogramm Ökologischer Landbau und andere Formen nachhaltiger Landwirtschaft (BÖLN)
Project manager:	Dr. F. Weihrauch
Project staff:	M. Jereb, J. Schwarz, M. Felsl, A. Baumgartner
Duration:	01.05.2013 - 30.04.2016

Objective

Currently, there are no effective plant protection agents for combating the two-spotted spider mite *Tetranychus urticae* available to organic hop farmers, and the distribution of predatory mites is the only promising alternative. Sustained spider-mite control by established predatory-mite populations (as is sometimes practised in Germany in wine or fruit growing, for example) is not possible in hop fields because the aerial parts of the hop plants, and with them potential overwintering shelters, are completely removed during harvesting. The aim of this project is to create suitable overwintering sites by sowing cover crops in the tractor aisles and thus permitting the establishment, over several vegetation periods, of a steady predatory-mite population. Tall fescue grass (*Festuca arundinaceae*), stinging nettle (*Urtica dioica*) and small-flowered quickweed (*Galinsoga parviflora*) were tested for their suitability as undersown ground cover.

In addition, it is planned to optimise the use of laboratory-bred predatory mites in terms of numbers released and timing of their release, and to develop a standard method of application that provides an effective and economically viable alternative to acaricide use.

Method and results

Section 6.2, pages 62-68, contains a detailed report.

Minimising the use of copper-containing plant protection agents in organic and integrated hop farming

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Pflanzenschutz Hopfen *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Plant Protection)*
Financed by:	Erzeugergemeinschaft Hopfen HVG e.G. *(HVG hop producer group)*
Project manager:	Dr. F. Weihrauch
Project staff:	J. Schwarz, D. Ismann, G. Meyr, J. Weiher
Cooperation:	Pichlmaier's Naturland farm, Haushausen
Duration:	01.03.2014 - 28.02.2017

Objective

According to the German Federal Environment Agency, as one of the organisations that have assessed the toxicological effects of copper-containing plant protectives on the environment and users, the use of these products should be discontinued. At this juncture, however, organic farmers of practically all crops cannot manage without this active agent. The aim of this four-year, 2010-2013 experimental project, which was set up by Germany's BLE (Federal Agency for Agriculture and Food) and managed via the BÖLN programme, was thus to test the extent to which the amount of copper used per season in hop growing can be reduced without affecting crop yields and the quality of the harvested hops. The intention was to reduce the currently permitted copper dose rate of 4.0 kg/ha/year by at least 25 %, to 3.0 kg/ha/year. In the wake of the successful conclusion of this project, the current follow-up project aims to look closely at the 3.0 kg Cu/ha/year level reached to date and, as far as possible, to investigate the effects of a further reduction in the use of copper.

Results

The results of the BÖLN project were re-confirmed in 2014, with hop downy mildew being controlled effectively in a number of cultivars with 3.0 kg Cu/ha/year. The results obtained after reducing the dose rate still further, to 2 kg/ha, were not all acceptable, and where only 1 kg/ha pure copper was used, the level of effectiveness was significantly less in one cultivar, nearly 50% of whose cones were infected by harvesting time. What was remarkable, however, was the pronounced improvement in effectiveness obtained by combining the 1 kg/ha trial variant with liquorice extract. By harvesting time, the level of effectiveness matched that of the 2 kg/ha variant. By contrast, 72.5% of the cones were infected by harvesting time in the case of a completely copper-free variant, where Biocin F plant tonic was used instead – the same level as for the untreated control variant.

Click-beetle monitoring in Hallertau hop yards with the help of pheromone traps

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Pflanzenschutz Hopfen *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Plant Protection)*
Financed by:	Self-financed; Syngenta Agro GmbH, Maintal
Project manager:	Dr. F. Weihrauch
Project staff:	Dr. F. Weihrauch, J. Schwarz, M. Jereb
Cooperation:	JKI Braunschweig, Syngenta Agro GmbH, Maintal
Duration:	03/2010-12/2014

Objective

The soil pests commonly referred to as wireworms are in fact the larvae of click beetles (Elateridae). Wireworms have apparently been causing more and more damage to hops (especially young plants) over the last few years. The actual biology of this pest is, admittedly, still largely unknown and insight gained so far into the period of larval development, for instance, stems solely from studies conducted several decades ago on the striped click beetle, *Agriotes lineatus*. Other species, however, have much shorter periods of larval development, which must naturally be taken into consideration if measures to combat this pest are to be effective. The actual range of click beetles currently found in hops has not been ascertained to date.

Within the framework of a multi-year, nation-wide joint project aimed at remedying this situation, adult click-beetle monitoring commenced in the Hallertau in 2010. In 2014, the fifth and last project year, the number of beetles caught in pheromone traps in two conventional hop yards at Steinbach (Kehlheim district, 475 m a.s.l., soil: sandy clay) and at Hagertshausen (Pfaffenhofen district, 450 m a.s.l., soil: sandy clay) was compared. In Steinbach, soil traps for wireworms were positioned in a hilled row where apparent wireworm damage had been observed in 2013. The traps were baited with germinating wheat grains and emptied at fortnightly intervals.

Results

Over a 15-week period in 2013 (April 17th – July 31st), a total of 432 adult beetles (nine species, six of them *Agriotes* species) were caught in the pheromone traps (Hagertshausen: 108 beetles, Steinbach: 324 beetles). The striped click beetle, *A. lineatus*, was the main species at Steinbach, making up some 40% of the catch. It was followed by the common click beetle, *A. sputator* (25 %), and *A. ustulatus* (just under 20%). *A. sputator* predominated at Hagertshausen (29%), followed by the dusky click beetle, *A. obscurus*, (25 %) and *A. acuminatus* (19 %).

Cross breeding with the Tettnanger landrace

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtungsforschung Hopfen und AG Hopfenqualität/Hopfenanalytik
	(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Breeding Research and WG Hop Quality/Hop Analytics
Financed by:	Ministry of Rural Affairs and Consumer Protection, Baden-Württemberg
	Tettnang Hop Growers' Association; Erzeugergemeinschaft Hopfen HVG e.G. *(HVG hop producer group)*
	Gesellschaft für Hopfenforschung e.V., (Society of Hop Research)
Project managers:	Dr. E. Seigner, A. Lutz
Project staff:	A. Lutz, J. Kneidl, D. Ismann and breeding team (all from IPZ 5c)
	Dr. K. Kammhuber, C. Petzina, B. Wyschkon, M. Hainzlmaier and S. Weihrauch (all from IPZ 5d)
Cooperation:	Straß hop experimental station of the LTZ (Augustenberg Center for Agricultural Technology) in Baden-Württemberg, F. Wöllhaf
Duration:	01.05.2011 - 31.12.2016

Objective

The aim of this breeding project, commenced in 2011, is to develop a cultivar with the typical Tettnanger landrace aroma, or at least a traditionally fine aroma similar to that of the Tettnanger, but with significantly improved yields and fungal resistance compared with the original Tettnanger. Since this objective cannot be achieved purely by selective breeding within the naturally occurring variability of the Tettnanger landrace, an attempt must be made to achieve it via targeted cross-breeding of Tettnanger with pre-selected male hops. The male breeding lines stem from crosses with fine, traditional-type aroma lines bred in Hüll. The father plants were selected additionally on the basis of broad disease resistance and, thanks to their pedigree, were intended to contribute good agronomic performance.

Results

730 pre-selected female seedlings obtained from 18 targeted crosses performed since 2010 between the Tettnanger landrace and male hop plants stemming from Hüll aroma-breeding projects were planted out in the Hüll breeding yard for seedling assessment. Thanks to good growth conditions in the 2014 season, cones from 22 seedlings were harvested and their contents chemically analysed (EBC 7.7; cf. Tab. 1.2)

Tab. 1.2: 2014 yields

Cross	α-acids (%)[1]	β-acids (%)[1]	cohumulone (%)[2]	xanthohumol (%)[1]
Tettnanger	3.5	4.3	23	0. 32
2011/024	3.5 – 4.1	5.9 – 7.4	22 - 24	0.34 – 0.35
2011/025	5.3 – 7.8	7.2 – 8.2	20 - 22	0.48 – 0.60
2012/025	8.2 – 9.1	4.1 – 4.6	24 - 26	0.43 – 0.45
2012/026	5.1 – 7.1	4.0 – 6.1	15 - 27	0.41 – 0.47
2012/027	5.1	6.7	17	0.27
2012/029*	3.5 – 8.4	8.5 – 10.2	19 - 20	0.37 – 0.52
2012/031	5.4 – 7.2	3.8 – 5.3	27 - 34	0.35 – 0.42
2013/044	9.0	4.5	21	0.38
2013/045*	4.0 – 9.0	4.5 – 8.9	22 - 29	0.33 – 0.57
2013/047	6.3	4.6	22	0.27

[1]in % (w/w); [2]relative, in % of alpha-acids *A descendant of this cross was selected for the *Stammesprüfung*.

Two breeding lines were selected from the seedlings bred in 2012 and 2013 for the next selection stage, known as the *Stammesprüfung*. The positive assessment of these seedlings is based on their resistance and agronomic properties and on their components, which are ultimately responsible for the fine, hoppy and spicy aroma. During the *Stammesprüfung*, scheduled to begin in spring/autumn 2015, the two lines will be cultivated and assessed in replicate for four years at two Hallertau locations and in the hop yard at the Straß experimental station in Tettnang.

Outlook

From the breeders' point of view, the 4-year *Stammesprüfung* as of 2015 is the start of an initial major project phase. Much more reliable estimations of yield, aroma, bitter content and resistance to diseases and pests will then be possible because breeding-line potential can be measured under different soil and weather conditions.

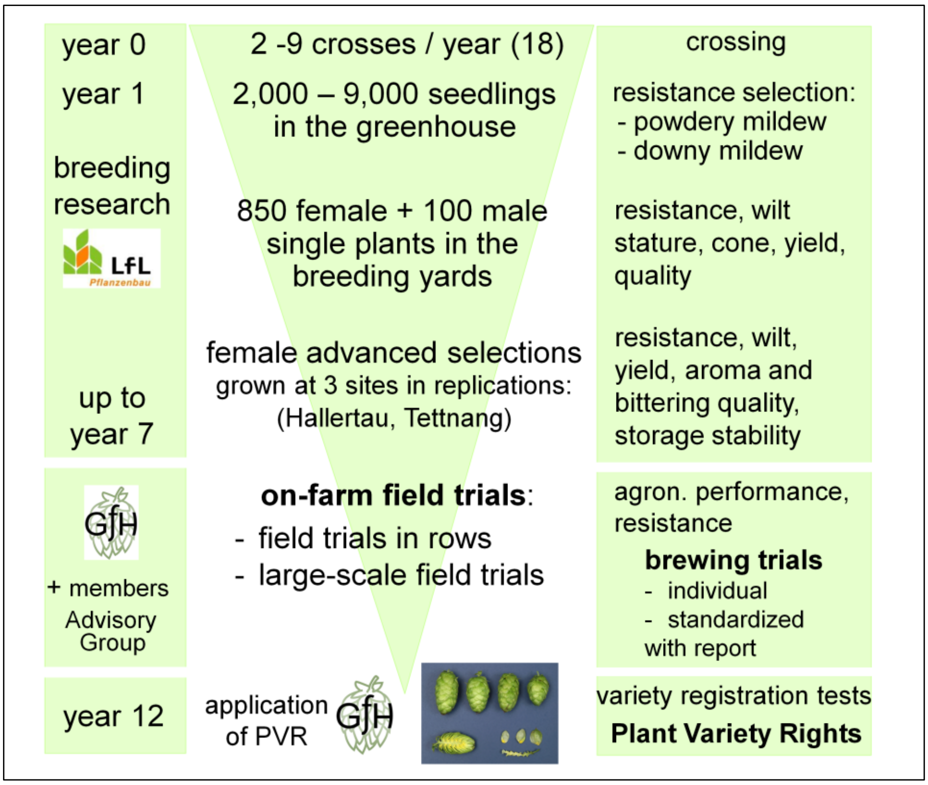

Fig. 1.3: Overview of the various stages in the development of a new cultivar similar to Tettnanger

It is evident from Fig. 1.3 that even after the Stammesprüfung stage has been reached, it will be a number of years before the first line stemming from this breeding project has undergone field-scale testing (in-line and large-area trial plantings) and is available as a possible GfH candidate for a new variety release.

PM isolates and their use in breeding PM-resistant hops

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtungsforschung Hopfen *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Breeding Research)* Financed by: Gesellschaft für Hopfenforschung e.V. (2013 - 2014) *(Society of Hop Research)* Erzeugergemeinschaft Hopfen HVG e.G. (2015 - 2016) *(HVG hop producer group)*
Project managers:	Dr. E. Seigner, A. Lutz
Project staff:	A. Lutz, J. Kneidl S. Hasyn (EpiLogic)
Cooperation:	Dr. F. Felsenstein, EpiLogic GmbH, Agrarbiologische Forschung und Beratung, Freising
Duration:	01.01.2013 – 31.12.2016

Objective

PM isolates with characteristic virulence properties have been used for PM resistance-testing in the greenhouse and lab since 2000. Together with the constantly optimised testing systems in the greenhouse and the lab, they enable the breeding of hop cultivars that guarantee optimum brewing and food quality along with reliable supplies even in years marked by high infestation levels.

Results

In 2014, eleven previously characterised single-spore isolates of *Podosphaera macularis*, the fungus that causes powdery mildew in hops, were used within the context of the following issues or investigations:

- **PM isolates – maintenance and characterisation of virulence:** As every year, the virulence situation of all PM isolates was verified in February prior to commencement of the tests. To this end, a selection of eleven hop varieties carrying all the hitherto-known resistance genes was used to differentiate between the virulence properties. This measure provides certainty that, even years after their cultivation, none of the isolates available for testing have lost any of their virulence genes via mutation. The virulence properties of PM populations new to the hop-growing region and the greenhouse were also investigated in this way.
- **PM-resistance testing in the greenhouse:** All the seedlings (approx. 220,000) from 97 crosses performed in 2013 were inoculated artificially in the greenhouse, under standardised infection conditions, with three PM isolates carrying all the virulence properties widespread throughout the Hallertau region of Bavaria. This enabled us to monitor a large number of seedlings and clarify the extent to which they show resistance properties essential for cultivation in the Hallertau. Only seedlings classified as PM-resistant were transferred to the vegetation hall for further selection.
- **PM-resistance testing in the laboratory by detached-leaf assay:** In addition, breeding lines, cultivars and wild hops assessed in the greenhouse as resistant were re-assessed by EpiLogic in laboratory leaf tests. The leaves were inoculated with an English PM isolate (R2 resistance gene) and an isolate of regional importance from the Hallertauer growing region. Only breeding lines and cultivars found in both tests (greenhouse and detached leaf test) to show broad resistance to powdery mildew were used for further selection purposes.
- **Assessment of the virulence situation in the hop-growing region and leaf-test evaluation of resistance sources:** The virulence genes of the current PM populations in German hop-growing areas are determined every year. In 2014, the reaction of 11 cultivars and wild hops from what is known as the set of differential varieties (i.e. varieties carrying all resistance genes known in the world to date) to all currently available PM isolates was tested, thus making it possible to judge whether existing resistances in today's cultivars are still fully effective (as in the case of Hallertauer Merkur) or effective only in specific regions, as is the case with Herkules.

Tab. 1.3: Overview of PM-resistance testing in 2014 with 11 previously characterised PM isolates

2014	Greenhouse tests		Laboratory tests	
	Plants	**Assessments**	**Plants**	**Assessments**
Seedlings from 97 crosses	Approx. 220,000 by mass screening		-	-
Breeding lines	180	810	170	1.356
Cultivars	14	70	6	37
Wild hops	34	168	34	98
Virulence properties of the PM isolates	-	-	11	646
Total (individual tests)	**228**	**1,048**	**221**	**2,137**

Mass screening in trays; individual tests = selection of individual plants in pots

Meristem cultures to eliminate viruses – faster provision of virus-free planting stock

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtungsforschung Hopfen *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Breeding Research)*
	Financed by: Wissenschaftliche Station für Brauerei in München e.V. *(Scientific Station for Brewing in Munich)*
Project managers:	Dr. E. Seigner and A. Lutz
Project staff:	B. Haugg
Cooperation:	Dr. L. Seigner and IPS 2c team
Duration:	01.07.2014 – 31.12.2015

Objective

Virus-free hop planting stock has been an important part of our quality drive for years. The findings from virus and viroid monitoring in Germany's hop-growing areas and the Hüll breeding yards (Seigner et al., 2014) clearly show how important meristem culture is for the provision of virus-free planting stock, both for German hop growers and for Hüll breeding work.

The aim of this project is to significantly speed up the provision of virus-free hop plants.

Method

To produce virus-free hop plants, the shoot tips are first heat-treated prior to excision of the uppermost growth zone (= meristem), located at the apex of the shoot. These meristems regenerate to complete plants on special culture media.

To verify that hops grown from meristems are really free of virus infections, their leaves are examined by the IPS 2c team for the various hop-typical viruses via the DAS-ELISA (Double Antibody Sandwich Enzyme Linked Immunosorbent Assay) and RT-PCR (Reverse Transcriptase Polymerase Chain Reaction) techniques. Testing for hop mosaic carlavirus (HpMV) and apple mosaic ilarvirus (ApMV) was always performed via ELISA, as the less expensive detection method, while the molecular technique was used to detect American hop latent carlavirus (AhpLV), hop latent virus (HpLV), hop stunt viroid (HpSVd) and hop latent viroid (HpLVd) infections and in cases where only very little in-vitro starting material was available for testing.

Results

The excised and prepared meristem grows into a small shoot relatively quickly. However, the stages of continued shoot growth and cloning make virus elimination a tedious process. Up to 10 months elapse from commencement of virus elimination by meristem preparation, through the various tissue-culture stages, to virus-testing of the new plants grown from meristems. Our aim is therefore to significantly speed up the whole process by optimising various culture-system parameters.

Investigation of *Verticillium* infections in the Hallertau district

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtungsforschung Hopfen und AG Hopfenbau/Produktionstechnik *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Breeding Research and WG Hop Cultivation/Production Techniques*
Financed by:	Erzeugergemeinschaft Hopfen HVG e.G. *(HVG hop producer group)*
Project manager:	Dr. S. Seefelder
Project staff:	P. Hager, D. Eisenbraun
Cooperation:	Dr. S. Radišek, Slovenian Institute of Hop Research and Brewing, Slovenia Prof. B. Javornik, University of Lublijana, Slovenia IPZ 5a (Work Group for Hop Cultivation/Production Techniques)
Duration:	01.01.2014 - 31.12.2014

Objective

The increased incidence of hop wilt affecting all hop varieties in isolated regions of the Hallertau prompted the resumption of earlier *Verticillium* research work terminated in 1985. Various problems were dealt with in sub-projects. Given the fact that wilt symptoms may also be due to less dangerous causes, this research work was primarily intended to establish a reliable detection method that permits definitive diagnosis of the dangerous *Verticillium* wilt. A further intention was to investigate the effectiveness of bioantagonists, as bacterial adversaries, in protecting hop plants from *Verticillium* infection. Issues concerning the genetics and virulence of the *Verticillium* fungus were clarified in advance by way of molecular AFLP screening.

Methods

- Conventional breeding techniques to cultivate single-spore *Verticillium* isolates from hop bine samples
- DNA isolation from pure cultures of fungi, hop bines and soil samples
- Molecular and microscopic examinations to differentiate between *Verticillium albo-atrum* and *V. dahliae*
- Infection test to determine virulence
- Isolation of hereditary *Verticillium* directly from hop bines

Results

Once the distinction between mild and aggressive forms of the Hallertauer *Verticillium* fungus had been confirmed for the first time, a molecular *in-planta* test was developed as part of the research project. This test obviates the need for tedious fungus cultivation and permits simultaneous detection of *Verticillium-albo-atrum* and *Verticillium dahliae.* With the help of a homogeniser, special glass/ceramic mixtures and a commercial fungus isolation kit, hereditary *Verticillium* material was extracted directly from hop bines. In subsequently performed real-time PCR assays, *Verticillium* wilt can be conclusively identified.

This new *Verticillium* detection tool was used immediately to test 325 plants from a propagation facility for latent *Verticillium* infection. None of the samples tested *Verticillium*-positive. By contrast, *Verticillium albo-atrum* was identified in one of 58 Hüll breeding lines tested. The experimental studies to investigate hop-root colonisation by bioantagonists known to protect other crops from soil pathogens were concluded successfully. However, whether a bioantagonist effective against infection by this dangerous soil-borne fungus can be developed on *Verticillium*-contaminated ground is currently unclear.

Outlook

The establishment of a practicable artificial *Verticillium*-infection method for selecting tolerant breeding lines should be one of the top goals of hop breeding, as this will provide a long-term solution to the hop-wilt problem.

Monitoring for dangerous hop viroid infections in Germany

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenschutz, AG Pathogendiagnostik und Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtungsforschung Hopfen, *(Bavarian State Research Center for Agriculture, Institute for Plant Protection, WG for Pathogen Diagnostics, and Institute for Crop Science and Plant Breeding, WG for Hop Breeding Research)*
Financed by:	Wissenschaftliche Station für Brauerei in München e.V. *(Scientific Station for Brewing in Munich)*
Project manager:	Dr. L. Seigner, Institute for Plant Protection (IPS 2c); Dr. E. Seigner, A. Lutz (both from IPZ 5c)
Project staff:	G. Bachmair, B. Hailer, C. Huber, L. Keckel, M. Kistler, D. Köhler, F. Nachtmann (all from IPS 2c); A. Lutz, J. Kneidl (IPZ 5c)

Cooperation: Dr. K. Eastwell, Washington State University, Prosser, USA;
Dr. S. Radišek, Slovenian Institute of Hop Research and Brewing, Slovenia;
IPZ 5a (WG Hop Cultivation/Production Techniques)
IPZ 5b (WG Plant Protection in Hop Growing)
Local hop consultants
Hop Producers' Ring
Hop farms
Eickelmann propagation facility, Geisenfeld

Duration: March - December 2014

Objective

Since 2008, the LfL has been monitoring its hop breeding yards and field crops in all German hop-growing areas for hop stunt viroid. A resumé of this work was published in 2014 (Seigner et al., 2014). In 2014, samples were tested additionally for hop citrus viroid, which was detected for the first time in Slovenia in 2013 (CVd IV = CBCVd: Radišek et al. 2013; Jakse et al., 2014).

As these harmful organisms cause massive yield and alpha-acid losses in hops, particularly under stress-inducing conditions, the goal of the monitoring activities is to detect and eradicate these foci of infection as early as possible. These pathogens cannot be controlled with plant protection agents.

Method

Leaf samples taken from hop plants growing in the LfL's breeding yards, a GfH propagation facility and hop farms in the Hallertau, Tettnang and Elbe-Saale growing areas were tested molecularly (RT-PCR = reverse transcriptase polymerase chain reaction) in the LfL's pathogen diagnostics lab (IPS 2c) for the two pathogens shown in Tab. 1.4. Foreign varieties and plants received at Hüll from abroad and kept under quarantine were also tested.

Tab. 1.4: Viroids able to cause serious damage to hops

Viroid German name	Viroid English name	Abbreviation	Detection method
Hopfenstauche-Viroid	Hop stunt viroid	HpSVd	RT-PCR*
Zitrusviroid IV	Citrus viroid IV	CVd IV = CBCVd	RT-PCR#

* using primers from Eastwell and Nelson (2007) and from Eastwell (personal communication, 2009); # primer published by Ito et al. (2002)

To ensure that the RT-PCR assay was functioning correctly, it was always backed up by an internal, hop-specific, mRNA-based RT-PCR control (Seigner et al. 2008).

Results

A total of 239 samples were tested for HpSVd and CVd IV. Neither of the two viroids was detected in any of the samples, a sign that they have not yet found their way into German hop cultivation and that a fair chance of averting the imminent danger exists.

Provided that appropriate precautionary measures based on intensive testing continue to be taken and that primary foci of infection are rigorously eradicated, it should be possible to effectively keep the two viroids at bay in future, too.

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Acknowledgement

Our thanks go to Dr. Ken Eastwell, USA, and Dr. Sebastjan Radišek, Slowenia, for their support in this work.

1.2 Main research areas

1.2.1 Hop Breeding main research areas

Development of high-performance and highly resistant hop breeding stock and varieties of the aroma, high-alpha and special-flavor type.

Project managers:	A. Lutz, Dr. E. Seigner
Project staff:	A. Lutz, J. Kneidl, S. Seefelder, E. Seigner, IPZ 5c team
Cooperation:	Dr. K. Kammhuber, IPZ 5d team
	Hop expert group of the GfH
	Weihenstephan Research Center for Brewing, Technical University of Munich/Weihenstephan, Chair of Brewing and Beverage Technology, Dr. F. Schüll
	Bitburger Brewery Group's experimental brewery, Dr. S. Hanke
	National and international brewing partners
	Partners from the hop trade and hop-processing industry
	Association of German Hop Growers
	Hop growers

Objective

The aim of hop breeding is to develop high-performance cultivars that meet the market requirements of the brewing industry, including those of craft brewers, for traditional aroma- and high-alpha-type hops and, as of late, also for hops with especially fruity aromas (special-flavor hops). It goes without saying that the requirements of German hop growers must also be met.

Material and methods

Eighty-two crosses were performed in 2014 with this goal in mind. The selection procedure outlined in Fig. 1.3 for development of a hop cultivar similar to Tettnanger basically applies to all breeding projects. Section 4.1.2 contains details.

Results

Interesting breeding lines for traditional aroma, special-flavor and high-alpha varieties are in the pipeline and are available to the GfH's hop expert group and all interested brewers for assessment (see details under 4.1.2).

Optimisation of screening procedures for assessing hop tolerance towards downy mildew (*Pseudoperonospora humuli*)

Project managers:	Dr. E. Seigner, A. Lutz
Project staff:	B. Forster

Objective

Downy mildew, caused by the *Pseudoperonospora humuli* fungus, has become a huge problem in hail-damaged hop stands during the last few years and prompted renewed prioritisation of breeding to improve downy mildew resistance. Initial work, commenced in 2012, focused on improving seedling screening in the greenhouse (Jawad-Fleischer, 2013; Seigner und Forster, 2014). Efforts are now underway to supplement the findings concerning the reaction of hop plants to downy mildew by means of a detached-leaf assay.

Method

Building on the downy-mildew screening studies conducted in the USA, UK, CZ and, in particular, in Hüll by Dr. Kremheller during the 1970s and 1980s, work on developing a test system using detached hop leaves was commenced.

Leaves from hop varieties with distinctly different downy-mildew tolerances were inoculated with a sporangia suspension and their reaction assessed visually 5-14 days post innoculation. The various trial parameters were reviewed and optimised.

Results and outlook

Initial findings resulting from the detached-leaf-assay work in 2013 were compiled in a Bachelor thesis (Jawad-Fleischer, 2014). This work was continued in 2014 and the reproducibility, in particular, of the inoculation tests substantially improved. Instead of inoculating the plants with a Preval sprayer, a pipette was used to apply defined amounts of sporangia to the leaf undersides. Further improvements focused especially on preserving zoospore vitality (Jones et al., 2001) allowed spores, chloroses and necroses to be reliably elicited on the leaves of the hop plants under test, depending on their respective susceptibilities to downy mildew. The vitality of the starting leaves and of the fungus were confirmed once again to be the crucial factors for obtaining conclusive susceptibility/tolerance results with this detached-leaf assay.

The plan is to test individual parameters once again in 2015 and then clarify the comparability of downy-mildew tolerance as estimated in laboratory assays with field data from hop farms.

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1.2.2 Hop Cultivation/Production Techniques: main research areas

Optimisation of hop drying in a belt dryer

Project staff: J. Münsterer

During the 2013 and 2014 harvests, it was shown in small-scale trials that drying performance is significantly enhanced and external quality best preserved by selectively controlling the air speed and drying temperature in the first third of the upper drier belt. The plan is to continue this research in field trials and confirm the findings. To this end, measures to modify and/or optimise airflows in existing belt driers are required or already planned.

Reaction of various cultivars to reduced trellis height (6 m)

Project staff: S. Fuß

Disastrous storm damage during the last few years, which caused hop trellis systems in the Hallertau region to collapse prior to harvesting, has prompted studies to investigate whether trellis height can be reduced to 6 m without compromising yields. According to initial calculations, this measure would reduce the static load on the Hallertau trellis system by around 15 - 20 % and greatly improve its stability under conditions of extreme wind velocities.

In addition, trellis costs could be reduced without impairing stability through use of the shorter, weaker central poles. Potential plant protection benefits might exist as well, because the tops of the hop plants, being closer to the target area, would receive more spray.

In a previously concluded project, the height of the hop trellis was reduced from 7 m to 6 m in trial plots in a number of commercial hop yards (growers of various hop cultivars). The aim was to study the reaction of the different cultivars to reduced trellis height (plant growth, susceptibility to disease/pests, yield and quality). Tests were conducted on the following aroma varieties: Perle und Hallertauer Tradition, and on the following bitter varieties: Hallertauer Magnum, Hallertauer Taurus and Herkules. A general recommendation that hop farmers reduce trellis height for statical reasons is not yet possible on the basis of the trial results because only one location was tested per cultivar.

In 2014, trial results for the Hallertau Tradition variety were obtained for the last time in a commercial hop yard and evaluated. Details of the evaluation are contained in Section 5.

In addition, trial plots with 7-m and 6-m trellises were established in 2012 in the LfL's new breeding yard in Stadelhof and planted, in several replications, with the Perle, Herkules and Polaris varieties. This trial setup facilitates observation and comparison of the way in which the hop varieties react to the different trellis heights. The hops on the trial plots were not harvested in 2013 on account of hail damage. The trial crop was harvested for the first time in 2014 and furnished initial interesting results. However, a further two trial years needs to be evaluated before any results are published.

Variation in cover-crop sowing and incorporation times in hop-growing

Project staff:	J. Portner
Duration:	2012-2015

The sowing of cover crops between hop rows protects against erosion by water and reduces nitrate transfer and leaching after the harvest. In the past, cover crops have usually been sown in early summer after ploughing, the consequence being that any heavy rainfall after sowing and before the cover crop has grown sufficiently has caused serious localised erosion.

At a location subject to erosion, a trial was set up with 7 different cover-cropping variants and involving different sowing times (no sowing, summer sowing and autumn sowing) and different incorporation times (ploughing under in April through to mulching in early June without ploughing) with the aim of optimising the cover-cropping system. The plan is to use recorded yield data, biological and physical soil-parameter measurements and qualitative soil-erosion observations to compile information pointing to ways of optimising the process.

Harvesting-time trials for the Mandarina Bavaria, Hallertau Blanc and Polaris flavor-hop varieties

Project staff:	J. Münsterer, K. Kammhuber, A. Lutz
Duration:	2014-2016

Harvesting-time trials for Mandarina Bavaria, Hallertauer Blanc and Polaris are being conducted at three different locations so that optimum harvesting-time recommendations can be made for these new special-flavor hop varieties in future. Twenty hop plants from field crops are harvested twice weekly in fourfold replication at five harvesting times. The intention is to find out which harvesting time is best for each of the above varieties in terms of the various characteristics, such as yield, alpha-acid content, aroma and external and internal quality criteria.

1.2.3 Hop Quality and Analytics: main research areas

Performance of all analytical studies in support of the Hop Department work groups, especially Hop Breeding Research

Project manager:	Dr. K. Kammhuber
Project staff:	E. Neuhof-Buckl, S. Weihrauch, B. Wyschkon, C. Petzina, M. Hainzlmaier, Dr. K. Kammhuber
Cooperation:	WG Hop Cultivation/Production Techniques, WG Plant Protection in Hop Growing, WG Hop Breeding Research
Duration:	Long-term task

Hops are grown and cultivated mainly for their components. Component analysis is therefore essential to successful hop research.

The IPZ 5d team (Hop Quality and Analytics work group) carries out all analytical studies needed to support the experimental work of the other work groups. Hop Breeding Research, in particular, selects breeding lines according to laboratory data.

Development of an NIRS calibration model for alpha-acid and moisture content

Project manager: Dr. K. Kammhuber
Project staff: E. Neuhof-Buckl, B. Wyschkon, C. Petzina, M. Hainzlmaier, Dr. Klaus Kammhuber
Duration: September 2000 to (open-ended)

As of 2000, work commenced on the development of an HPLC-data-based NIRS calibration equation in Hüll and the laboratories of the hop-processing firms. In view of the rising number of alpha-acid analyses, the aim was to replace wet chemical analysis by a cheap, fast method with acceptable repeatability and reproducibility for routine use.

It was decided, within the Working Group for Hop Analysis (AHA), that such a method could be deemed suitable for routine use and for use as an analytical method for hop supply contracts if it was at least as accurate as conductometric titration according to EBC 7.4.

However, as no further improvement was possible, it was decided to discontinue development of a common calibration equation in 2008. At the Hüll laboratory, however, work on developing an NIRS model continues. A NIRS model for determining moisture content is also being developed. NIRS is suitable as a screening method for hop breeding. It saves a lot of time and cuts the costs for chemicals. We have found that analytical accuracy improves with each additional year of work.

Chemical analyses for Work Group 3d, "Medicinal and Aromatic Plants"

Project manager: Dr. K. Kammhuber
Cooperation: Medicinal and Aromatic Plants work group
Project staff: E. Neuhof-Buckl, Dr. K. Kammhuber
Duration: 2009 to (open-ended)

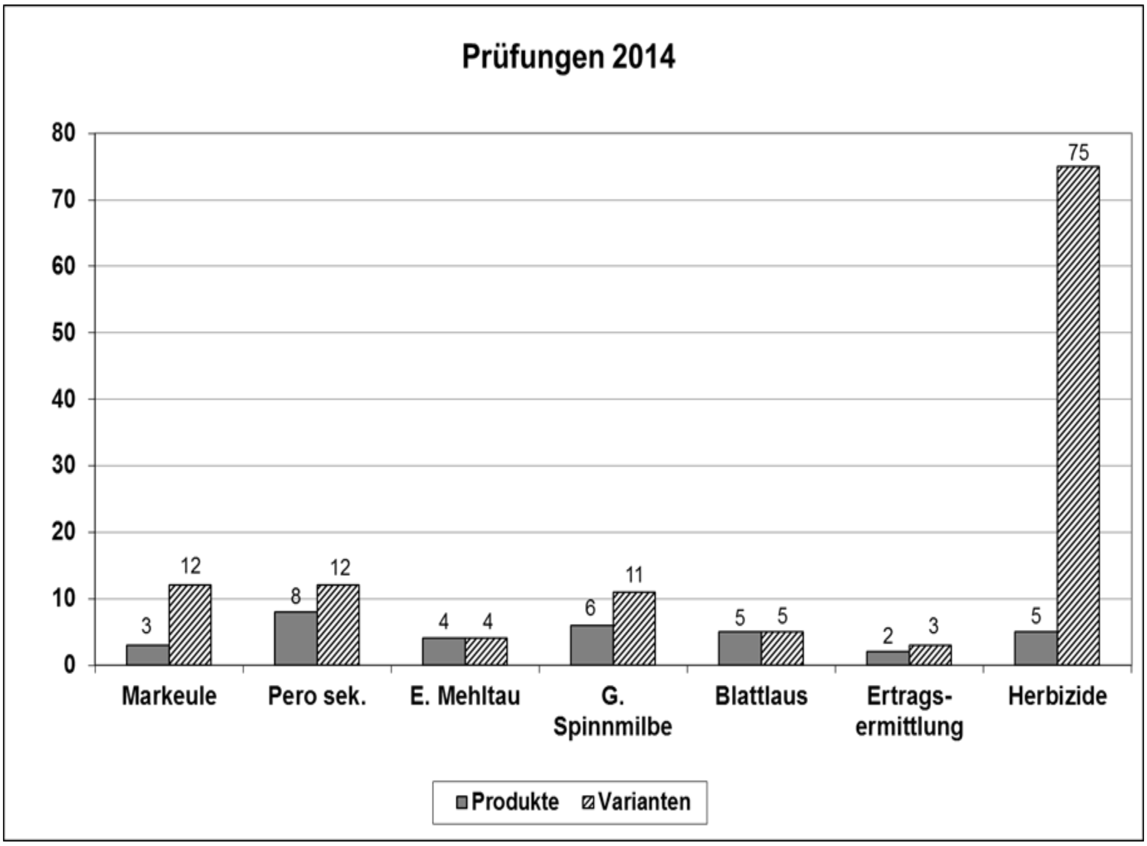
In order to make greater use of the Hüll laboratory equipment, analyses have also been carried out for the Medicinal and Aromatic Plants work group since 2009. The active agents contained in the following plants are analysed via HPLC:

Leonorus japonicus (Chinese motherwort): flavonoids, stachydrine, leonurine
Saposhnikovia divaricata (Fang Feng herb): prim-O-glucosylcimifugin,
5-O-methylvisamminoside
Salvia miltiorrhiza (red sage): salvianolic acid, tanshinone
Paeonia lactiflora (Chinese or white paeony): Paenoniflorin

1.2.4 **Plant Protection in Hop Growing: main research areas**

Tests performed on plant protection agents in 2014 for licensing and approval purposes and for advisory-service documentation

Project manager: W. Sichelstiel
Project staff: J. Schwarz, G. Meyr, J. Weiher, O. Ehrenstraßer, M. Felsl



2 Weather conditions and hop growth in 2014 – effects on production techniques in the Hallertau

LR Johann Schätzl

The winter of 2013/2014 was one of the warmest and driest in over 40 years. It failed to deliver the ground frost needed to mellow the soil and repair the structural damage caused by the wet harvest season in 2013.
The spring was also warmer and drier than average, enabling the growing season to start early and training to commence as of mid-April. In favourable locations, hop growth had a headstart of up to 14 days. However, growth was slowed down again in May and June by cold nights. June also brought drought stress, particularly to the northern and western parts of Bavaria's Hallertau region. This curtailed laterals development and flower setting at locations with light and structurally damaged soils. The initial headstart in growth had melted away by early July, when the hop plants were flowering. Copious rain and warm weather followed, prolonging flowering and cone-formation duration. Harvesting of moderately early varieties commenced on 28th August. While hop growth, and thus maturation, differed greatly depending on the location and amount of rainfall, overall yields in 2014 were very good thanks to ample water supplies in July and August. Just under 38 500 t hops were harvested in Germany, 40 % more than in 2013. Alpha-acid content was average as a whole but differed markedly from variety to variety. The Hall. Tradition, Spalter Select and Hall. Magnum varieties, in particular, were below average, whereas Perle, Hall. Taurus and Herkules were clearly above the multi-annual mean.

Special weather conditions and their effects:

- Very dry, warm April

Thanks to the warm, dry spring, tillage and pruning were performed from as early as the beginning of March until early April under favourable conditions and with dry soil. In yards where pruning had been carried out early, crowning commenced as early as the beginning of April. The first fast-growing stands, benefiting from early pruning, had already been trained and hilled by the end of April. The plunge in temperature from 16th to 17th April, with night frost and temperatures as low as – 4 °C, caused regional frost damage both to shoots awaiting training and those already trained. Rosy Rustic caterpillar damage to hop shoots was identified unusually early, as of mid-April, in some hop yards. Infestation was especially severe on acreages that had been affected in 2013. The dry, warm winter set off a virtual boom in vole population growth, whereas the dry spring limited primary downy mildew infections to a few isolated cases.

- Cold, wet May; early PM outbreaks

In Hüll, precipitation in May totalled 129.8 mm, clearly in excess (by 24.7 mm) of the 10-year mean. The mean temperature of 12.4°C was 1°C below the 10-year figure. Most hop farmers managed to conclude mulching and primary hilling during the first half of May. Initial hop stripping was performed using caustic nutrient solutions or, in some cases, by stripping off the leaves manually. Frequent showers led to outbreaks of primary downy mildew in a number of hop yards. Previous control measures carried out via watering after the plants had been pruned were not always satisfactory on account of the dry weather at that time. The total of 20 wet days boosted downy mildew infection and led to a steep rise in the number of zoosporangia in the spore traps.

A spray warning was accordingly issued for all varieties on 22nd May. 2014 was unusual in that PM outbreaks were reported as early as May, prompting a recommendation for timely treatment of all susceptible varieties and for stands in affected locations. Towards the end of May, hop-aphid colonisation and initial spider-mite infection were observed despite application, via watering, of Actara.

- Extremely dry June

At the Hüll location, only 48.8 mm rain fell during the entire month of June, 86 % of it during the last week. The 10-year mean of 110.6 mm is much higher. Drought stress and extreme day/night temperature fluctuations disturbed growth and hindered the formation of laterals in problem locations with very light or clayey soils. A late outbreak of primary downy mildew affected some stands of susceptible varieties during the first week of June. This led to a renewed rise in zoosporangia counts, prompting a spray warning for susceptible varieties on 10th June to protect against possible secondary infections. As the month progressed, the dry weather dried out the downy fungal growth, making it unnecessary to combat the fungus for the following six weeks. By contrast, ongoing targeted spraying against PM was required in affected locations. Whereas aphid migration decreased, some yards witnessed common-spider-mite outbreaks that necessitated control measures. Some of these endangered stands, particularly those at sandy locations, were treated with acaricides. In several yards, increasing numbers of plants showed signs of withering due to persistent Rosy Rustic infestation.

- July as “hop patcher”

Rainfall in July, half of it during a storm on the 21st, totalled 162.7 mm. This was much more than the 10-year mean of 110.1 mm. Benefiting from the humid weather, the hop plants underwent renewed growth and had a long flowering phase. By the end of July, all varieties were developing cones. The weather also caused a rise in downy-mildew infection pressure, so that, after a six-week interval, a downy-mildew spray warning was again issued for all varieties on 24th July. PM infection pressure continued unchanged in July despite regular spraying, and even repeated treatments did not prevent the fungus from spreading from the leaves to the flowers and cones.

- Weather conditions up until harvesting make for good yields

Sufficient rain (109.7 mm) and cool, changeable weather up until the end of August resulted in good cone formation, making for high yields and satisfactory hop components. The ongoing rainfall in July and August increased the danger of downy-mildew infection still further, necessitating spray warnings on 1st, 12th and 28th August and appropriate control measures. The cold, wet weather promoted further spreading of *Verticillium* wilt, particularly at problematic and endangered locations. The occurrence of lethal Verticillium strains means that all previously tolerant varieties may now be affected. One unusual event was the detection of the rare disease Cercospora cantuariensis in a number of Herkules stands shortly before harvesting. However, as far as diseases are concerned, 2014 will be remembered as the “mildew year”.

Hüll weather data (monthly means and monthly totals) for 2014 compared with 10- and 50-year means

Month		Temp 2 m above ground Mean (°C)	Min.∅ (°C)	Max.∅ (°C)	Relat. hum. (%)	Precipi-tation (mm)	Days with ppn. >0.2 mm	Sun-shine (h)
January	2014	1.5	-1.3	4.5	93.9	51.9	12.0	27.0
∅	10-y.	-0.6	-4.1	2.9	88.3	62.3	13.7	63.7
	50-y.	-2.4	-5.1	1.0	85.7	51.7	13.7	44.5
February	2014	2.9	-1.5	8.0	83.9	10.5	6.0	89.0
∅	10-y.	-0.5	-4.7	4.2	85.5	44.3	12.9	84.0
	50-y.	-1.2	-5.1	2.9	82.8	48.4	12.8	68.7
March	2014	6.2	-0.3	13.5	75.9	25.5	6.0	188.8
∅	10-y.	3.6	-1.5	9.4	80.8	59.3	12.6	146.6
	50-y.	2.7	-2.3	8.2	78.8	43.5	11.3	134.4
April	2014	10.1	4.1	16.2	76.7	28.2	10.0	162.4
∅	10-y.	9.6	3.2	16.3	73.6	63.0	11.0	205.5
	50-y.	7.4	1.8	13.3	75.9	55.9	12.4	165.0
May	2014	12.4	7.1	17.9	77.0	129.8	17.0	168.2
∅	10-y.	13.4	7.2	19.6	74.1	105.1	15.2	215.0
	50-y.	11.9	5.7	17.8	75.1	86.1	14.0	207.4
June	2014	16.9	9.0	23.9	66.7	48.8	8.0	279.7
∅	10-y.	16.8	10.7	23.0	75.5	110.6	15.1	217.9
	50-y.	15.3	8.9	21.2	75.6	106.1	14.2	220.0
July	2014	18.6	12.8	24.9	79.8	162.7	19.0	206.6
∅	10-y.	18.4	12.1	25.4	75.2	110.1	14.6	246.0
	50-y.	16.9	10.6	23.1	76.3	108.4	13.9	240.3
August	2014	15.8	10.7	21.7	84.0	109.7	16.0	189.6
∅	10-y.	17.3	11.3	24.3	80.0	119.3	14.2	215.1
	50-y.	16.0	10.2	22.5	79.4	94.9	13.3	218.4
September	2014	14.1	9.5	19.7	90.2	48.9	10.0	133.1
∅	10-y.	13.6	8.1	20.2	83.6	62.1	11.2	170.1
	50-y.	12.8	7.4	19.4	81.5	65.9	11.4	174.5
October	2014	10.8	6.8	15.5	93.8	77.3	12.0	96.1
∅	10-y.	8.8	4.1	14.8	87.6	49.2	9.9	120.1
	50-y.	7.5	2.8	13.0	84.8	60.0	10.4	112.9
November	2014	5.4	2.8	8.7	96.2	41.7	4.0	52.6
∅	10-y.	3.8	0.4	7.7	91.2	54.6	12.0	62.2
	50-y.	3.2	-0.2	6.4	87.5	58.8	12.6	42.8
December	2014	2.5	-0.4	5.0	92.6	46.9	20.0	27.1
∅	10-y.	0.2	-2.8	3.4	91.0	61.8	14.2	52.2
	50-y.	-0.9	-4.4	1.6	88.1	49.1	13.3	34.3
∅ 2014		9.8	4.9	15.0	84.2	781.9	140.0	1620.2
10 - year mean		8.7	3.6	14.3	82.2	901.5	156.6	1798.4
50 - year mean		7.4	2.5	12.5	81.0	828.8	153.3	1663.2

The 50-year mean is based on the period from 1927 through 1976,
The 10-year mean is based on the period from 2004 through 2013.

3 Statistical data on hop production

LD Johann Portner, Dipl.-Ing. agr.

3.1 Production Data

3.1.1 Pattern of hop farming

Tab. 3.1: Number of hop farms and their hop acreages in Germany

Year	No. of farms	Hop acreage per farm in ha	Year	No. of farms	Hop acreage per farm in ha
1975	7,654	2.64	1995	3,122	7.01
1976	7,063	2.79	1996	2,950	7.39
1977	6,617	2.90	1997	2,790	7.66
1978	5,979	2.94	1998	2,547	7.73
1979	5,772	2.99	1999	2,324	7.87
1980	5,716	3.14	2000	2,197	8.47
1981	5,649	3.40	2001	2,126	8.95
1982	5,580	3.58	2002	1,943	9.45
1983	5,408	3.66	2003	1,788	9.82
1984	5,206	3.77	2004	1,698	10.29
1985	5,044	3.89	2005	1,611	10.66
1986	4,847	4.05	2006	1,555	11.04
1987	4,613	4.18	2007	1,511	11.70
1988	4,488	4.41	2008	1,497	12.49
1989	4,298	4.64	2009	1,473	12.54
1990	4,183	5.35	2010	1,435	12.81
1991	3,957	5.70	2011	1,377	13.24
1992	3,796	6.05	2012	1,295	13.23
1993	3,616	6.37	2013	1,231	13.69
1994	3,282	6.69	2014	1,192	14.52

Tab. 3.2: Acreage, no. of hop farms and average hop acreage per farm in the German hop-growing regions

Hop-growing region	Hop acreages				Hop farms				Hop acreage per farm in ha	
	in ha		Increase + / Decrease - 2014 vs. 2013				Increase + / Decrease - 2014 vs. 2013			
	2013	2014	ha	%	2013	2014	Farms	%	2013	2014
Hallertau	14,086	14,467	381	2.7	989	966	- 23	- 2.3	14.24	14.98
Spalt	350	348	- 2	- 0.6	62	55	- 7	- 11.3	5.65	6.33
Tettnang	1,208	1,209	1	0.1	149	140	- 9	- 6.0	8.11	8.64
Baden, Bitbg. + Rheinl-Pal.	20	20	± 0	± 0	2	2	± 0	± 0	10.00	10.00
Elbe-Saale	1,186	1,265	79	6.7	29	29	± 0	± 0	40.89	43.62
Germany	**16,849**	**17,308**	**459**	**2.7**	**1.231**	**1.192**	**- 39**	**- 3.2**	**13.69**	**14.52**

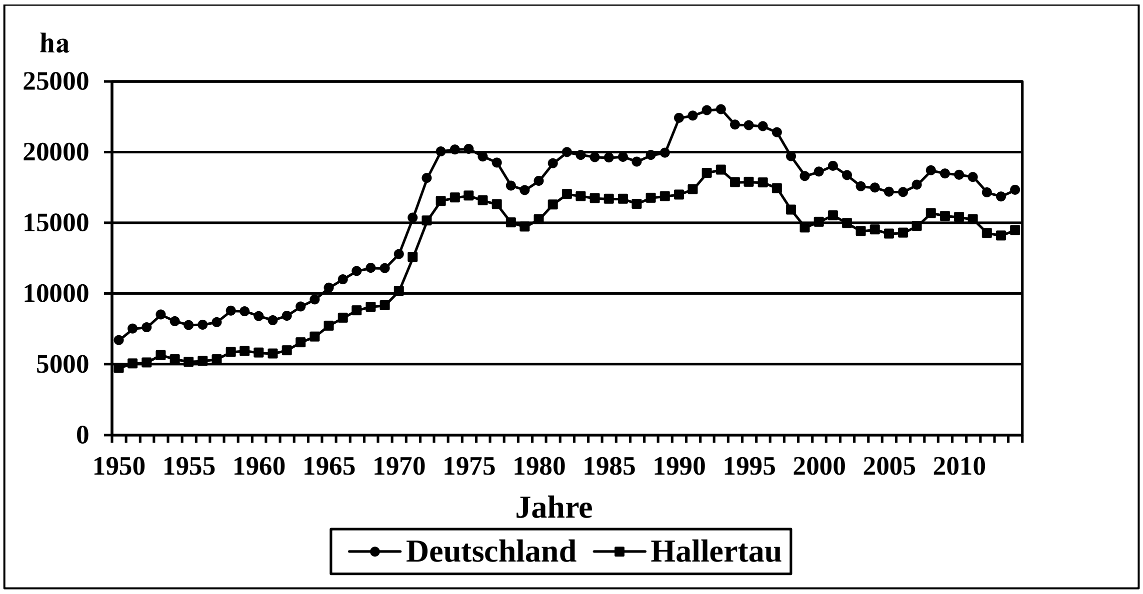


Fig. 3.1: Hop acreages in Germany and in the Hallertau

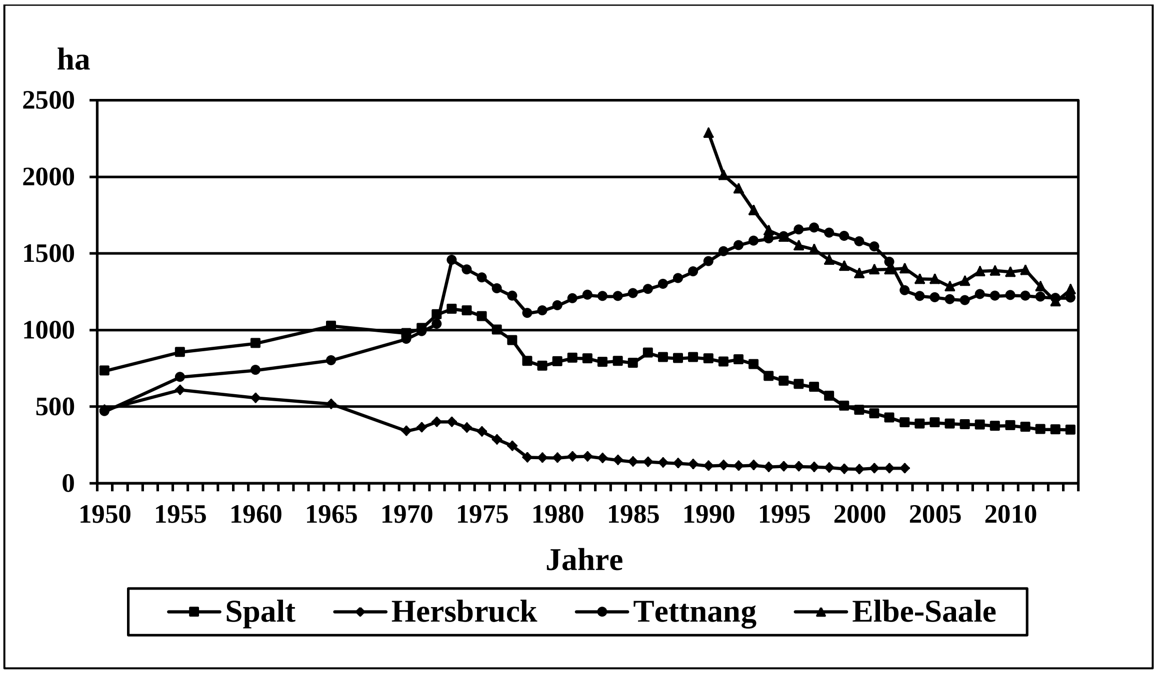


Fig. 3.2: Hop acreages in the Spalt, Hersbruck, Tettnang and Elbe-Saale regions

Hersbruck hop-growing region has been included in the Hallertau since 2004.

Hop varieties

The reduction in hop acreage witnessed in previous years has come to a halt, with the area under hop increasing by 459 ha in 2014 and total hop acreage in Germany therefore amounting to 17,308 ha. Of the aroma varieties, only Hallertauer Mittelfrüher, Tettnanger and Smaragd had some of their acreage cleared. With the exception of Herkules, all the bitter and high-alpha varieties saw some of their acreages cleared, in all 75 ha. Acreages previously planted with Hallertauer Magnum (- 460 ha) are being increasingly replanted with Herkules (+ 536 ha).

The trend towards increased cultivation of special-flavor or dual-purpose hops has continued, with the acreage more than doubling in 2014, to 286 ha, and accounting for 1.7 % of the total area under hop. A further increase is expected for the coming years.

An exact breakdown of varieties according to growing regions is given in Tables 3.3 and 3.4.

Tab. 3.3: Hop varieties in the German hop-growing regions in ha in 2014

Aroma varieties

Region	Total acreage	HA	SP	TE	HE	PE	SE	HT	SR	OL	SD	Other	Aroma varieties	
													ha	%
Hallertau	14,467	623			919	2,857	434	2,696	360	61	26	7	7,983	55.2
Spalt	348	43	112		5	23	80	31	9	1	1	0	306	88.0
Tettnang	1,209	171		762		67	6	54	13	1	12		1,086	89.9
Baden, Bitburg and Rhinel.-Pal.	20	1				8	2	4					15	77.8
Elbe-Saale	1,265					199		40				14	253	20.0
Germany	**17,308**	**838**	**112**	**762**	**924**	**3,154**	**523**	**2,825**	**381**	**63**	**39**	**21**	**9,644**	**55.7**
% acreage by variety		4.8	0.6	4.4	5.3	18.2	3.0	16.3	2.2	0.4	0.2	0.1		

Variety changes in Germany

2013 (in ha)	16,849	925	112	787	847	3,048	496	2,661	324	28	41	13	9,281	55.1
2014 (in ha)	17,308	838	112	762	924	3,154	523	2,825	381	63	39	21	9,644	55.7
Change (in ha)	459	-86	0	-25	77	106	27	164	57	35	-2	8	362	0.6

Tab. 3.4: Hop varieties in the German hop-growing regions in ha in 2014

Bitter and high-alpha varieties

Region	NB	BG	NU	TA	HM	TU	MR	HS	CM	Other	Bitter varieties	
											ha	%
Hallertau	173	17	145	1	1,934	564	27	3,345	3	26	6,235	43.1
Spalt					2		4	32		1	39	11.1
Tettnang						5		94			99	8.2
Baden, Bitburg and Rhinel.-Pal.					3			2			4	21.6
Elbe-Saale	94		28		704	25		149		2	1,002	79.2
Germany	**267**	**17**	**173**	**1**	**2,642**	**594**	**31**	**3,622**	**3**	**28**	**7,379**	**42.6**
% acreage by variety	1.5	0.1	1.0	0.0	15.3	3.4	0.2	20.9	0.0	0.2		

Variety changes in Germany

2013 (in ha)	281	19	184	1	3,102	709	38	3,086	3	31	7,454	44.2
2014 (in ha)	267	17	173	1	2,642	594	31	3,622	3	28	7,379	42.6
Change (in ha)	-14	-2	-12	0.0	-460	-116	-6	536	0.0	-3	-75	-1.6

Tab. 3.5: Hop varieties in the German hop-growing regions in ha in 2014

Special-flavor and dual-purpose varieties

Region	CA	HC	HN	MB	PA	Flavor varieties	
						ha	%
Hallertau	25	42	51	86	44	248	1.7
Spalt	1	1		1		3	0.9
Tettnang	4	4	4	8	4	24	2.0
Baden, Bitburg and Rhinel.-Pal.	0	0	0	0	0	0	0.6
Elbe-Saale				5	5	10	0.8
Germany	**30**	**48**	**56**	**99**	**53**	**286**	**1.7**
% acreage by variety	0.2	0.3	0.3	0.6	0.3		

Variety changes in Germany

2013 (in ha)	10	12	14	35	43	114	0.7
2014 (in ha)	30	48	56	99	53	286	1.7
Change (in ha)	**20**	36	42	64	10	172	1.0

3.2 Yields in 2014

Approximately 38,499,770 kg (= 769,995 cwt.) hops were harvested in Germany, as compared with 27,554,140 kg (= 551,083 cwt.) in 2013. The crop thus weighed 10,945,630 kg (= 218,913 cwt.) more than in the previous year, an increase of around 39.7 %.

At 2,224 kg, the mean per-hectare yield was above average, with the high yields of 2013 being repeated in all growing regions except Elbe-Saale.

Mean alpha-acid contents for the various varieties were average in 2014. Of the aroma varieties, Hersbrucker Spät was disappointing, while Perle, surprisingly, was slightly above average. Of the bitter and high-alpha varieties, Hallertauer Magnum and Nugget had below-average alpha contents. However, these were more than compensated for by the higher levels achieved with Hallertauer Taurus and Herkules. The total alpha-acid produced in Germany from the freshly harvested 2014 crop is estimated at approx. 4,100 t.

Tab. 3.6: Per-hectare yields and relative figures in Germany

	2009	2010	2011	2012	2013	2014
Yield kg/ha and (cwt./ha)	1,697 kg (33.9 cwt.) (Severe hail damage)	1,862 kg (37.2 cwt.) (Hail damage)	2,091 kg (41.8 cwt.) (Hail damage)	2,013 kg (40.3 cwt.)	1,635 kg (32.7 cwt.) (Hail damage)	2,224 kg (44.5 cwt.)
Acreage in ha	18,473	18,386	18,228	17,124	16,849	17,308
Total yield in kg and cwt.	31,343,670 kg = 626,873cwt.	34,233,810 kg = 684,676cwt.	38,110,620 kg = 762,212cwt.	34,475,210 kg = 689,504cwt.	27,554,140 kg = 551,083cwt.	38,499,770 kg = 769,995cwt.

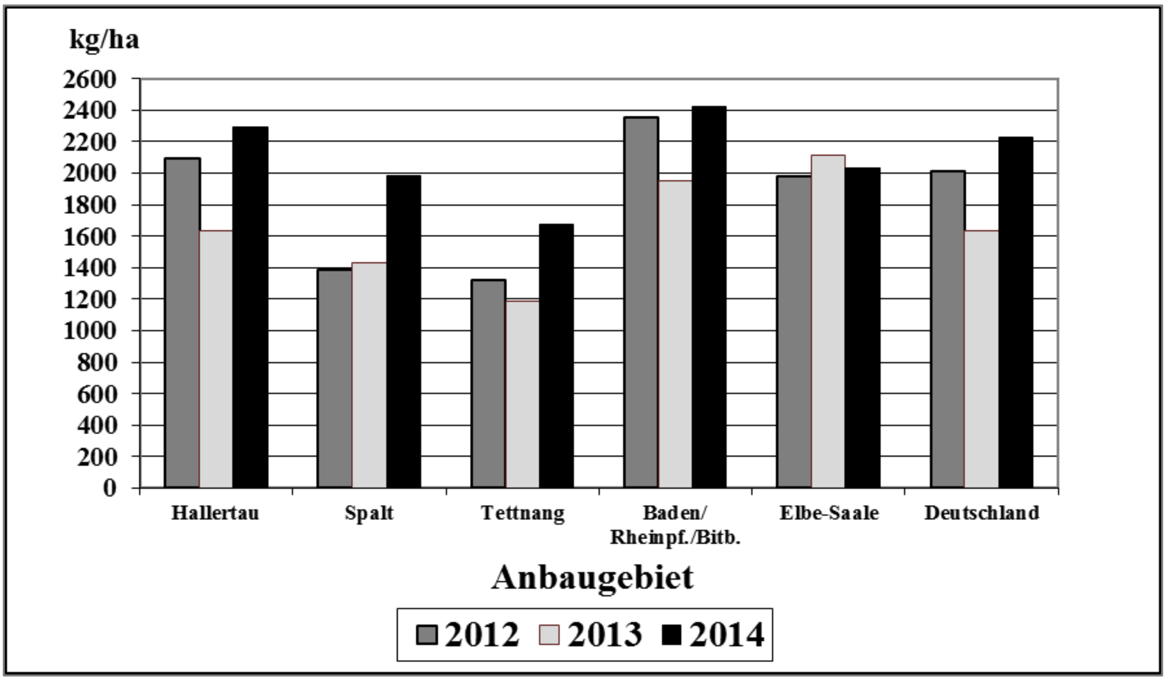


Fig. 3.3: Average yields by hop-growing region in kg/ha

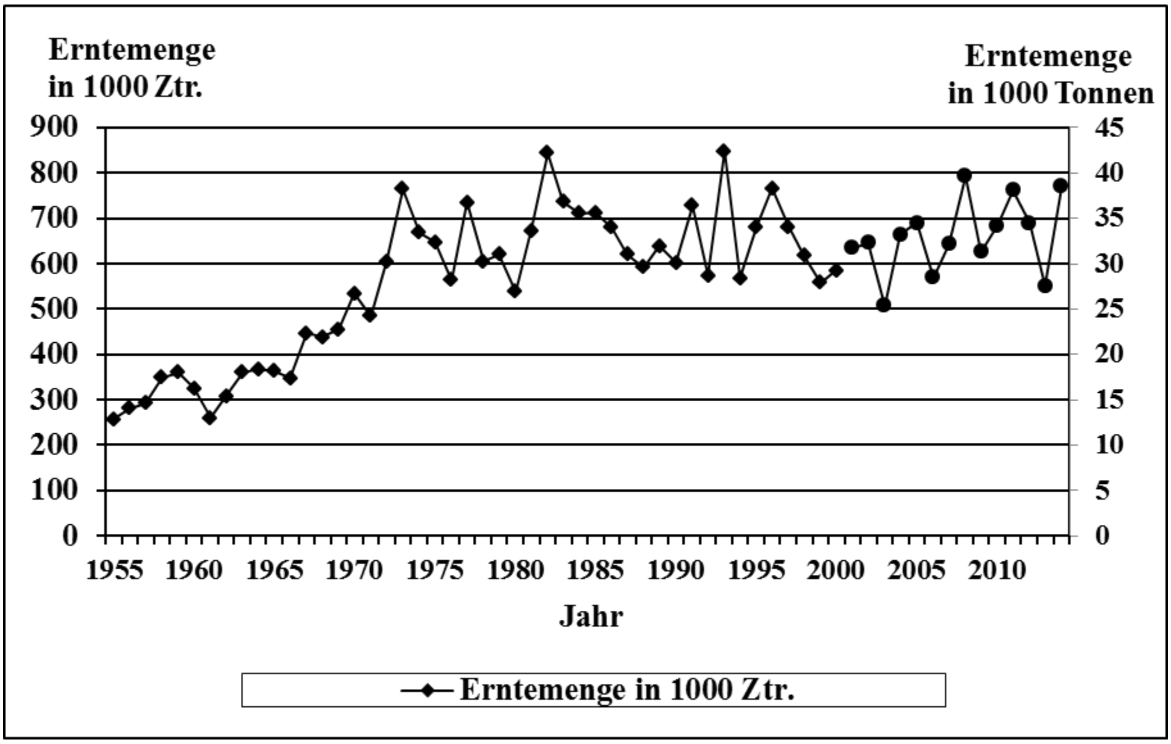


Fig. 3.4: Crop volumes in Germany

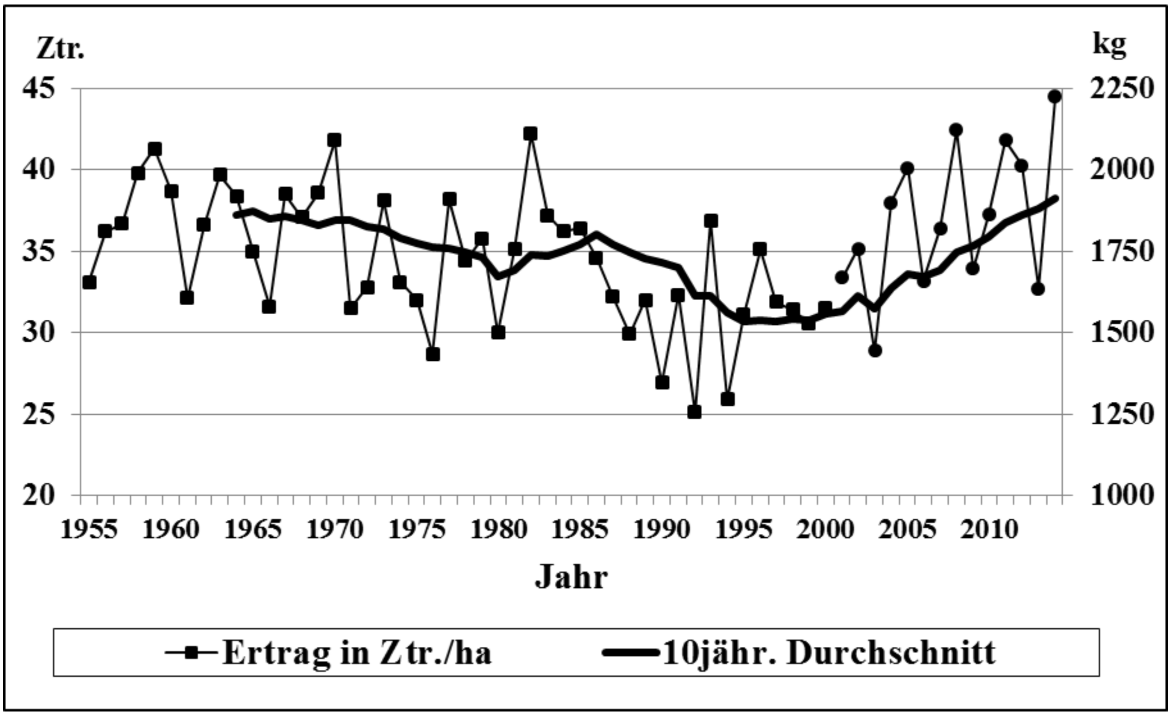


Fig. 3.5: Average yields (cwt. and kg/ha) in Germany

Tab. 3.7: Yields per hectare by German hop-growing region

Region	Yields in kg/ha total acreage								
	2006	2007	2008	2009	2010	2011	2012	2013	2014
Hallertau	1,701	1,844	2,190	1,706	1,893	2,151	2,090	1,638	2,293
Spalt	1,300	1,532	1,680	1,691	1,625	1,759	1,383	1,428	1,980
Tettnang	1,187	1,353	1,489	1,320	1,315	1,460	1,323	1,184	1,673
Bad. Rhinel.-Pal./Bitburg	1,818	2,029	1,988	1,937	1,839	2,202	2,353	1,953	2,421
Elbe-Saale	1,754	2,043	2,046	1,920	1,931	2,071	1,983	2,116	2,030
∅ Yield / ha **Germany**	**1,660 kg**	**1,819 kg**	**2,122 kg**	**1,697 kg**	**1,862 kg**	**2,091 kg**	**2,013 kg**	**1,635 kg**	**2,224 kg**
Total crop Germany (t and cwt.)	28,508 t 570,165	32,139 t 642,777	39,676 t 793,529	31,344 t 626,873	34,234 t 684,676	38,111 t 762,212	34,475 t 698,504	27,554 t 551,083	38,500 t 769,995
Acreage Germany	17,170	17,671	18,695	18,473	18,386	18,228	17,124	16,849	17,308

Tab. 3.8: Alpha-acid values for the various hop varieties

Region/Variety	2005	2006	2007	2008	2009	2010	2011	2012	2013	**2014**	∅ 5 years	∅ 10 years
Hallertau Hallertauer	4.4	2.4	3.9	4.4	4.2	3.8	5.0	4.6	3.3	**4.0**	**4.1**	**4.0**
Hallertau Hersbrucker	3.5	2.2	2.6	2.9	3.4	3.5	4.5	3.0	1.9	**2.1**	**3.0**	**3.0**
Hallertau Hall. Saphir	4.1	3.2	4.6	5.1	4.5	4.5	5.3	4.4	2.6	**3.9**	**4.1**	**4.2**
Hallertau Perle	7.8	6.2	7.9	8.5	9.2	7.5	9.6	8.1	5.4	**8.0**	**7.7**	**7.8**
Hallertau Spalter Select	5.2	4.3	4.7	5.4	5.7	5.7	6.4	5.1	3.3	**4.7**	**5.0**	**5.1**
Hallertau Hall. Tradition	6.3	4.8	6.0	7.5	6.8	6.5	7.1	6.7	5.0	**5.8**	**6.2**	**6.3**
Hallertau North. Brewer	9.8	6.4	9.1	10.5	10.4	9.7	10.9	9.9	6.6	**9.7**	**9.4**	**9.3**
Hallertau Hall. Magnum	13.8	12.8	12.6	15.7	14.6	13.3	14.9	14.3	12.6	**13.0**	**13.6**	**13.8**
Hallertau Nugget	11.3	10.2	10.7	12.0	12.8	11.5	13.0	12.2	9.3	**9.9**	**11.2**	**11.3**
Hallertau Hall. Taurus	16.2	15.1	16.1	17.9	17.1	16.3	17.4	17.0	15.9	**17.4**	**16.8**	**16.6**
Hallertau Herkules			16.1	17.3	17.3	16.1	17.2	17.1	16.5	**17.5**	**16.9**	
Tettnang Tettnanger	4.5	2.2	4.0	4.2	4.2	4.0	5.1	4.3	2.6	**4.1**	**4.0**	**3.9**
Tettnang Hallertauer	4.8	2.6	4.3	4.7	4.5	4.2	5.1	4.7	3.3	**4.6**	**4.4**	**4.3**
Spalt Spalter	4.3	2.8	4.6	4.1	4.4	3.7	4.8	4.1	2.8	**3.4**	**3.8**	**3.9**
Elbe-S. Hall. Magnum	14.4	12.4	13.3	12.2	13.7	13.1	13.7	14.1	12.6	**11.6**	**13.0**	**13.1**

Source: Working Group for Hop Analysis (AHA)

4 Hop breeding research

RDin Dr. Elisabeth Seigner, Dipl.-Biol.

By breeding new hop cultivars, the Work Group for Hop Breeding Research seeks to remain constantly at the cutting edge of developments. Breeding activities in Hüll encompass the entire hop spectrum, from the noble aroma hops through to super-high-alpha varieties and, of late, special-flavor hops, which have fruity, citrusy and floral aromas and thus appeal particularly to creative brewers. Aside from brewing quality and good agronomic performance, improved resistance mechanisms against major diseases and pests constitute the main criterion for selection of new seedlings, thus enabling German hop farmers to produce top-quality hops cost efficiently and with minimal environmental impact. Traditional cross-breeding has been supported for years by biotechnological methods. Virus-free planting stock, for example, can only be produced by way of meristem culture. Use is also made of molecular techniques in research work on the genetic material of hop plants and in the identification of hop pathogens.

4.1 Traditional breeding

4.1.1 Crosses in 2014

A total of 82 crosses were carried out during 2014. Table 4.1 shows the number of crosses performed for each breeding goal.

Tab. 4.1: Cross-breeding goals in 2014

Breeding programme combined with resistance/ tolerance towards various hop diseases	Further requirements	No. of crosses
Aroma type	Traditional aromas and resistances	25
	Special aromas and resistances	22
	High beta-acid content	2
High-alpha-acid type	Improved resistances	29
	High beta-acid content	4

4.1.2 Innovations in the selection of Hüll breeding lines

Objective

The aim of hop breeding is to develop high-performance cultivars that meet the market requirements of the brewing industry, including those of craft brewers, for traditional aroma- and high-alpha-type hops and, as of late, also for hops with especially fruity aromas (special-flavor hops). It goes without saying that the requirements of German hop growers and the national and international hop industry must also be met.

Results

In order to bring the development of new hop varieties more closely in line with the requirements and wishes of the hop and brewing industries, the LfL teamed up with the Society of Hop Research, the German Hop Growers' Association and the German Hop Trading Association to draw up and establish a new selection plan.

Healthy breeding stock – top priority

The time-tested procedures for the first phase of cultivar breeding, involving the performance of crosses, resistance tests and trial cultivation in the LfL's breeding yards, have not been radically changed but rather intensified. The LfL is responsible for all planning and decisions, giving healthy breeding stock the topmost priority. In implementing this goal, we have optimised the methods used for testing disease resistance/tolerance and intensified all our endeavours to provide healthy virus- and *Verticillium*-free planting stock for cultivation trials in our Stadelhof breeding yard and for the various field trials. To this end, for example, we routinely test all seedlings and breeding lines for *Verticillium* with a highly sensitive molecular technique (cf. 4.3). We also confirm, via RT-PCR and ELISA testing, that all plants are free of dangerous viral and viroid infections, as only *Verticllium*-free breeding stock free of dangerous viral and viroid infections is permitted for these cultivation trials in Stadelhof and commercial hop yards. Testing for resistance/tolerance towards powdery and downy mildew is performed right from the beginning. Test methods have been improved over the past few years and work is still being done to optimise them (cf. 2013 Annual Report and 1.2.1 in this Report).

A number of innovations agreed jointly by the LfL, GfH, the German Hop Trading Association and the German Hop Growers's Association are taking effect during the second phase of cultivar breeding, commencing with cultivation trials for promising breeding lines on hop farms and going right through to application by the GfH for registration of a new cultivar. Hop traders and brewers, in particular, have been involved more closely and on a broader basis in this selection process, with hop traders carrying the entire costs for in-row field trials of promising breeding lines on hop farms. Further innovations followed:

Hop expert group

A 15-member expert group in which representatives of the entire value added chain are pooling their expertise took up its work in January 2014:

- Aroma description and evaluation of interesting breeding lines, based on aroma, components, resistances, agronomics and breeding trials. The LfL is responsible for pre-selecting interesting lines.
- Proposing promising breeding lines for large-scale growing trials
- Drawing up a plan for standardised brewing trials
    - Pre-screening of breeding lines (on the basis of "dry-hopping" trials)
    - Full-scale brewing trials with breeding lines from large-scale growing trials
- Drawing up a catalogue for brewing-trial and brewing-results feedback

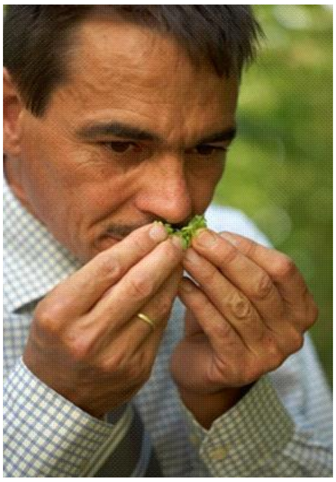
 

Fig. 4.1: Members of the GfH's expert group and Anton Lutz, breeder and head of this panel of experts, evaluating hop aroma

(Photos, with A. Lutz on the left, from Brauwelt No. 3, 57 -59, 2015: Lutz, A. and Seigner, E.)

Standardised brewing trials

Individual brewing trials with interesting breeding lines are now complemented by trials performed according to standardised specifications. The expert group has compiled a form to facilitate uniform reporting on the brewing trials. Brewing results based on standardised specifications furnish comparable findings relating to the flavour imparted to the beer by the breeding lines under test, bringing advantages to brewers, hop traders and the LfL alike.

The following two-stage plan for standardised brewing trials was drawn up by the expert group (Hanke et al., 2015). The GfH finances these brewing trials.

Phase 1: Pre-screening of interesting breeding lines by standardised dry-hopping trials designed to test whether organoleptically perceived hop aromas influence aroma and flavour in beer.

These trials are conducted at the Weihenstephan Research Brewery, Technical University of Munich/Weihenstephan, Chair of Brewing and Beverage Technology, Prof. Dr. Becker, under the direction of Dr. F. Schüll.

Phase 2: Follow-up brewing trials with breeding lines from large-scale growing trials, with assessment of bitter quality and whirlpool-aroma quality combined in each case with dry-hopping quality.

These brewing trials are perfomed at the Bitburger Brewery Group's experimental brewery under the direction of Dr. Stephan Hanke.

Phase 1 of the evaluation was implemented in 2014 with four aromatic breeding lines from which 34 beers were brewed. These were assessed according to the expert group's beer-tasting guidelines by numerous tasters as of February 2015. The evaluation-phase-two beers from the 2010/08/33 and 2010/72/20 breeding lines, which are already being grown in large-area trial plantings (see 4.1.3), have been available for tasting since March 2015.

Large-scale growing trials

Large-scale growing trials with breeding lines deemed promising on account of their resistance properties, agronomic performance, components and aroma are being set up on hop farms. These trials will not only furnish information on all cultivation aspects but also produce a sufficiently large harvest for processing studies and brewing trials. An additional advantage is that, in the event of cultivar registration, sufficient plant material will be available for propagation purposes.

The following procedure was laid down:

- The GfH's hop expert group recommends breeding lines for growing trials to the GfH's board members for their approval
- Growing is carried out under the direction of and at the expense of the applicant (GfH member)
- The aim is to plant up an area of at least one ha
- Growing-trial locations are limited to Germany
- The harvest is not certified and, as such, may not be marketed commercially
- The sale of beer obtained from brewing trials is permissible provided the breeding line is not named

Large-scale growing trials with two breeding lines, 2010/08/33 and 2010/72/20 (see details under 4.1.3), commenced in summer.

Fig. 4.2 is a diagram showing the development of a new hop cultivar. Close cooperation between all relevant business circles (GfH, hop growers, hop traders, hop processors and brewers) speeds up the selection of breeding lines for which the GfH files an application for cultivar registration and which are then launched on the market.

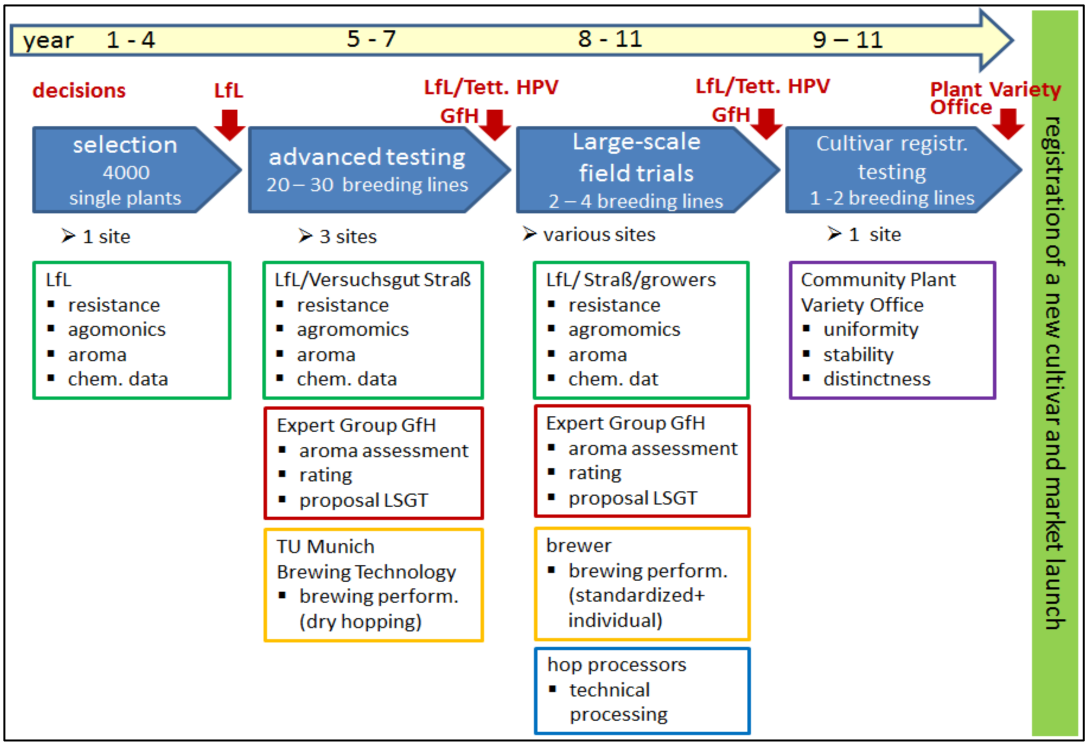


Fig. 4.2: Selection of a breeding line up to cultivar registration, in close cooperation between the LfL and all relevant business circles; GfH = GfH board members; LSGT = large-scale growing trial, CRT = cultivar registration testing (from Brauwelt Nr. 3, 57-59, 2015: Lutz, A. and Seigner, E.)

Referenzen

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4.1.3 **Breeding lines with special potential**

Objective

The primary aim of expanding traditional breeding by breeding hop cultivars with special citrusy, fruity, exotic and floral aromas that tend to be untypical of hops is to substantially improve the competitiveness of German hops on the world market.

Material and methods

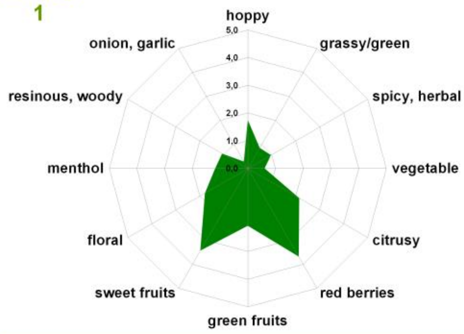
After being artificially inoculated with PM and downy mildew, the seedlings from special crosses were pre-selected on the basis of their resistance. These seedlings were then transferred to the vegetation hall for further selection based on sex, growth vigour and leaf health before being planted out in the field as single plants, where their performance was assessed for three years. The most promising seedlings were then transferred to two locations, where twice-replicated blocks of six plants each were assessed more closely *(Stammesprüfung).* Breeding lines with convincing resistance reactions, agronomic performance and components, including aroma, were cultivated in rows (60 – 200 plants/breeding line) on selected hop farms with experimental acreages. Breeding lines shown in the various tests to be healthy, have high performance potential and also traditional and interesting new aroma combinations were submitted for appraisal to the GfH's panel of experts (see 4.1.2). Two promising breeding lines with highly positive assessments were ultimately approved for large-scale field trials by the GfH's board members.

Results

In spring/summer 2014, after release of the two promising breeding lines, 2010/08/33 and 2010/72/20, large-scale growing trials commenced at the selected hop farms. These hectare-scale plantings furnish valuable findings in all areas and supplement those obtained from the LfL's own advanced trials *(Stammes- und Hauptprüfung)* and the row plantings on experimental acreages. Together, these findings form the basis of our current knowledge pool (see Fig. 4.3).

Aroma assessment

Ranking:
1

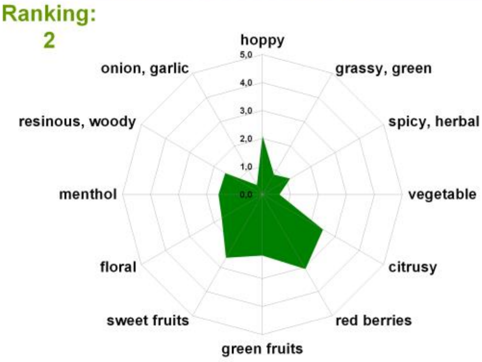


Pleasant hoppy aroma, intensively fruity, harmonious sweet fruits (apricot, passion fruit), red berries (blackberries, raspberries)

Current results from on-farm field trials	
Agronomic benefits	vigorous, homogenous, good twining ability, compact big cones, good yield potential
Agronomic disavantages	slightly topped, slightly hermaphrodite, low alpha acid contents; not suitable for production on sites which are prone to Verticillium wilt
Bitter substances (EBC 7.7):	
Alpha acids in % (w/w)	3.5 (2 - 5)
Beta acids in % (w/w)	7.0 (5 - 10)
Cohumulone (rel. in % of α-acids)	18 (15 - 21)
Xanthohumol in % (w/w)	0.5 (0.3 - 0.6)
Total oil content (EBC 7.10): ml/100 g hops	1.4 - 1.75
Aroma description	pleasant hoppy aroma, intensively fruity, harmonious, sweet fruits (apricot, passion fruit), red berries, raspberries
Trial brews	positive feedback

Aroma assessment

Ranking:
2



pleasant, mild, red berries (black currants), sweet fruits (peach, pear, tropical fruits, slightly resinous

Current results from on-farm field trials	
Agronomic benefits	vigorous, homogenous, robust, cylindrical, nice stature, good formation of laterals, good yield potential, very nice cones; fully powdery mildew resistant
Agronomic disadvantages	many large leaves
Bitter substances (EBC 7.7):	
Alpha acids in % (w/w)	10.5 (9 - 13)
Beta acids in % (w/w)	5.5 (4.5 - 6)
Cohumulone (rel. in % of α-acids)	42 (40 - 42)
Xanthohumol in % (w/w)	0.5 (0.45 - 0.55)
Total oil content (EBC 7.10): in ml/100 g hops	2.2 (2.1 - 2.4)
Aroma description	pleasant, mild, black currants, slight peach note, tropical fruits, slightly resinous
Trial brews	positive feedback

Fig. 4.3: Current knowledge base for the two breeding lines 2010/08/33 and 2010/20/72; chemical data provided by IPZ 5d

4.2 Research work on the increased occurrence of Verticillium infections

Objective

Hop wilt, caused by the soil fungi *Verticillium albo-atrum* and, less often, *Verticillium dahliae*, currently poses a major challenge to hop growers and hop researchers alike. The incidence of hop wilt on hop farms in the Hallertau has been increasing since 2005. Even varieties such as Northern Brewer and Perle, previously classified as *Verticillium*-tolerant, have been affected since then. Virulence tests on *Verticillium* strains found in the Hallertau, performed via artificial infection (Radišek et al., 2006), and, in particular, molecular biological techniques (Seefelder et al., 2009) have shown that not only mild but also highly aggressive *Verticillium* strains have now spread to Germany (Maurer et al., 2014). Whereas the Hüll breeding lines are able to tolerate attacks by mild strains of the hop-wilt fungus, these highly aggressive *Verticillium* strains kill off all the currently available Hüll hop varieties, including their roots (which is why they are often called "lethal" strains).

As no plant protective agents are available for combating *Verticillium*, other solutions must be found to help hop growers in Germany protect their crops from the huge threat posed by *Verticillium* wilt. One successful approach resulting from systematic research work has been the establishment of a molecular test which enables the fungus to be detected directly from hop bines (*"in-planta test"*) (Maurer et al., 2013) and with which healthy, *Vertcillium*-free planting stock can be identified very reliably and relatively quickly. *V. albo-atrum* and *V. dahliae* are listed as harmful organisms (Council Directive 2000/29/29) and are regarded worldwide as high-risk pathogens. This molecular detection system is therefore of major importance and has already proved to be a highly successful tool. It is used, for example, to guarantee that planting stock provided by the Hüll Hop Research Centre for further propagation is free of *Verticillium*. The method is also an integral part of all research activities related to the *Verticillium* fungus.

Material and methods

Molecular detection of *Verticillium*

The lower section of hop bines and, in special cases (infection tests, in particular on propagation material), also leaves and lateral stems were tested for *Verticillium* infection using the molecular *in-planta* test (Maurer et al. 2013a). The specially developed real-time PCR assay (Maurer et al., 2013) permitted simultaneous detection of *Verticillium albo-atrum* and *Verticillium dahliae*. The PCR was preceded by DNA isolation (hop DNA + fungal DNA) directly from hop bines using the Invisorb Spin Plant Mini Kit (Invitek) and a homogeniser (MP Biomedicals).

All the plants tested were sampled in duplicate and thus tested twice. In each real-time PCR assay, positive control (I) (*Verticillium*-DNA) and positive control (II) (*in-planta* DNA from an infected hop plant) were analysed simultaneously with the sample under test, as shown in Fig. 4.4.

A special primer (Seefelder, 2014) developed by the Work Group and endorsed by Dr. Radisek in a personal communication was used to distinguish between mild and aggressive forms of *Verticillium*.

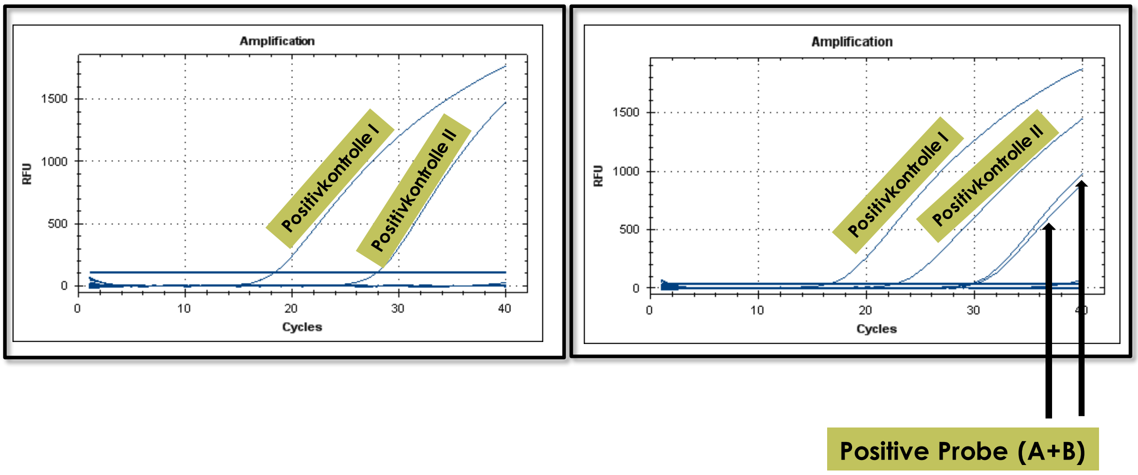


Fig. 4.4: Real-time PCR of a sample testing negative (left) and of one testing positive (right): one sample tested positive (sub-samples A and B).

Results

All the hop-bine samples taken from mother plants grown in a propagation facility tested negative in the real-time PCR assay. No *Verticillium* was detected. This test confirmed the results of the simultaneously conducted test in which bine sections were laid on selective media, where no *Verticillium* was detected, either. Of the 58 Hüll Hop Research Center breeding-line plants, one was found to have a latent *Verticillium* infection.

Outlook

Whereas very few hop stands in the Hallertau showed wilt symptoms in 2013 on account of the extremely hot weather, pronounced wilt damage was visible in 2014. The best way of finding a long-term solution to the *Verticillium* problem is to breed hop cultivars with significantly improved tolerance towards this dangerous soil fungus. Selecting wilt-tolerant breeding lines in hop yards has proved very difficult in years with prolonged heat waves because *Verticillium* growth is best at temperatures around 20 °C.

Referenzen

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5 Hop Cultivation/Production Techniques

LD Johann Portner, Dipl.-Ing. agr.

5.1 Nmin test in 2014

The N_{min} nitrogen fertiliser recommendation system has become an integral part of fertiliser planning on hop farms. In 2014, 490 hop farms (48 %) in the Hallertau and Spalt growing areas of Bavaria participated in the N_{min} test, with 2652 hop yards being tested for their N_{min} levels and the recommended amount of fertiliser calculated.

The chart below tracks the numbers of samples tested annually for N_{min} since 1983. N_{min} levels in Bavarian hop yards averaged 80 kg N/ha in 2014 and were thus distinctly higher than those of 2013 (52 kg N_{min}/ha), the probable reasons being low nitrogen take-up by the 2013 crop and the warm, dry winter, during which nitrogen transfer and leaching were minimal. At 150 kg N/ha, the average amount of fertiliser recommended for Bavarian hop yards, which is calculated from the N_{min} figure, was accordingly lower than in 2013.

As every year, levels fluctuated considerably from farm to farm and, within farms, from hop yard to hop yard and variety to variety, which means that it is still advisable to perform separate tests for determining ideal amounts of fertiliser for hop yards.

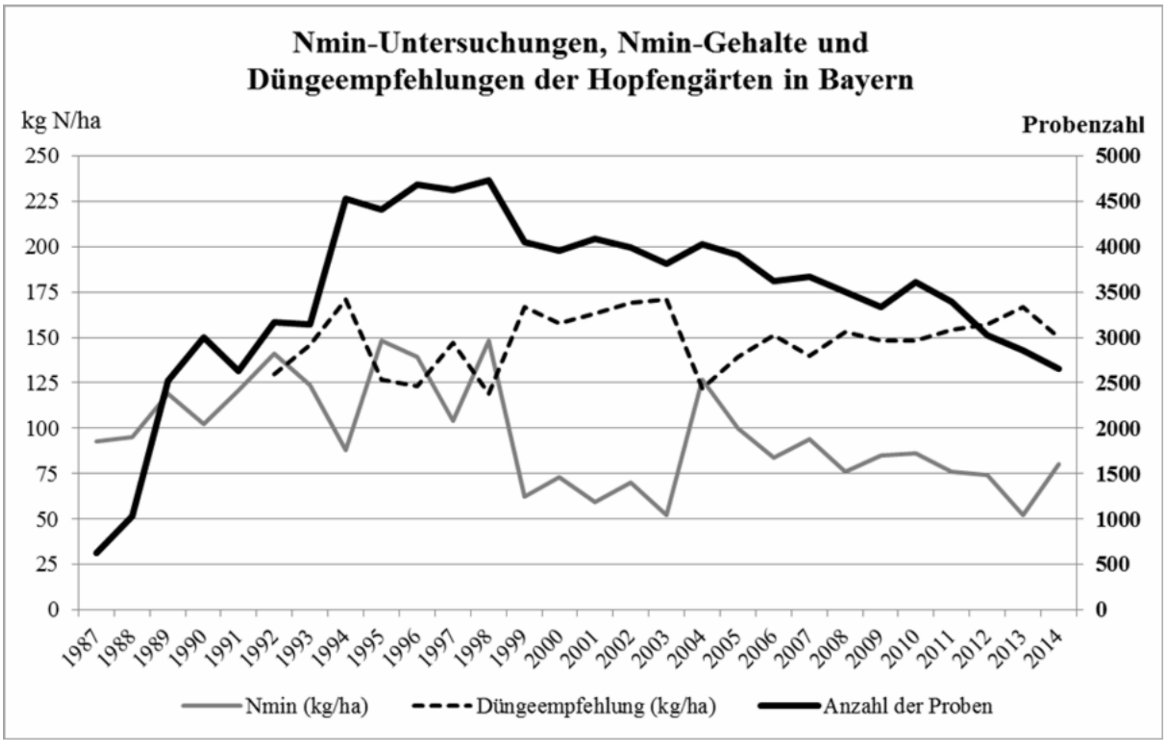

Fig. 5.1: N_{min} tests, N_{min} levels and recommended amounts of fertiliser in Bavarian hop yards over the years

The next table lists the number of hop yards tested, average N_{min} levels and average recommended amounts of fertiliser by administrative district and hop-growing region in Bavaria in 2014. It can be seen from the list that N_{min} levels are highest in the Hersbruck quality-seal district, while levels in the Spalt growing area are below average. N_{min} levels in the Hallertau region were lowest in the Landshut district.

Tab. 5.1: Number, average N_{min} levels and fertiliser recommendations for hop yards by administrative district and region in Bavaria in 2014

District/Region	**Number of samples**	**N_{min} kg N/ha**	**Fertiliser recommendation kg N/ha**
*SD Hersbruck	48	132	94
Eichstätt (plus Kinding)	213	88	151
Pfaffenhofen	927	80	151
Kelheim	1011	80	152
Freising	260	77	154
SD Spalt (minus Kinding)	73	70	140
Landshut	120	66	154
Bavaria	**2652**	**80**	**150**

*SD = quality **s**eal **d**istrict

The following table lists N_{min} levels by variety and recommended fertiliser amount.

Tab. 5.2: Number, average N_{min} levels and fertiliser recommendation in 2014 for various hop varieties in Bavaria

Variety	**No. of samples**	**N_{min} kg N/ha**	**Fertiliser recommendation kg N/ha**
Herkules	535	73	171
Hall. Magnum	337	68	158
Nugget	21	73	155
Hall. Taurus	140	80	149
Hallertauer Mfr.	154	65	146
Hersbrucker Spät	186	85	145
Perle	497	86	142
Hall. Tradition	492	90	142
Spalter Select	102	91	139
Spalter	40	67	139
Saphir	57	92	136
Northern Brewer	38	99	136
Mandarina Bavaria	13	100	130
Other	40	86	144
Bavaria	**2652**	**80**	**150**

5.2 Influence of variations in drying temperature and harvesting times on total oil content of Mandarina Bavaria

Initial situation and objective

It has been shown in numerous trials aimed at optimising hop drying that drying performance and external hop quality mainly depend on whether the right air speed is selected relative to cone depth and drying temperature. To investigate the effects of variations in drying temperature and harvesting times on internal quality, flavor hops were dried in small-scale driers and total oil content as well as selected individual oil components analysed.

Method

Hop cones of the Mandarina Bavaria variety were harvested on eight different harvesting dates and dried in small-scale driers at drying temperatures of 60° C, 65° C and 70 °C. The hops for the drying variants were grown on a commercial hop farm. Prior to harvesting, plants were selected at random and earmarked for each of the harvesting dates. Eight harvesting dates falling on Mondays and Thursdays were selected in the period from 27.08.2013 (D1) to 23.09.2013 (D8). The green hops harvested on each of these dates were distributed over six small-scale driers, each with a drying surface of 30 x 30 cm. With an initial load per drier of 2.5 kg green hops, the average loading depth came to 22 cm. The hop samples were dried at temperatures of 60°, 65° and 70°, the temperature being set manually on the driers. An air speed of over 0.4 m/s was selected for all the drying variants, thereby ensuring that at the start of drying, when the water extracted from the cones was at a maximum, it was expelled completely via the drying-air stream in all the drying variants. This was an important prerequisite for preventing impairment of external quality. The hop cones in the drier were turned and stirred at regular intervals to ensure a uniform flow of drying air and thus even drying. The targeted moisture content of approx. 9 % at the end of drying was ascertained by weighing, the required final weight first having been calculated via the dry-matter content. The dried hops were conditioned in paper sacks until they were fully homogeneous. Hop samples dried at each of the different trial temperatures were pooled and analysed in the Hüll hop laboratory headed by Dr. Klaus Kammhuber. In addition to routine analysis, the total oil content and the individual oil components were determined.

Results and discussion

Drying was terminated when the targeted weight had been reached, thereby ensuring that all samples harvested on the same date and dried at the different temperatures had the same final moisture content. This enabled us to compare the different drying variants. What was also crucial in this context was that, at an average moisture content of 9.8 %, the hop samples were not overdried. The average drying time at a drying temperature of 70 °C was 180-200 minutes. Additional drying times of 20-30 minutes were needed on average to achieve the same end weight at 65 °C and of 60-80 minutes at 60 °C.

The analyses show that temperature did not influence either total-oil content or individual oil components such as myrcene, linalool, ß-caryophyllene, humulene and geraniol.

The results are only isolated figures that cannot be statistically corroborated, as this would require a considerable amount of time-consuming experimental and analytical work. Even so, it may be concluded from the raw data obtained that only the harvesting date and not the drying temperature influences total oil content and the individual oil components. We plan to conduct further trials to confirm this finding.

5.3 Reaction of Hallertauer Tradition to reduced trellis height (6m)

Goal

Disastrous storm damage during the last few years, which caused hop trellis systems in the Hallertau region to collapse prior to harvesting, prompted studies to investigate whether trellis height can be reduced to 6 m without compromising yields. According to initial calculations, this measure would reduce the static load on the Hallertau trellis system by around 15 - 20 % and greatly improve its stability under conditions of extreme wind velocities.

In addition, trellis costs could be reduced without impairing stability through the use of shorter, weaker central poles. Potential plant protection benefits might exist as well because target areas would be closer to the sprayer. The tops of the plants would receive more spray, drift would be reduced and new PPA-application techniques might even be possible.

The reaction of the aroma varieties Perle and Hallertauer Tradition and of the bitter varieties Hallertauer Magnum, Hallertauer Taurus and Herkules to reduced trellis height (plant growth, susceptibility to disease/pests, yield and quality) had already been tested in a number of commercial hop yards in an earlier project. The results were published in the 2011 Annual Report. These trials are being repeated at other locations so that general recommendations can be drawn up for hop farmers. Whereas the tests in the Stadelhof trial yard have not yet been concluded, the results of the three-year trial with Hallertau Tradition at a location near Pfeffenhausen were evaluated in 2014.

Method

In the search for a suitable location, the soil was assessed very thoroughly so as to provide, as far as possible, the same starting conditions for the variants. The trial yard was divided into 4 equal-size plots, each of which was 10 pole intervals long and one pole interval wide. The trellis height in two plots was reduced from 7 m to 6 m by putting up additional wire netting. The two-pole-wide 6-m trellis was thus directly adjacent to the 7-m trellis.

In each plot, twice replicated randomized trial blocks of 20 adjacent hop plants were earmarked for harvesting. It was agreed with the hop grower that the trial plot should be farmed conventionally to ensure a uniform approach to plant protection measures, fertilisation and tillage in all four plots so as not to impair the results obtained for the 6-m plants.

Fig. 5.2: 7-m trellis reduced to 6 m by additional wire netting

Yield, alpha-acid content and moisture content of the green cones were measured for the harvested trial blocks. During the trial years, cone samples from each plot were examined for cone formation and disease. No differences were ascertained.

Results

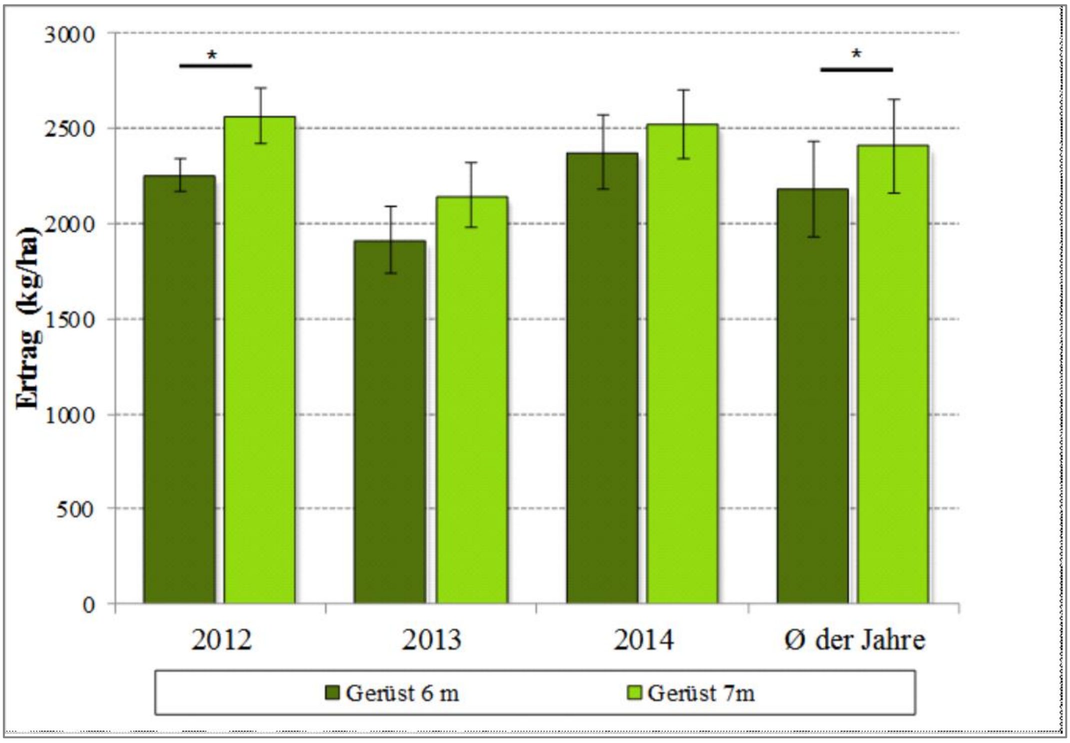

Fig. 5.3: Influence of trellis height on yield for Hallertauer Tradition

*Comparison of yields (kg/ha), with standard deviations, obtained on 6-m and 7-m trellises for the aroma variety Hallertauer Tradition (n = 12). Significant differences in yield were tested intraspecifically via multifactor ANOVAs and characterised (p < 0,05 *, p < 0,01 ** and p < 0,001***).*

Notable differences in yield were recorded for the 6-m and 7-m Hallertauer Tradition variants at the Pfeffenhausen location, with the yield deficit measured in 2012 and the deficit as averaged over the three trial years for the 6-m variant being statistically significant.

The extent of the trend towards higher yields on 7-m trellises, found in all varieties, varied from variety to variety; so far, however, the difference was statistically significant at two locations only, for Hallertauer Tradition and Herkules. It should be noted that both these locations are excellent for hop-growing.

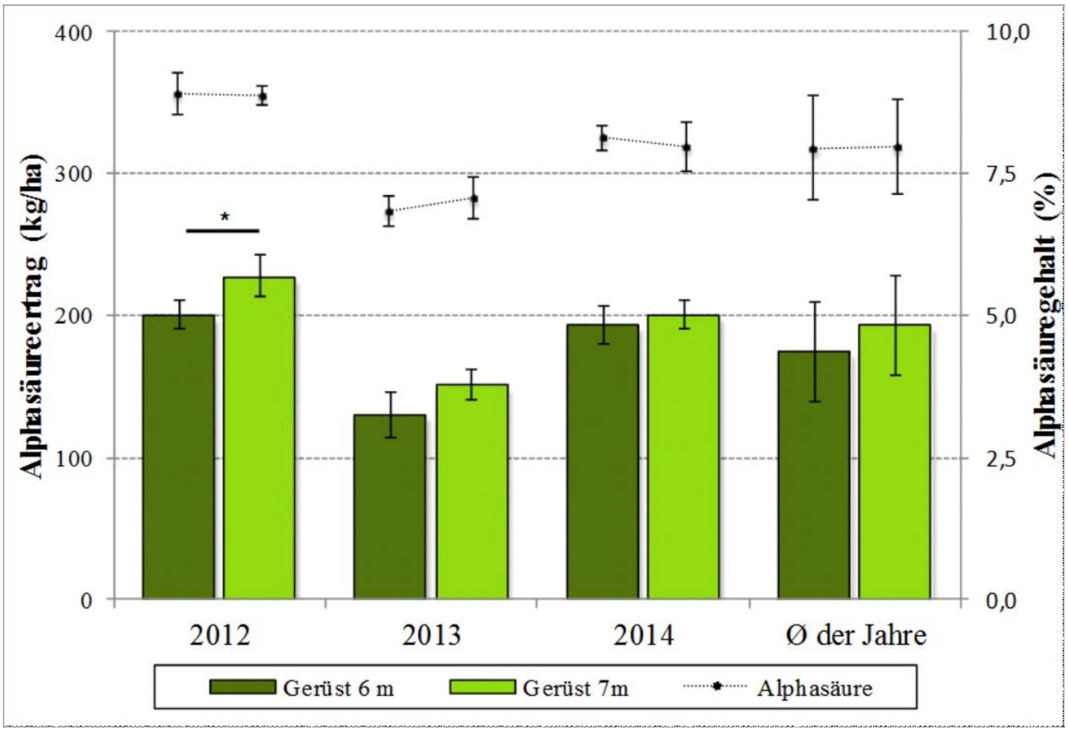

Fig. 5.4: Influence of trellis height on alpha-acid content and yield for Hallertauer Tradition

*Comparison of alpha-acid content (%) and alpha-acid yield (kg/ha) obtained on 6-m and 7-m trellises for the aroma variety Hallertauer Tradition (n = 12). Significant differences in yield were tested intraspecifically via multifactor ANOVAs and characterised ($p < 0,05$ *, $p < 0,01$ ** and $p < 0,001$***).*

The small differences in alpha-acid content are negligible. The trend towards higher alpha-acid yields on 7-m trellises was only statistically significant in 2012.

5.4 LfL projects within the Production and Quality Initiative

As part of a production and quality campaign on behalf of agriculture in Bavaria, the Bavarian State Research Center for Agriculture has launched the second phase of a programme to collect, record and evaluate representative yield and quality data for selected agricultural crops from 2014 – 2018. The first phase of the programme ran from 2009 – 2013. This work is performed on behalf of the hops department of the Institute for Crop Science and Plant breeding by its advisory service partner Hallertau Hop Producers' Ring. The goals of the new hop projects are described briefly below, and the 2014 results summarised.

5.4.1 **Annual survey, examination and evaluation of post-harvest hop quality data**

Dry-matter and alpha-acid monitoring

One trained bine was harvested weekly from each of three aroma and three bitter varieties growing in ten commercial hop yards spread over the Hallertau on five (aroma varieties) and seven (bitter varieties) dates from 19.08. - 30.09.2014 and dried separately to a final moisture content of approx. 10 %. On the following day, an accredited laboratory determined the alpha-acid content at 10 % moisture and the dry-matter content of the green hops. These data were communicated to the LfL's hop expert group for evaluation. The averaged results were posted on the internet in the form of tables and charts, enabling hop growers to read off the optimal harvesting times for the major hop varieties.

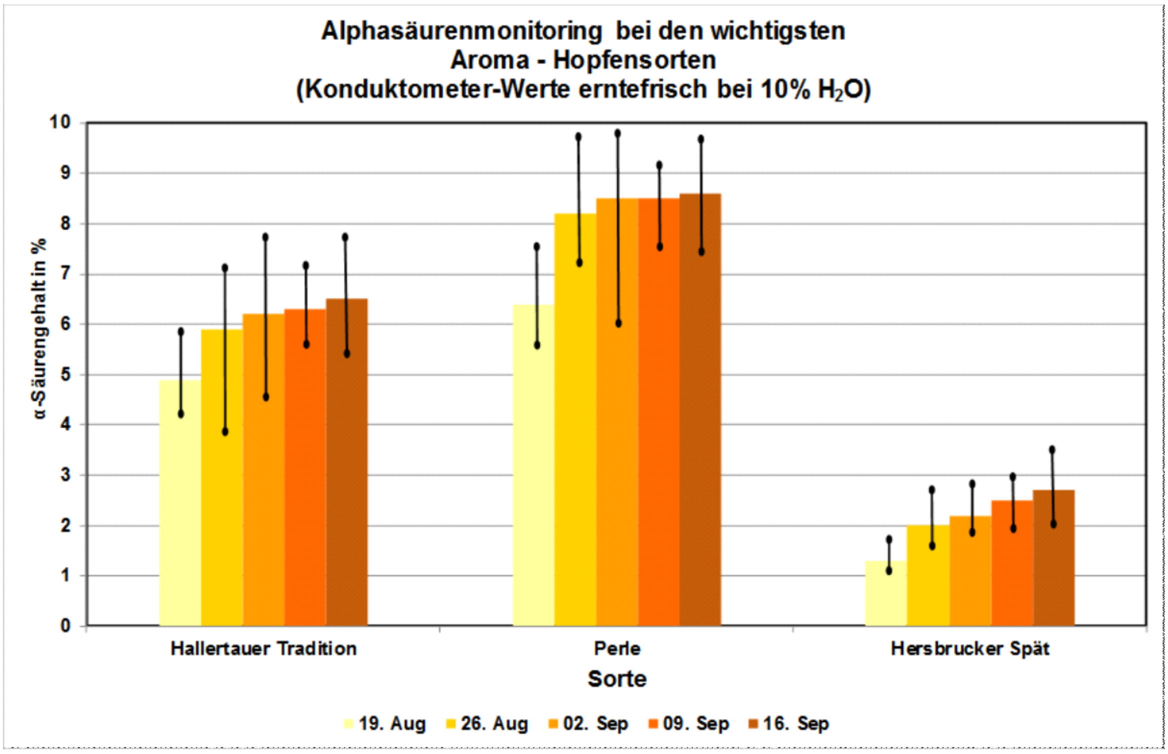

Fig. 5.5: Alpha-acid monitoring for the major aroma varieties in 2014

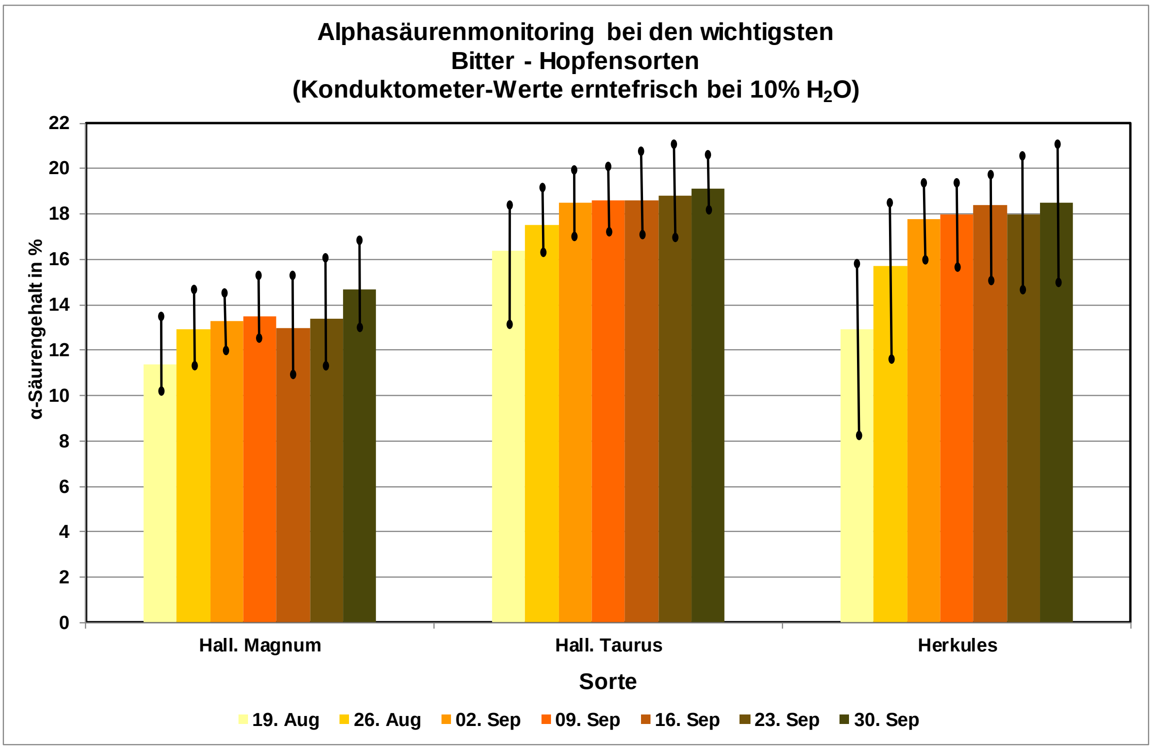

Fig. 5.6: Alpha-acid monitoring for the major high-alpha varieties in 2014

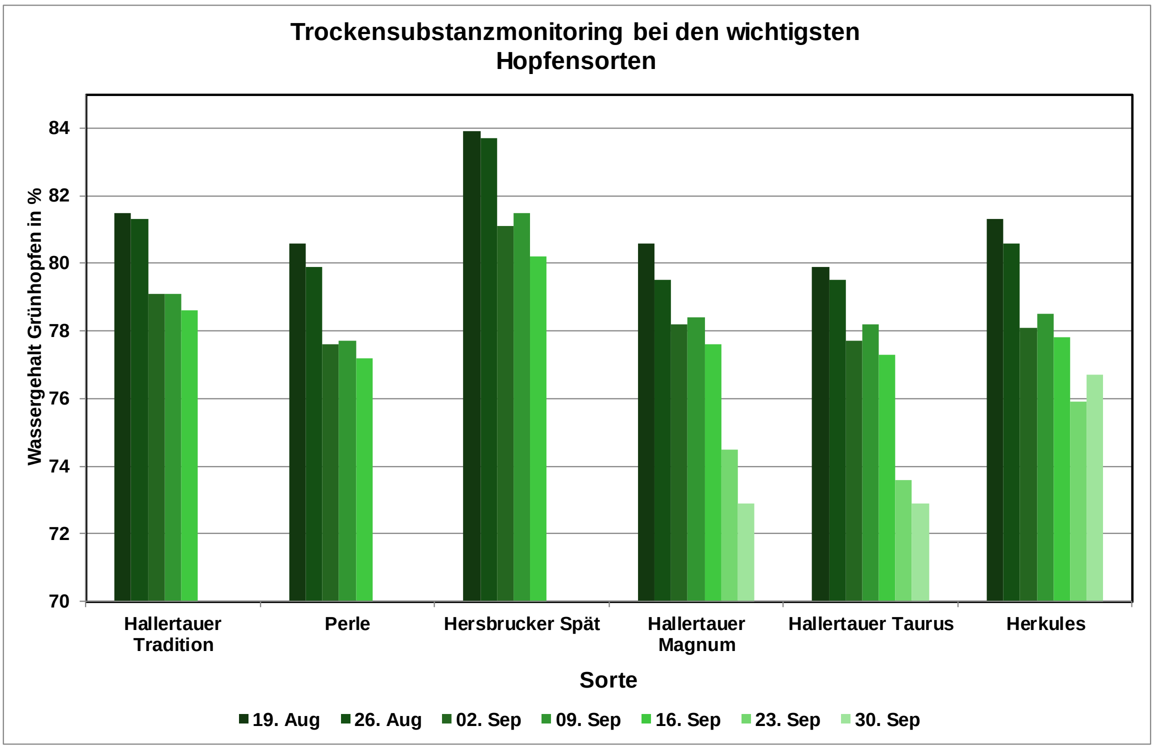

Fig. 5.7: Dry-matter monitoring for the major hop varieties in 2014

Influence of location and production-related measures on hop quality

Quality data collected within the framework of the NQF provide valuable information on hop quality in the year in question and indicate disease/pest susceptibility, production-related errors or incorrect treatment of harvested hops.

During the project it is planned to supplement the neutral quality assessments of 150 lots of HT, PE, HM and HS with the relevant alpha-acid contents and selected location- and production-related data. It is hoped that evaluation of a combination of location-specific parameters and production-related measures with quality-related data will provide a valuable basis for recommendations.

As only 94 of the expected 600 data sets were submitted in 2014, stratification and evaluation were not possible.

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

Surveys and accurate assessments of aphid and spider-mite infestations in commercial hop yards are necessary in order to provide advice and develop control strategies.

To this end, weekly assessments of hop-aphid and common spider-mite infestations were conducted on 10 dates in 30 representative hop yards (planted with various cultivars) in the Hallertau (22), Spalt (5) and Hersbruck (3) growing regions and average infestation with aphids (count) and spider mites (infestation index) calculated.

The infestation findings were used to provide advice and develop control strategies.

5.4.3 Ring analyses to verify the quality of alpha-acid assays for hop supply contracts

For years, supplementary agreements to hop supply contracts have stipulated that the alpha-acid content of the hop lots delivered be taken into account in the hop price. Alpha-acid contents are determined in state-owned, company and private laboratories, depending on available testing capacity. The specification compiled by the Working Group for Hop Analysis (AHA) contains a precise description of the procedure (sample division and storage), lays down which laboratories carry out post-analyses and defines the tolerance ranges permissible for the analysis results. Ring analyses are organised, carried out and evaluated by the LfL in its capacity as an unbiased organisation so as to guarantee high-quality alpha-acid analyses in the interest of the hop growers.

Within this project, it is the task of the Hop Producers’ Ring to sample a total of 60 randomly selected hop lots in the Hallertau on 9 - 10 sampling dates and to supply the samples to the LfL’s Hüll laboratory.

5.5 Leader project: “Hallertau model for resource-saving hop farming”

Initial situation and objective

Hop farming is the main form of crop husbandry in the Hallertau region. The focus on hop farming in this region has evolved over time and has shaped the cultural landscape. Hop cultivation is resource-intensive and therefore harbours ecological risks, one of which is the high degree of soil erosion susceptibility associated especially with row crops such as hops. Another is the large amount of nitrogen needed in hop-growing in order to obtain optimum yields and qualities. The problem here is that hop plants take up most of their nitrogen relatively late in the vegetation season, from mid-June to August. Nitrogen remaining in the soil can no longer be used in autumn and winter and is subject to displacement or even leaching. Minimizing nitrogen leaching, however, is a crucial water-conservation issue. Scientific studies have also shown that nitrogen absorption in hop is poor, necessitating a rich supply of nitrogen if optimal yields are to be obtained. The nitrogen is often taken up incompletely, remaining in the soil after harvesting in the form of nitrate.

Within the leader model project of the Hallertau water board, in which various partners from agencies and associations work together, the aim is to investigate whether modified nitrogen strategies will enable commercial hop farming to remain feasible without neglecting groundwater protection requirements.

Method

Initial trials in the Hallertau region and in Thuringia showed that if fertiliser is applied by banding (2-m band) rather than broadcasting, the same yield can be achieved with approx. a third less fertiliser. One aim of the research project “Hallertau model for resource-saving hop farming”, scheduled to run from 2009-2015, is to verify this finding. To achieve this aim, N-fertilisation trials will be performed in several replications, in which N application by broadcasting (240 kg N minus N_{min}) is compared with banded application (2-m band) using a third less fertiliser. In order to obtain insight into nitrogen dynamics in the soil around the hop plants, we intended to simultaneously measure substance transfer at various depths (0.5 m, 1.2 m, 2.0 m and 4.0 m) in the soil of the different variants using suction cups. Limited project funding meant we could only install a suction-cup system in one replication, making a statistically significant yield evaluation of a trial harvest impossible. Twenty hop plants were nevertheless harvested at our own expense from each of the plots fertilised by broadcasting or banding. The yields were determined and the alpha-acid contents measured.

Results

The trial crop was not harvested in 2010 because severe infection with primary downy-mildew had caused highly disparate plant growth. It was also feared that, on account of the extensive digging activity connected with installation of the suction-cup system in spring 2010, the soil profile would still be disturbed to such an extent as to preclude uniform soil and growing conditions.

The following chart shows the average kg/ha figures obtained for crop and alpha yields over the years 2011-2014 as well as alpha-acid content in %. These figures only indicate a trend and cannot be rated as a finding on account of the lack of replications.

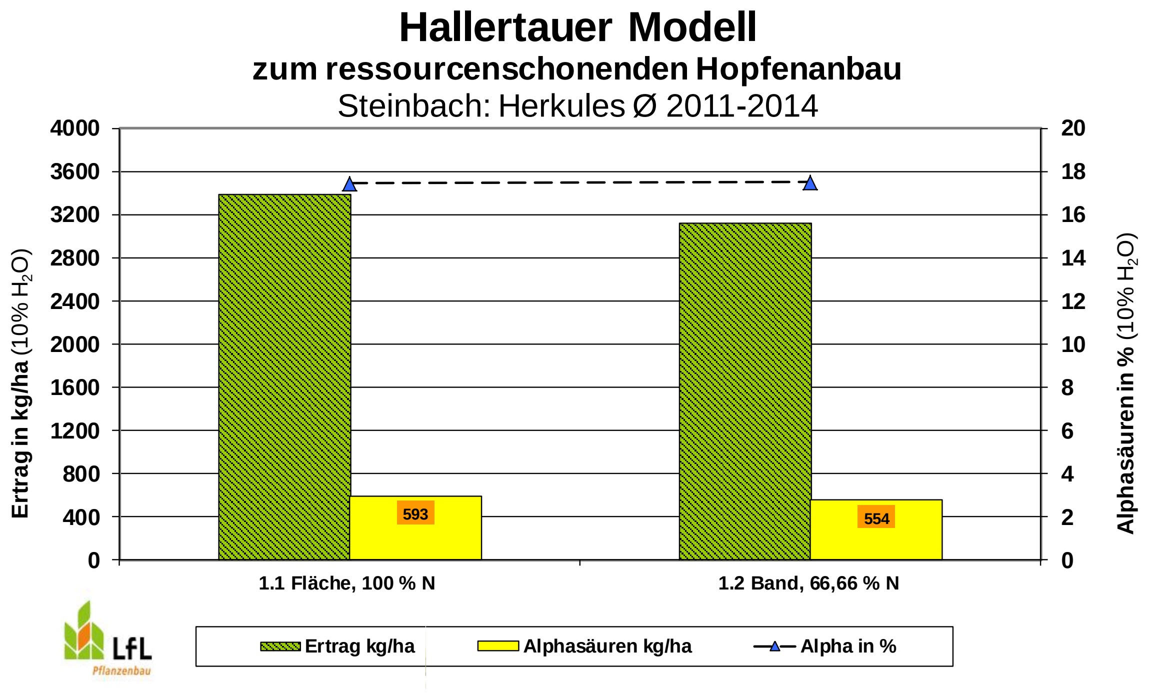

Fig. 5.8: Trend graph of yield, alpha-acid content and alpha-acid yield/ha in plots fertilised by broadcasting and banding

With increasing trial duration, the plot fertilised by banding (1/3 less N fertiliser) reacted negatively – both optically and in respect of yield – to the lower amount of N fertiliser, making it impossible to confirm the earlier trial results from the Hallertau and Thuringia.

However, given the lack of an accurate, multiple-replication trial setup and harvesting regime, no reliable conclusions can be drawn and certainly no fertiliser recommendations made on the basis of these findings.

5.6 Advisory and training activities

Besides applied research on production techniques for hop cultivation, the Hop Cultivation/Production Techniques work group (IPZ 5a) processes trial results for practical application and makes them directly available to hop farmers by way of special consultations, training and instruction sessions, workshops, seminars, lectures, print media and the internet. The work group is also responsible for organising and implementing the downy mildew warning service and updating the relevant data, cooperating with the hop organisations and providing training and expert support for its joint service provider, the Hop Producers' Ring.

The group's training and advisory activities in 2014 are summarized below:

Written information

- The 2014 "Green Pamphlet" entitled "Hops – Cultivation, Varieties, Fertilisation, Plant Protection and Harvest" was updated jointly with the Plant Protection in Hop Growing work group following consultation with the advisory authorities of the German states of Baden-Württemberg and Thuringia. 2450 copies were distributed by the LfL to the national offices for food, agriculture and forestry (ÄELF) and research facilities, and by the Hallertau Hop Producers' Ring to hop growers.
- 24 of the 52 faxes sent in 2014 (52 for the Hallertau region + 5 for Spalt +1 for Hersbruck) by the Hop Producers' Ring to 1,198 hop growers contained up-to-the minute information from the work group on hop cultivation and spray warnings.
- 2652 soil-test results obtained within the context of the N_{min} nitrogen fertilisation recommendation system were checked for plausibility and approved for issue to hop-growers.
- Advisory notes and specialist articles were published for hop-growers in 2 circulars issued by the Hop Producers' Ring and in 8 monthly issues of the Hopfen Rundschau.
- 48 field records were evaluated by a working group with the hop-card-index (HSK) recording and evaluation program and returned to farmers in written form.

Internet and Intranet

Warnings and advice, specialist articles and papers were made available to hop-growers via the internet.

Telephone advice and message services

- The downy-mildew warning service, provided jointly by the WG Hop Cultivation/Production Techniques (Wolnzach) and the WG Plant Protection in Hop Growing (Hüll) and updated 74 times during the period from 13.05.2014 to 29.08.2014, was available via the answerphone (Tel. 08442/9257-60 and 61) or internet.
- Consultants from the Hop Cultivation/Production Techniques work group answered around 2,200 special questions by telephone or provided advice in one-to-one consultations, some of them on site.

Talks, conferences, guided tours, training sessions and meetings

- 6 training sessions for consultants from the Hop Producers' Ring
- Weekly note swapping with the Ring experts during the vegetation period
- 9 meetings on hop cultivation, organised jointly with the Offices for Food, Agriculture and Forestry (ÄELF)
- 45 talks
- 6 guided tours through trial facilities for hop growers and the hop industry
- 5 conferences, trade events and seminars

Basic and advanced training

- Setting of 5 Master’s examination topics and assessment of 4 work projects for the examination
- 16 lessons for hop-cultivation students at the Pfaffenhofen School of Agriculture
- 1-day course during the summer semester at the Pfaffenhofen School of Agriculture
- Exam preparation and examination of agricultural trainees focusing on hop cultivation
- 1 information event for pupils at Pfaffenhofen vocational school
- 6 meetings with the “Business Management for Hop Growers” working group

6 Plant Protection in Hop Growing

LD Wolfgang Sichelstiel, Dipl.-Ing. agr.

6.1 Pests and diseases in hops

6.1.1 Aphids

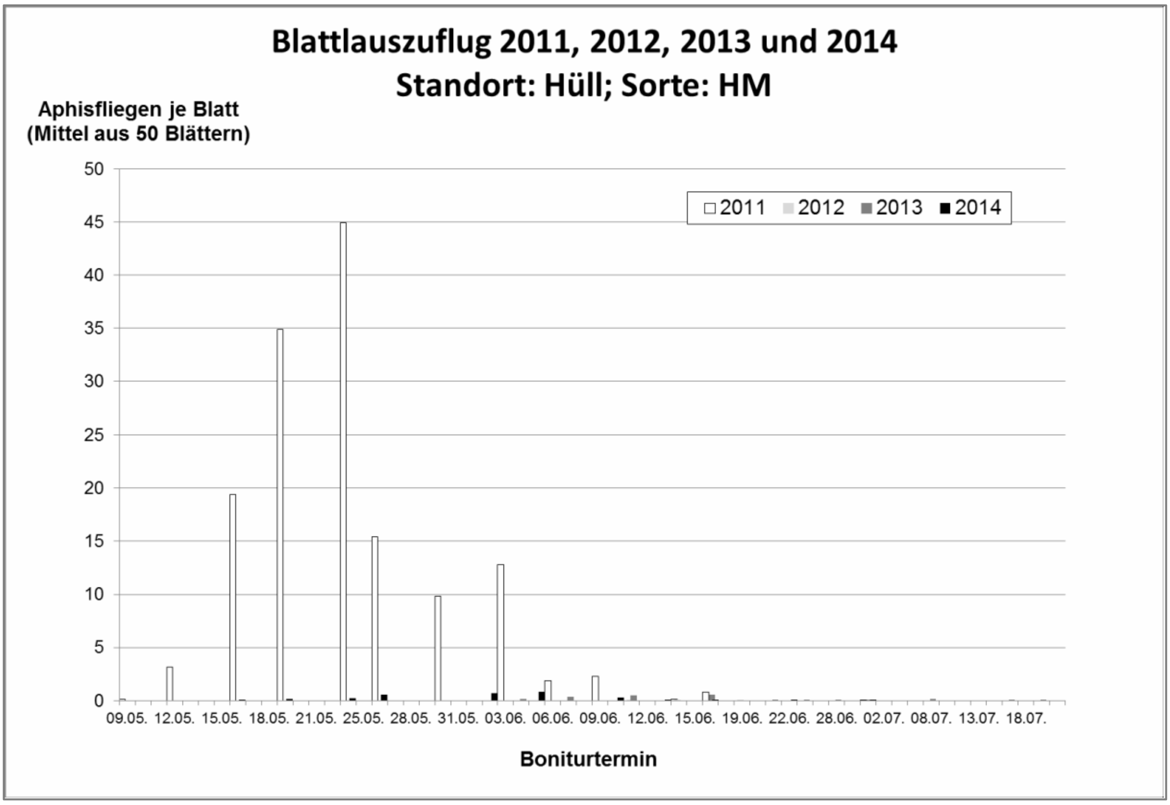

Fig. 6.1: Aphid migration

Tab. 6.1: Pest monitoring at 30 locations in the Bavarian hop-growing areas in 2014

Date	Aphids per leaf			Spider mites per leaf		
	Ø	min.	max.	Ø	min.	max.
26.05.	0.29	0.00	1.42	0.06	0.00	0.65
02.06.	0.53	0.00	3.78	0.06	0.00	0.85
10.06.	0.95	0.00	11.72	0.10	0.00	0.80
16.06.	0.27	0.00	2.50	0.12	0.00	0.80
23.06.	0.49	0.00	6.26	0.09	0.00	0.90
30.06.	1.05	0.00	1.80	0.25	0.00	1.35
07.07.	1.67	0.00	19.70	0.19	0.00	1.15
14.07.	2.74	0.00	46.90	0.13	0.00	1.15
21.07.	0.18	0.00	2.00	0.08	0.00	0.55
28.07.	0.09	0.00	1.76	0.08	0.00	0.55
	Main spraying dates 04.07. - 18.07.2014 23 locations untreated			Main spraying dates 17.06 - 18.07.2014 3 locations untreated		

As in the two preceding years, hop-aphid outbreaks were rare in 2014 and migration levels were extremely low. In many cases, it was unnecessary to take any hop-aphid control measures. Low to moderate levels of infestation justifying at least one precautionary treatment were observed in one third of the hop yards in mid-July.

Spider-mite outbreaks justifying treatment occurred in isolated cases as of mid-June and, in a maximum of one third of the hop yards under observation, as of mid-July. In almost all cases, one treatment sufficed to keep infestation under control. In three hop yards, infestation levels were so low as to make treatment unnecessary.

6.1.2 Downy mildew

Tab. 6.2: Downy- and powdery-mildew information and spray warnings faxed by the Hop Producers' Ring in 2014

Fax No.	Date	Info.	Spray warnings			
		Primary downy mildew	Secondary downy mildew			Powdery mildew
			Suscep. cultivars	All cultivars	Late cultivars	
16	16.04.	x				
19	13.05.	x				
21	22.05.	x		x		Susceptible cvs
23	05.06.	x				If diseased
25	10.06.	x	x			If diseased
29	02.07.					If diseased
32	11.07.					x
35	24.07.			x		x
37	01.08.			x		x
40	12.08.			x		Susceptible cvs
42	28.08.				x	x

6.2 Release and establishment of predatory mites for sustainable spider-mite control in hops

Introduction and goal

The two-spotted spider mite, *Tetranychus urticae,* is a major pest in hop growing, causing immense cone damage and sometimes even complete crop failure in warm years. Currently, there are no effective plant protection agents available to organic hop farmers.

Trials conducted over the last two decades at the Hüll hop research institute (e.g. WEIHRAUCH 2008) have shown that spider-mite populations in hop fields can be kept under satisfactory control via release of purchased laboratory-bred predatory mites.

The aim of this project, funded by the Federal Agency for Agriculture and Food (BÖLN project No. 2812NA014), is to develop a standard spider-mite control method that is an effective and economically viable alternative to acaricide use. To this end, we intend to create overwintering habitats that will enable the establishment of indigenous predatory mites, in particular *Typhlodromus pyri*. The project is currently scheduled to run from June 2013 to April 2016.

In agricultural practice, the best-known examples of successfully established predatory-mite populations, especially the indigenous *Typhlodromus pyri* species, are those in fruit orchards and vineyards; their success is due to the fact that the mites can overwinter directly beneath loose bark or suberised pruning wounds on trees. This is not possible in hop fields because the aerial parts of the hop plants, and with them potential overwintering shelters, are completely removed during harvesting. The plan, therefore, is to sow ground cover in the tractor aisles, thereby creating suitable winter habitats and enabling the establishment of a constant population of predatory mites that will colonise the ground cover over a number of vegetation periods and reduce the annual cost of purchasing additional predatory mites.

Trials conducted by AGUILAR- FENOLLOSA et al. (2011 a, b, c) demonstrated that undersown tall fescue grass *(Festuca arundinaceae)* in stands of clementines was accepted as a habitat by predatory mites and led to a reduction in the spider-mite population in the citrus crop. In 1992, SCHWEIZER demonstrated that a cover of certain weeds, especially small-flowered quickweed *(Galinsoga parviflora)*, reduced the spider-mite population on hop plants because, for a certain time, the spider mites show a preference for these weeds over hop plants. This finding was confirmed in subsequent investigations conducted by WEIHRAUCH (1996) in the Hallertau growing region with an undersown weed cover of G. parviflora. Further observations (WEIHRAUCH 2007) showed that a dense population of predatory mites had colonised stinging nettle plants growing all along the edge of a hop yard. In addition to influencing spider-mite populations on hop plants, undersown ground cover might therefore also promote the abundancy and diversity of predatory mites and serve as a natural habitat and overwintering shelter. *Festuca arundinaceae*, the most promising species, was selected for the current project.

In 2013, the first trial season, small-flowered quickweed *(Galinsoga parviflora)* and stinging nettle *(Urtica dioica)* were also included in the trials but were replaced in 2014 because adverse weather conditions and poor germination prevented the establishment of a weed cover in the respective plots. In 2014, strawberries were planted in place of stinging nettle and a grassland mixture (BQSM-D2a) was sown in place of quickweed. Among other grasses, this mixture contains meadow foxtail, meadow-grass and meadow fescue. Studies conducted by ENGEL (1991) showed that *T. pyri* feeds almost exclusively on the pollen from these grasses when they flower at the end of May, which means they play a major role for this spider-mite species. These findings suggest that this grassland mixture might serve as an alternative source of nutrition for *T. pyri* and might attract these mites in spring and keep them in the hop stand even if a spider-mite population has yet to build up.

A further aim is to optimise the release method, release rate, release frequency and release timing for laboratory-bred predatory mites. In the trial, use was made of the autochthonous predatory mites (a) *Typhlodromus pyri* and (b) *Amblyseius andersoni*, with attention focusing on their overwintering capability. For comparison, a mixture of the allochthonous predatory-mite species (c) *Phytoseiulus persimilis* and *Neoseiulus californicus* (mix) was tested for its effectiveness under field conditions.

The carrier material was either felt strips (*T. pyri*), bean leaves (mix) or vermiculite (mix and *A. andersoni*). Distribution of the vermiculite with the Airbug blower was tested for the first time in 2014.

Material and methods

Trial location and trial design

The trials were carried out in cooperation with four farmers, who made some of their hop-farming acreage available for the trial. Two of the farmers manage their hop acreages conventionally and two in accordance with Bioland standards. The trial acreages were spread across the Hallertau and the Hersbruck growing area as follows:

Tab. 6.3: Locations and breakdown of trial designs

Location	District	Cultivar	Design
Hüll	PAF	Herkules	1-factor block
Oberulrain	KEH	Perle	2-factor block
Ursbach (Bioland)	KEH	Hallertauer Tradition	1-factor block
Großbellhofen (Bioland)	LAU	Opal	
Benzendorf (Bioland)	ERH	Smaragd	

Each location was assigned a different trial variant, for which, except at Oberulrain, unifactorial blocks were pegged out in fourfold replication. At Oberulrain, a 2-factorial block was pegged out so as to enable detection of interactions between the ground cover and predatory mites.

Each plot measured approx. 600 m² (30 m long and 20 m wide) and was planted with 108 hop plants = 216 trained bines/plot. The following trial variants were set up:

(1) *Typhlodromus pyri*, ground cover: tall fescue grass

(2) *Typhlodromus pyri*, ground cover in 2013: stinging nettle; in 2014: strawberries

(3) *Typhlodromus pyri*, ground cover in 2013: small-flowered quickweed; in 2014: grassland mixture BQSM-D2a

(4) Mix (*P. persimilis* and *N. californicus*)

(5) *Amblyseius andersoni*, ground cover: tall fescue grass

The beneficials were released from the beginning of June to mid-June in 2013 and 2014, after the basal leaves of the hop plants had been removed. The release methods tested depended primarily on what the breeders supplied. Bean leaves and felt strips were attached to the hop plants 1.60 m above ground, above the leafless stalk section. Beneficials on vermiculite were released with a Koppert Airbug blower by walking at a steady pace through the hop stands.

The following table shows the release units and the numbers of beneficials released.

Tab. 6.4: Predatory mites/unit and numbers of mites released

Predatory mite	Predatory mites/unit	No. of mites released in 2013	No. of mites released in 2014
Typhlodromus pyri	**Felt strips**: 5/strip	5,000 pred. mites/ha ➢ One felt strip for every 4th trained bine	No *T.pyri* available
Mix (*Phytoseiulus persimilis* and *Neoseiulus californicus*)	**Bean leaves**: 5,000/leaf **Vermiculite**: 1,500/unit	50,000 pred. mites/ha ➢ 12.5 pred. mites/bine ➢ Bean leaves distributed uniformly on each bine	50,000 pred. mites/ha ➢ 12.5 pred. mites/bine ➢ Bean leaves ➢ Airbug
Amblyseius andersoni	**Small packets (2013)**: 250/packet **Vermiculite (2014):** 25,000/unit	50,000 pred. mites/ha ➢ Small packets positioned at two points/plot row	125,000 pred. mites/ha ➢ 31 pred. mites / bine ➢ Airbug
Amblyseius cucumeris	**Vermiculite (2014)**: 10,000/unit	-	100,000 pred. mites/ha ➢ 25 pred. mites/bine ➢ Airbug

Each location was assessed at fortnightly intervals by selecting ten plants per plot, removing a leaf from the bottom, middle and top of the plant and then counting the number of spider mites and predatory mites as well as their eggs.

The hops from the trial plots were harvested at the end of the season and the cones assessed and compared with cones from a commercially farmed acaricide-sprayed plot. In addition, 100 cones were picked from each plot shortly before harvesting and emptied into our modified Berlese funnel in order to catch all the arthropods in the cones in 70% alcohol for counting.

Results

2013 season

The plan for the first season was to establish the undersown ground cover and release the predatory mites. Predatory mites were released at all five locations prior to occurrence of the pest (0 spider mites/leaf).

The spider-mite populations that built up in the control plots at all five locations during the course of the season were so small that no statistically significant effect of the predatory mites was identifiable. A maximum of between 0.6 and 10 spider mites were counted per leaf at harvest time at the five locations, too few to have any negative effects on yield or quality.

Adverse weather conditions and poor seed germination in 2013 unfortunately prevented establishment of the ground cover, meaning that no suitable winter habitat was available in the hop yards.

Tall fescue grass and stinging nettle were sown again in spring 2014. Stinging nettle and small-flowered quickweed unfortunately had to be replaced because the nettles had still not become established by summer and quickweed seed had become too dear. A grassland mixture (BQSM D 2a) and strawberries were chosen instead.

2014 season

As in 2013, no spider-mite populations built up at the Ursbach, Hüll, Benzendorf and Großbellhofen locations. Predatory mites were released at these locations at a pest pressure of 0.1 spider mites/leaf, i.e. in isolated cases of spider-mite infestation. The low spider-mite incidence (fewer than 3 spider mites/leaf) witnessed at all five locations at harvest time again made it impossible to detect any clear effect of the predatory mites compared with the control. A major problem in the 2014 season was the non-availability of *T.pyri*. For unknown reasons, we received no feedback from our former supplier, and *T. pyri* is no longer produced by established suppliers of the beneficial either.

An alternative autochthonous predatory-mite species, *A. cucumeris*, which, until then, had not been provided for in the trial design, was included at short notice at the Oberulrain location. The predatory-mite species released here were *A. cucumeris* (25 predatory mites/trained bine) and *A. andersoni* (31 predatory mites/trained bine). They were released in the respective plots in week 27 at a pest pressure of six spider mites/leaf. Three weeks later (week 30), by which time the spider-mite count had increased substantially, predatory mites were released again at the same release rate. Levels of infestation increased steadily throughout the season in all the trial variants, with spider-mite counts in the variants treated with beneficials averaging between 169 and 240 towards the end of the season. At no point in time were spider-mite counts found to have been reduced by the predatory mites, although, at 273 spider mites/leaf, the tall-fescue-grass variant (without beneficials) showed the highest level of infestation. However, the undersown ground cover had no significant effect on the infestation level. Mutual ground cover/predatory-mite interaction was not statistically significant either, ruling out any influence of the ground cover on the severe spider-mite infestation. No significant differences in yield between hop plants treated conventionally with acaricides (13.7 spider mites/leaf) and the variants treated with beneficials were found, despite the latter having much higher infestation levels. The control was the only variant that differed from all others, by two to four dt/ha. Cone quality, unlike the yield, was impaired by the high levels of infestation, with cones from all the trial plots showing 100 % damage in heavily infested areas. The “weighted average” of infestation was between 3.6 and 3.8. However, the Berlese-funnel cones of the *A. cucumeris* variant were found to contain mites. This finding requires closer investigation, but could be a major initial indication that this species is able to colonise cones.

Implications and outlook

The release of predatory mites in Oberulrain must be deemed a failure. One major reason for this failure was the time at which the predatory mites were released. This hop yard was managed conventionally and Reglone was sprayed as a defoliant on 1. July (i.e. within the allowed period). The beneficials were not released until after this date so as not to endanger them, but by this time, the spider mites had spread into the middle sections of the hop plants.

At the time the predatory mites were released (10 weeks before harvesting), the number of spider-mites/leaf was between three and six and the pest index between 0.5 and 0.6, which meant that the damage threshold had already been exceeded (damage threshold model, WEIHRAUCH 2005). *A. andersoni* is more suitable for keeping *T. urticae* infestations at low levels than for reducing high levels of infestation (STRONG & CROFT 1995). In their opinion, 5-10 spider mites/leaf can lead to damage later on if no antagonists are present at this threshold. Infestation of this degree ten weeks before harvesting definitely poses a serious threat to harvest quality. The predatory mites should therefore have been released much earlier, before the spider-mite count reached 5/leaf. At the time of their release, it was too late for the predatory mites to decimate the spider-mite population. Spider mites had no influence on yields in 2013 and 2014, not even at the Oberulrain location. The lower yield obtained for the control at Oberulrain is more likely due to different soil conditions, since, although the variants with beneficials had higher spider-mite counts than the control, no losses in yield were recorded for the former. According to WEIHRAUCH (2005), the infestation level at harvest can usually reach 90 spider mites/leaf before economic losses are sustained. In Oberulrain, it was the cone quality that was particularly affected. These trials will be continued in 2015.

Fortunately, after two vegetation years, tall fescue grass and the other ground covers have now been successfully established, which will enable us to sample them for the first time in spring 2015.

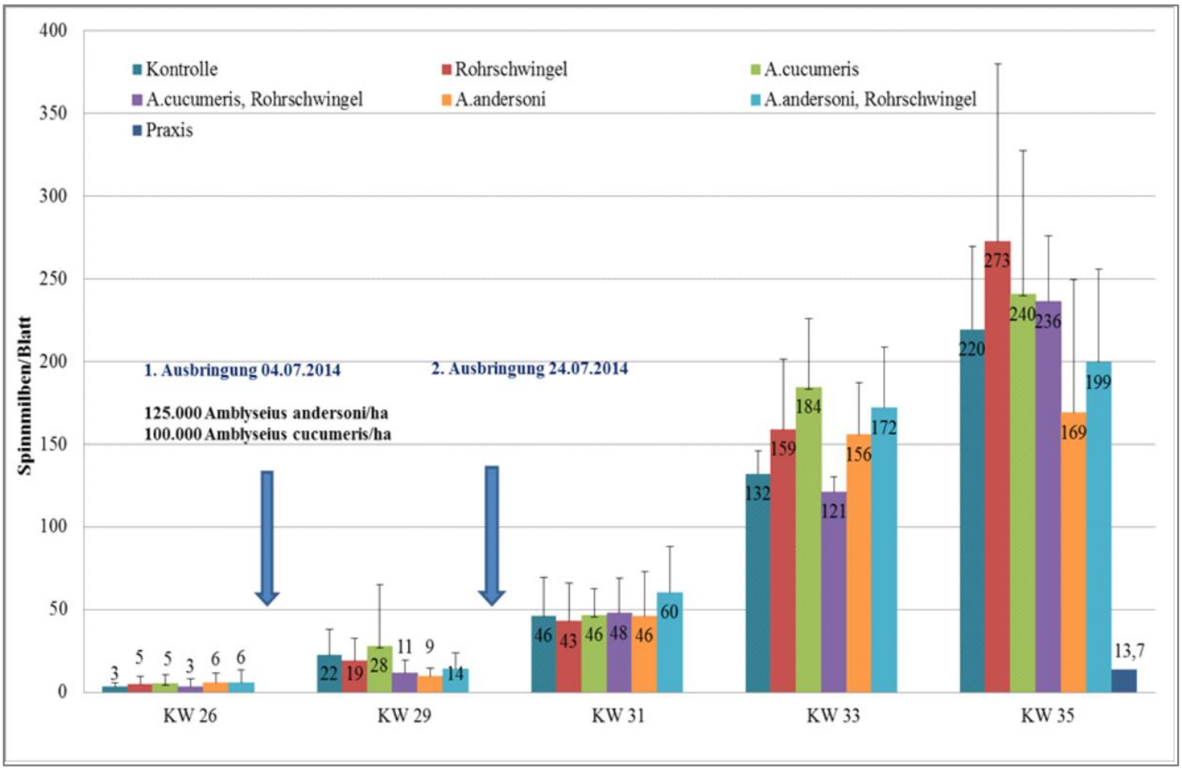

Fig. 6.2: Populations in 2014 at Oberulrain, spider mites/leaf n=120, cv.Perle, variants: control; tall fescue grass; A.cucumeris/tall fescue grass; A.cucumeris; A.andersoni; A.andersoni/tall fescue grass; acaricide-treated. Significant difference by ANOVA, P=0.0006.

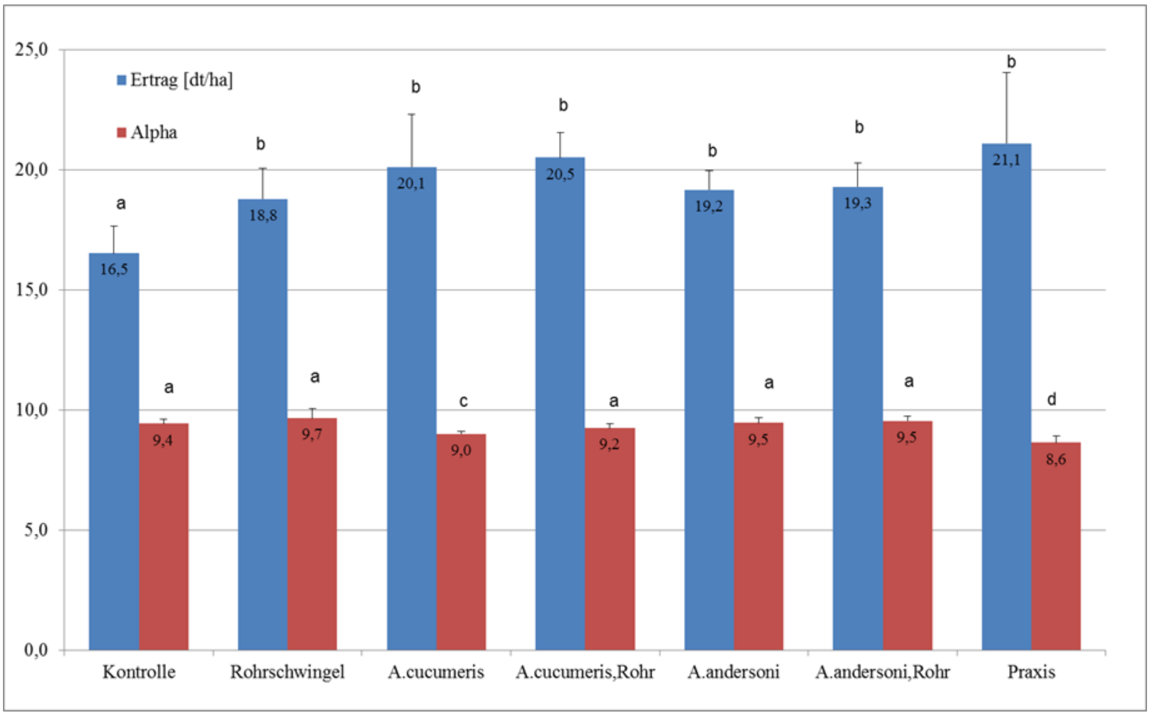

Fig. 6.3: Yield [dt/ha] and alpha-acid content [%], Oberulrain location, cv. Perle, harvest on 04.09.2014, n=4, significant differences in yield by ANOVA, P = 0.05; significant differences in alpha by ANOVA, P=0.005

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6.3 Monitoring flight habits of the Rosy Rustic moth (*Hydraecia micacea*) in hop yards via light traps

Background

The Rosy Rustic is regarded as a minor pest in hop-growing, its occurrence over the past ten years having been localised and of very short duration. The only noteworthy occurrence of the species in the Hallertau district to date was in 1969/1970, with a lesser outbreak in 1981/1982. In 2012, and to an even greater extent in 2013 and 2014, the number of reports of hop infestation with Rosy Rustic caterpillars increased again. Infestation was initially in the form of young caterpillars tunnelling in young hop shoots, and, later, of larger caterpillars in the roots, causing significant economic losses in isolated cases. To find out more about the moth's biology, occurrence and flight habits in hop yards its flight was monitored for the second year in 2014 using a light trap.

Material and methods

A light trap with a black light and a twilight switch was installed at a height of two metres on the edge of a hop yard near Steinbach in the Kehlheim district, in some parts of which more than 50 % of plants had been infected in 2013. The light trap was set up earlier in 2014 than in 2013, on 25. June. The trap was emptied daily and all the adult moths identified and counted.

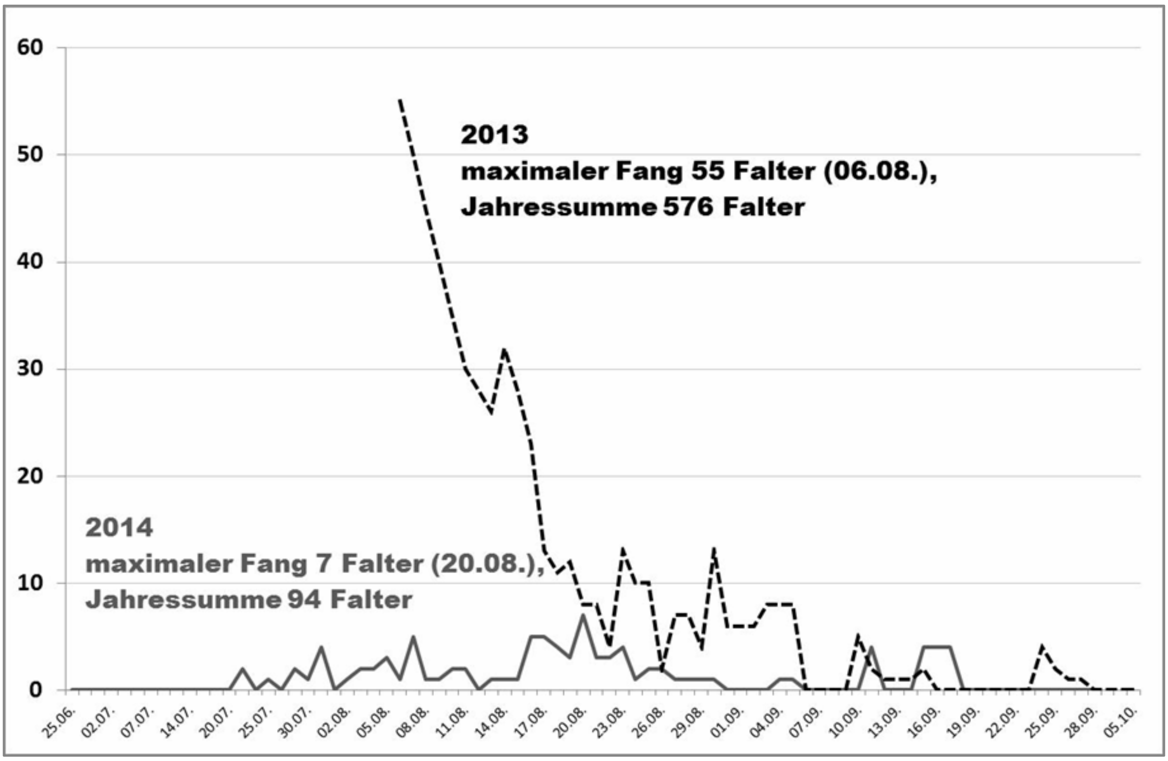


Fig. 6.4: Flight curve of the Rosy Rustic moth (Hydraecia micacea) near Steinbach in 2013 and 2014, based on the number of adult moths caught in the light trap

Result

Moth-catching did not commence in 2013 until early August, following a snap decision. As the curve in Fig. 6.2 shows, the flight period in 2013 had started earlier and it was not possible to clarify whether or not the catch of 55 moths on 6. August, 2013 reflected the peak of flight activity. The early commencement of monitoring activities in 2014 enabled us to record the actual start of the flight period (20. July). It lasted until the end of September in both years. The results suggest that the Rosy Rustic's flight period and therefore also its egg-laying period, which is essential to infestation in the following year, stretches from mid-July to the beginning of October and peaks in August. This work will be continued in 2015.

6.4 Which flea-beetle species infect hops?

As part of a multi-year project aimed at determining the influence of hop-aphid infestation on yield and quality (cf. WEIHRAUCH et al. 2012), samples of 100 green hop cones each were picked continually in the trial plots as from the start of cone formation and emptied into a modified Berlese funnel in order to determine the number of aphids hidden in the cones. As all the arthropods were expelled from the cones by heat etc., flea beetles were a by-catch. Recent identification of the 40 flea beetles extracted from cones collected at 15 different locations between 2008 and 2012 showed that they included three flea beetles (7.5 %) of the species *Chaetocnema concinna* (Marsham, 1802), sometimes known as the mangold flea beetle. The remaining 37 flea beetles were of the species *Psylliodes attenuatus* (Koch, 1803), the actual hop flea.

It may be assumed, therefore, that at least in summer, hop flower and cone infestation by flea beetles is attributable not only to the hop flea *P. attenuatus*, but also, to an extent of 5-10 %, to *C. concinna*.

Tab. 6.5: Identity of flea-beetle by-catches from cone samples collected at various Hallertau locations between 2008 and 2012.

Flea-beetle species	Date	No.	Site	CV
Psylliodes attenuatus	04.08.2008	1	Schweinbach	HM
Psylliodes attenuatus	12.08.2008	1	Grünberg	HT
Psylliodes attenuatus	18.08.2008	1	Hüll	SE
Psylliodes attenuatus	20.08.2008	1	Parleiten	SE
Psylliodes attenuatus	03.09.2008	2	Oberempfenbach	HM
Psylliodes attenuatus	03.08.2009	1	Buch	SE
Psylliodes attenuatus	03.08.2009	4	Oberempfenbach	HM
Psylliodes attenuatus	03.08.2009	3	Oberempfenbach	HS
Psylliodes attenuatus	03.08.2009	1	Untermantelkirchen	HT
Psylliodes attenuatus	04.08.2009	1	Nötting	SE
Psylliodes attenuatus	06.08.2009	1	Grünberg	HT
Psylliodes attenuatus	13.08.2009	1	Rohrbach	HM
Psylliodes attenuatus	02.08.2010	1	Martinszell	HM
Psylliodes attenuatus	03.08.2010	2	Oberempfenbach	HS
Psylliodes attenuatus	17.08.2010	1	Oberempfenbach	HM
Psylliodes attenuatus	17.08.2010	1	Schweinbach	HM
Chaetocnema concinna	30.08.2010	1	Eng'-münster	HM
Chaetocnema concinna	02.09.2010	1	Grünberg	HT
Chaetocnema concinna	01.08.2011	1	Schrittenlohe	diverse
Psylliodes attenuatus	01.08.2011	1	Oberempfenbach	HM
Psylliodes attenuatus	01.08.2011	3	Hüll	HM
Psylliodes attenuatus	01.08.2011	1	Schrittenlohe	diverse
Psylliodes attenuatus	01.08.2011	3	Oberulrain	PE
Psylliodes attenuatus	16.09.2011	1	Kirchdorf	HS
Psylliodes attenuatus	03.09.2012	5	Haushausen	HT

7 Hop Quality and Analytics

ORR Dr. Klaus Kammhuber, Dipl.-Chemiker

7.1 General

Within the Hops Dept. (IPZ 5) of the Institute for Crop Science and Plant Breeding, the IPZ 5d Work Group (WG Hop Quality and Analytics) performs all analytical studies required to support the experimental work of the other Work Groups, especially that of Hop Breeding Research. After all, hops are grown for their components. Hop analytics is therefore an indispensable prerequisite for successful hop research. The hop plant has three groups of value-determining components: bitter compounds, essential oils and polyphenols, ranked in order of importance. Until now the alpha acids have been regarded as the main quality characteristic of hops, as they are a measure of hop bittering potential and hops are added to beer on the basis of their alpha-acid content (internationally, approx. 4.3 g alpha acid per 100 l beer). Bittering-hop prices generally depend on alpha-acid levels, too. Fig. 7.1 shows the effect of hops in beer.

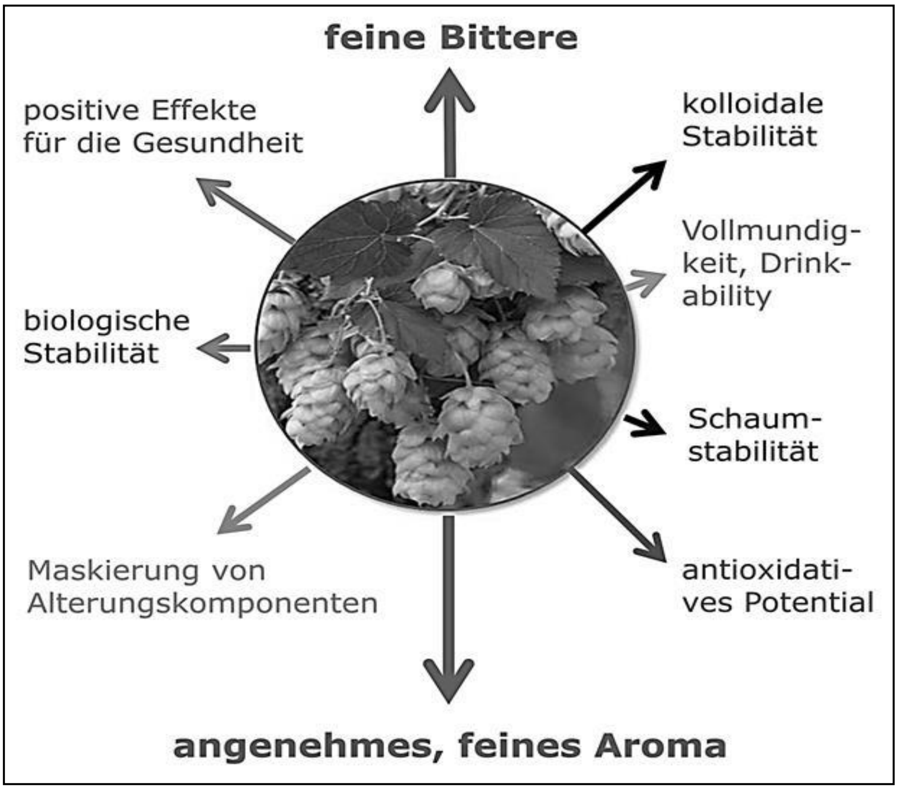


Fig. 7.1: Effect of hops in beer

With the craft brewer scene gaining increasing ground, especially in the USA, there has also been a shift in the interest taken in hop components. This trend has now spread to Germany and Europe, with all major breweries now running craft breweries. In this type of brewing, hops are added to the finished beer in the storage tanks (dry hopping). The alpha-acids do not dissolve, but the lower-molecular-weight esters and terpene alcohols, in particular, do dissolve, giving the beer a fruity, floral aroma. At the same time, the alcohol contained in beer (approx. 5 %) acts as a solubiliser and the solubility of the aroma components of the hops is slightly higher than in pure water. The alpha acids hardly dissolve at all, as they are not isomerized. However, the lower-molecular esters and terpene alcohols, above all, are dissolved, leading to fruity and flowery aromas in the beer.

Polyphenols and nitrate, however, are also transferred to the beer. Hops used for dry hopping must meet very special requirements with respect to plant hygiene. As yet, there are no reliable findings concerning the possible transfer of plant protective products, either.

Craft brewers are looking for hops with special aromas, some of them not typical of hops. Such hops are referred to collectively as “Special-Flavor Hops”.

Less interest has so far been taken in the polyphenols, the third group of hop components, although they help to give the beer body and contribute to drinkability and taste stability. They also possess anti-oxidant characteristics and thus have positive effects on health. Xanthohumol has attracted a lot of publicity in recent years, among other reasons because it has anti-inflammatory properties and shows beneficial effects in connection with cancer, diabetes and atherosclerosis. Our substantial research into xanthohumol will be continued in its entirety.

8-prenylnaringenin is another very interesting substance. This compound, although found only in trace amounts in hops, is nevertheless one of the most powerful phyto-œstrogens and is responsible for the slightly œstrogenic effect of hops. Although this effect had been known for centuries, the responsible substance was not identified until 10 years ago by Professor de Keukeleire.

7.2 Component optimisation as a breeding goal

7.2.1 Requirements of the brewing industry

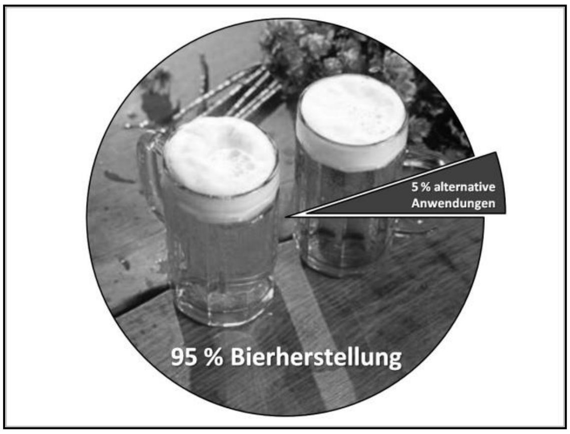


Fig. 7.2: Use of hops

The brewing industry, which purchases 95 % of hop output, is still the largest consumer of hops and will remain so in the future, too (*Fig. 7.2*).

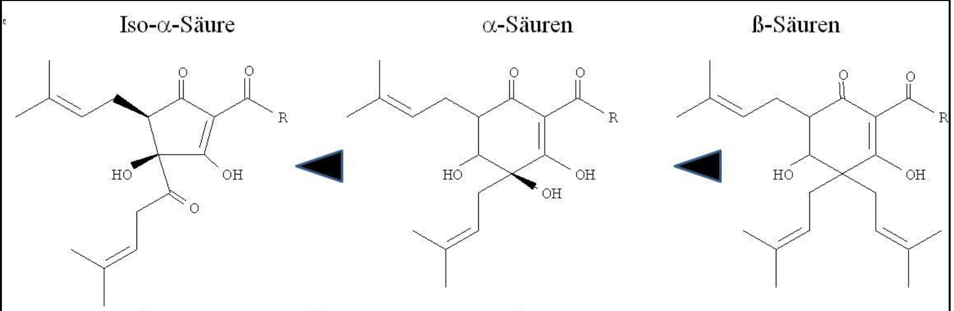
As far as hopping is concerned, breweries follow two extremely different approaches. The aim of the first approach is to obtain alpha-acids as cheaply as possible, with variety and growing region being irrelevant. The aim of the second is to cultivate beer diversity through a variety of hop additions and products, with importance still being attached to varieties and regions but costs playing no role at all. However, there are overlaps between these two extremes. The requirements of the brewing and hop industries regarding component composition are constantly changing. There is, however, general consensus on the need to breed hop varieties with α-acid levels that are as high as possible and remain very stable from year to year. Low cohumolone content as a quality parameter has declined in significance. For downstream and beyond-brewing products, there is even a demand for high-alpha varieties with high cohumolone levels.

Particularly as a result of the rapid growth of the craft brewers’ scene, there has been a return to increased variety awareness and a greater focus on the aroma substances. The essential oils in hops consist of 300-400 different substances.

There are numerous synergy effects. Some substances are perceived more strongly, others cancel each other out. Smell is a subjective impression, in contrast to chemical analysis, which provides objective data. Key substances must be defined, however, in order to permit analytical characterisation of aroma quality, too. Substances such as linalool, geraniol, myrcene, esters and sulphur compounds are important for hop aroma. Craft brewers are also interested in purchasing hops with "exotic" aromas such as mandarin-orange, melon, mango or currant.

7.2.2 Possible alternative uses

To date, only 5 % of hop output has been put to alternative uses, but it is planned to expand this share. Both the cones and the remainder of the hop plant can be utilised. The shives (woody core of the stem) have good insulating properties and are very stable mechanically; they are thus suitable for use as loose-fill insulation material and in composite thermal-insulation mats. Shive fibres can also be used to make moulded parts such as car door panels. As yet, no large-scale industrial applications exist, however. As far as the cones are concerned, the antimicrobial properties of the bitter substances are especially suited to alternative uses. Even in catalytic amounts (0.001-0.1 wt. %), the bitter substances have antimicrobial and preservative properties in the following ascending order: iso-α-acids, α-acids, β-acids (*Fig. 7.3*).



R = isobutyl	Cohumulone
R = isopropyl	n-Humulone
R = sec-butyl	Adhumulone

Fig. 7.3: Sequence of antimicrobial activity of iso-a-acids, a-acids and ß-acids

They destroy the pH gradient at the cell membranes of bacteria, which can no longer absorb any nutrients and die. The iso-α-acids in beer even provide protection against heliobacter pylori, a bacterium that triggers stomach cancer. The β-acids are especially effective against gram-positive bacteria such as listeriae and clostridiae and also have a strong inhibitory effect on the growth of Mycobacterium tuberculosis. This property can be exploited and the bitter substances in hops used as natural biocides wherever bacteria need to be kept under control. In sugar processing and ethanol production, formalin is already being very successfully replaced by β-acids.

Other potential applications exploiting the antimicrobial activity of hop β-acids include their use as preservatives in the food industry (fish, meat, milk products), the sanitation of biogenic waste (sewage sludge, compost), elimination of mould, improvement of the smell and hygiene of pet litter, control of allergens, and use as an antibiotic in animal food. In future, considerable demand for hops for use in such areas can be safely expected. Increased β-acid content is therefore one of the breeding goals in Hüll. Currently, the record is about 20 %, and there is even a breeding line that produces β-acids alone and no α-acids.

As the hop plant boasts a wide variety of polyphenolic substances, it is also of interest for the areas of health, wellness, dietary supplements and functional food. With a polyphenol content of up to 8 %, the hop plant is very rich in these substances. Work is being done on increasing xanthohumol content, with a breeding line containing 1.7 % xanthohumol already available. Other prenylated flavonoids, such as 8-prenylnaringenin, occur only in trace amounts in hops. Substances with a very high antioxidative potential include the oligomeric proanthocyanidins (up to 1.3 %) and glycosidically bound quercetin (up to 0.2 %) and kaempferol (up to 0.2 %). With a share of up to 0.5 %, the multifidols are also one of the principal components of hops. The term 'multifidols' comes from the tropical plant Jatropha multifida, which contains these compounds in its sap. *Fig. 7.4* shows their chemical structures. Multifidol glucoside itself has structure A. Hops mainly contain the B compound, but also A and C in smaller concentrations.

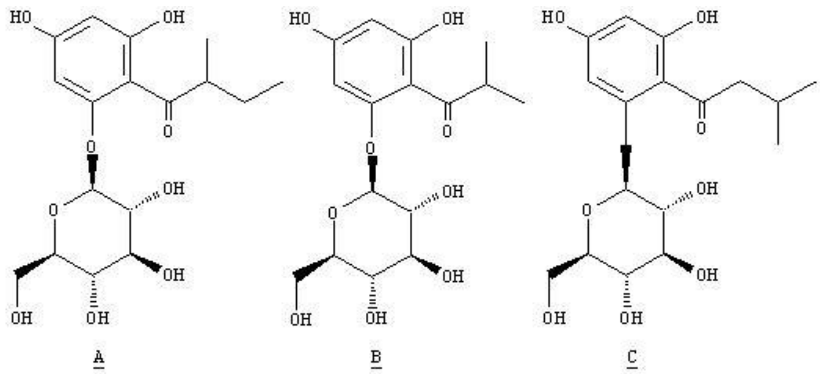


Fig. 7.4: Chemical structures of the multifidols

These substances might also be of interest to the pharmaceutical industry for their anti-inflammatory properties. Aroma hops generally have a higher polyphenol content than bitter hops. If specific components are requested, Hüll can react at any time by selectively breeding for the required substances in collaboration with Hop Quality and Analytics.

7.3 World hop range (2013 crop)

Essential-oil analyses of the world hop range are also performed every year via headspace gas chromatography and the bitter compounds analysed via HPLC. Tab. 7.1 shows the results for the 2013 harvest. The findings can be helpful in classifying unknown hop varieties.

Tab. 7.1: World hop range 2013

Variety	Myrcene	2-m.-iso-butyrate	Sub. 14 b	Sub. 15	Linalool	Aromadendren	Undecanone	Humulene	Farnesene	γ-muurolene	ß-selinene	α-selinene	Cadinene	Selinadiene	Geraniol	α-acids	ß-acids	ß/a	Cohumulone	Colupulone
Admiral	4117	1176	21	53	52	0	16	291	6	3	3	5	7	0	0	13.2	4.2	0.32	40.8	77.7
Agnus	1359	60	2	7	10	0	3	112	0	1	4	5	5	0	2	10.9	4.8	0.44	29.9	53.9
Ahil	3236	310	40	5	17	2	11	182	73	4	6	8	5	0	9	9.3	3.8	0.41	28.9	60.8
Alliance	1735	207	5	1	28	0	3	253	4	2	4	5	8	0	1	3.7	2.0	0.54	26.3	49.2
Alpharoma	1375	200	28	5	9	0	7	291	9	4	4	6	8	0	0	5.8	2.4	0.41	25.5	54.8
Apolon	4187	130	41	11	34	0	7	211	104	7	6	10	7	0	10	6.9	3.4	0.49	20.8	49.5
Aquila	2964	87	7	123	21	32	3	27	0	3	45	48	3	66	5	5.8	3.2	0.55	50.1	72.1
Aromat	3799	3	7	4	38	0	4	250	60	7	3	5	7	0	3	2.5	2.7	1.10	18.9	44.1
Atlas	3378	640	31	10	23	0	9	188	76	6	7	11	6	0	14	7.7	3.3	0.43	36.1	68.4
Aurora	4088	280	11	51	54	0	14	210	34	16	3	5	6	0	0	7.6	3.5	0.45	24.6	50.7
Backa	2783	573	17	28	37	0	6	242	14	3	0	5	7	0	0	8.0	4.4	0.55	41.6	61.8
Belgisch Spalter	2354	273	10	13	34	12	10	158	0	2	29	32	4	38	0	3.3	2.1	0.65	16.0	40.3
Blisk	2553	344	36	8	29	0	7	223	62	6	5	9	7	0	11	6.8	3.3	0.49	32.2	58.7
Bobek	4857	232	22	104	64	0	14	218	35	25	4	6	6	0	4	4.5	5.1	1.14	26.0	45.3
Bor	2227	211	6	65	11	0	4	269	0	2	3	4	6	0	3	6.9	3.1	0.45	22.9	51.7
Bramling Cross	3035	193	29	15	49	0	19	266	0	5	9	5	9	0	0	3.7	3.9	1.07	45.2	54.0
Braustern	1802	203	4	45	10	0	4	228	0	1	2	3	7	0	1	5.1	2.7	0.53	26.6	51.2
Brewers Gold	1658	321	17	18	18	0	6	170	0	6	6	8	6	0	9	7.0	4.0	0.57	38.7	65.5
Brewers Stand	8269	952	61	64	64	34	17	31	6	6	71	81	41	109	12	9.2	3.6	0.39	20.8	46.6
Buket	2478	294	7	78	34	0	5	195	18	2	3	5	6	0	2	8.1	4.5	0.55	22.5	49.9
Bullion	1670	251	17	28	17	0	3	157	0	1	5	7	5	0	2	6.9	4.2	0.60	43.1	67.7
Cascade	3946	240	35	11	24	0	5	228	26	14	17	20	7	0	6	4.5	4.5	1.02	35.6	51.7
Chang bei 1	2102	9	5	4	38	0	5	198	13	6	18	19	6	21	2	2.6	3.6	1.42	21.5	41.7
Chang bei 2	2494	3	3	3	44	0	7	199	16	6	16	17	6	19	2	2.4	3.7	1.56	21.3	42.6

Variety	Myr-cene	2-m.-iso-butyrate	Sub. 14 b	Sub. 15	Lina-lool	Aroma-dendren	Unde-canone	Humu-lene	Farne-sene	γ-muu-rolene	ß-seli-nene	α-seli-nene	Cadi-nene	Seli-nadie-ne	Gera-niol	α-acids	ß-acids	ß/a	Cohu-mulone	Colu-pulone
College Cluster	1422	207	20	16	13	0	4	173	0	1	6	7	5	0	2	5.5	1.5	0.28	25.0	39.2
Columbus	2345	154	19	14	11	0	10	147	0	8	10	15	14	17	2	12.9	4.7	0.36	37.0	59.1
Crystal	1687	80	20	15	41	39	9	190	0	17	34	36	6	41	1	2.1	5.1	2.49	6.8	36.8
Density	3315	252	10	9	59	0	12	241	0	11	7	5	10	0	0	3.2	3.4	1.05	46.7	56.5
Early Choice	2653	154	3	19	12	0	7	227	0	1	37	41	5	0	1	1.6	1.0	0.60	25.8	43.4
Eastwell Golding	1607	154	9	5	24	0	7	268	0	3	3	5	7	0	1	3.7	1.9	0.51	26.6	51.9
Emerald	1163	81	9	11	8	0	3	272	0	2	2	4	6	0	2	6.3	5.0	0.79	28.8	49.8
Eroica	3092	653	80	188	6	0	10	179	0	9	9	10	5	0	0	11.1	6.4	0.58	43.1	64.4
Estera	2617	293	14	8	37	0	10	259	16	2	10	12	6	0	2	3.9	2.2	0.56	26.5	49.9
First Gold	2962	669	8	18	41	3	11	251	7	5	104	111	7	0	2	6.4	2.6	0.41	28.8	57.9
Fuggle	2455	230	6	5	35	0	7	239	17	11	3	6	7	0	1	3.7	1.8	0.48	28.8	48.5
Galena	2830	499	52	182	5	0	13	192	0	7	7	11	6	0	0	10.2	7.5	0.73	40.5	61.5
Ging Dao Do Hua	1800	632	11	2	23	0	8	249	0	3	58	60	18	0	6	3.6	2.9	0.80	46.6	62.5
Glacier	2725	55	13	2	42	0	9	274	0	3	3	6	7	0	2	3.7	6.5	1.74	12.6	40.9
Golden Star	1931	706	11	0	21	0	5	260	0	29	56	59	19	0	6	3.8	3.3	0.88	48.9	61.8
Granit	2139	241	11	22	9	0	9	174	0	4	6	8	4	0	2	5.9	3.3	0.55	25.7	50.8
Green Bullet	1638	39	29	7	17	0	6	269	0	6	5	4	7	0	0	6.8	4.2	0.62	36.4	60.9
Hall. Taurus	4848	148	29	33	55	0	6	224	0	3	63	69	6	0	2	16.8	4.7	0.28	20.5	46.7
Hall. Tradition	2265	268	32	2	54	0	17	300	0	6	4	6	8	0	3	5.7	3.1	0.54	28.9	51.1
Hallertau Blanc	10659	693	180	9	72	0	25	36	0	23	729	755	13	0	9	7.6	4.2	0.56	23.1	38.5
Hallertauer Gold	2934	232	50	7	44	0	11	287	0	5	3	6	7	0	2	5.9	4.7	0.80	22.6	44.7
Hallertauer Magnum	2681	203	49	23	9	1	6	270	0	3	2	4	5	0	1	15.0	6.6	0.44	25.9	50.8
Hallertauer Merkur	2130	268	23	11	28	0	4	267	0	2	4	4	6	0	1	12.7	4.5	0.35	18.7	46.4
Hallertauer Mfr.	2044	99	4	1	47	0	5	263	0	7	2	4	8	0	3	2.8	2.4	0.84	18.4	37.1
Harmony	2247	70	6	12	31	0	6	223	0	2	74	79	6	0	1	4.8	4.3	0.90	20.5	50.4
Herald	3338	740	9	153	19	0	9	127	0	4	14	16	3	0	3	10.5	3.4	0.33	34.9	75.0

Variety	Myr-cene	2-m.-iso-butyrate	Sub. 14 b	Sub. 15	Lina-lool	Aroma-dendren	Unde-canone	Humu-lene	Farne-sene	γ-muu-rolene	ß-seli-nene	α-seli-nene	Cadi-nene	Seli-nadie-ne	Gera-niol	α-acids	ß-acids	ß/a	Cohu-mulone	Colu-pulone
Herkules	3193	348	63	112	10	0	6	262	0	18	3	4	7	0	3	17.1	4.8	0.28	35.1	52.5
Hersbrucker Pure	3706	202	12	19	45	17	13	184	0	12	25	25	6	36	0	2.9	1.7	0.57	20.8	40.5
Hersbrucker Spät	2685	111	16	6	72	60	9	171	0	7	54	54	6	56	0	2.0	4.7	2.32	14.4	32.9
Huell Melon	10135	1525	34	120	37	4	27	54	128	47	358	378	16	91	18	6.6	8.8	1.34	29.3	48.3
Hüller Anfang	1633	120	8	5	33	0	2	270	0	4	3	5	8	1	0	2.6	2.7	1.04	13.8	39.4
Hüller Aroma	1995	148	13	7	41	0	7	282	0	3	5	7	8	0	2	3.2	2.7	0.86	29.7	50.4
Hüller Bitter	2139	225	53	3	27	15	12	157	0	4	46	54	32	77	3	6.0	4.3	0.73	27.8	48.9
Hüller Fortschritt	2569	66	11	1	38	0	12	296	0	9	4	6	7	0	0	2.1	2.7	1.30	26.0	43.0
Hüller Start	1492	47	2	2	17	0	6	273	0	14	4	5	9	0	1	1.9	2.5	1.34	16.0	41.2
Kazbek	1507	196	19	29	12	0	3	163	0	4	6	8	5	0	2	4.2	4.4	1.06	40.5	62.2
Kirin 1	967	323	10	8	16	0	8	274	0	3	52	54	15	0	4	4.6	3.8	0.83	50.7	62.2
Kirin 2	1154	491	11	2	17	0	11	279	0	4	59	60	18	0	6	4.8	3.9	0.81	50.2	60.8
Kitamidori	694	12	8	13	4	0	10	309	8	2	3	5	7	0	2	8.1	3.9	0.48	23.3	44.7
Kumir	1991	165	5	28	28	0	7	266	7	2	3	4	6	0	1	9.4	4.1	0.43	21.2	47.4
Late Cluster	9044	896	61	85	67	38	12	30	10	34	65	78	41	96	14	8.0	3.9	0.49	24.0	43.2
Lubelski	4769	3	16	3	48	0	17	267	60	7	3	7	6	0	3	4.0	3.1	0.77	19.7	43.0
Mandarina Bavaria	6124	366	36	44	26	0	9	241	9	21	68	108	9	0	14	8.8	6.8	0.77	31.4	50.9
Marynka	3009	337	5	69	17	0	5	120	127	3	5	8	4	1	5	9.0	2.8	0.31	18.3	47.5
Mt. Hood	702	85	18	3	15	0	4	225	0	11	4	5	8	0	2	3.1	4.6	1.46	23.6	42.2
Neoplanta	1351	166	7	26	7	0	4	196	13	9	2	4	6	0	1	7.1	3.0	0.42	32.2	64.5
Neptun	2349	180	52	9	31	0	2	185	0	10	3	4	6	1	1	13.4	4.1	0.30	20.6	39.6
Northern Brewer	2212	209	4	42	12	0	3	194	0	2	2	3	5	0	1	6.3	3.3	0.53	26.8	48.8
Nugget	1483	122	7	19	18	0	4	174	0	3	9	10	4	0	1	9.9	4.1	0.41	28.8	52.8
NZ Hallertauer	2887	160	8	16	36	5	16	204	12	6	24	27	6	33	2	3.0	5.1	1.73	45.1	55.3
Olympic	1354	100	5	18	15	0	9	182	0	2	8	9	4	0	1	11.0	4.4	0.41	28.5	53.1
Opal	2771	160	19	19	54	0	9	202	0	4	9	9	6	0	2	4.7	3.2	0.67	11.9	35.9

Variety	Myr-cene	2-m.-iso-butyrate	Sub. 14 b	Sub. 15	Lina-lool	Aroma-dendren	Unde-canone	Humu-lene	Farne-sene	γ-muu-rolene	ß-seli-nene	α-seli-nene	Cadi-nene	Seli-nadie-ne	Gera-niol	α-acids	ß-acids	ß/a	Cohu-mulone	Colu-pulone
Orion	1341	146	11	6	22	0	7	177	0	2	2	3	5	0	0	7.3	4.2	0.58	29.7	53.0
Outeniqua	630	8	7	0	6	0	10	251	0	9	51	59	7	0	0	9.7	4.6	0.48	24.6	49.2
Perle	1426	123	5	24	8	0	4	222	0	1	2	3	6	0	1	7.2	3.5	0.49	30.3	57.6
Phoenix	1752	261	3	15	12	0	5	244	7	10	43	49	5	0	2	9.8	2.7	0.28	20.2	48.8
Pilgrim	4369	656	8	145	19	0	9	200	0	22	44	48	4	0	6	6.6	3.4	0.51	38.5	59.1
Pioneer	1822	399	4	152	11	0	4	135	0	2	17	19	4	0	5	10.1	3.1	0.31	32.8	73.9
Polaris	2064	141	20	136	6	0	4	184	0	10	2	4	6	0	1	17.9	4.1	0.23	24.2	42.9
Premiant	2199	158	7	20	33	0	10	267	6	2	3	5	6	0	1	9.1	3.8	0.41	20.1	47.7
Pride of Kent	2086	108	13	3	47	0	9	289	0	3	4	5	7	0	0	4.2	2.0	0.47	28.7	56.3
Progress	9487	1035	66	83	75	43	18	28	0	58	72	87	44	112	12	8.7	3.4	0.40	21.0	45.4
Rubin	2410	246	34	20	16	0	7	216	0	3	72	78	8	0	4	9.2	2.9	0.31	30.7	61.4
Saazer	3116	2	10	4	32	0	7	255	42	15	3	6	7	0	4	2.5	2.4	0.98	23.5	40.5
Saphir	2488	42	4	15	28	7	8	142	0	8	13	14	4	18	3	1.7	3.2	1.89	12.0	43.3
Sladek	1832	171	4	23	30	0	4	258	4	2	3	4	6	0	1	8.3	3.2	0.39	20.1	48.0
Smaragd	2113	46	20	8	51	0	12	274	0	6	5	11	7	0	4	3.0	4.3	1.43	9.2	38.3
Southern Promise	295	16	5	7	2	0	7	230	0	3	13	17	6	23	0	8.0	4.0	0.50	29.5	59.1
Southern Star	558	36	10	3	4	0	17	297	8	6	4	7	9	0	0	8.0	4.2	0.53	31.6	58.7
Spalter	4716	3	14	5	56	0	7	247	58	9	3	7	7	0	10	3.0	2.9	0.98	23.6	43.6
Spalter Select	5959	160	28	5	108	30	21	201	70	8	30	37	6	44	3	2.6	2.8	1.06	22.0	44.8
Sterling	1081	81	6	14	14	0	6	181	0	2	8	9	5	0	0	10.2	3.9	0.38	26.8	51.1
Strisselspalter	1384	74	20	8	34	37	8	213	0	4	29	31	6	36	2	2.2	4.5	2.08	15.4	34.4
Super Alpha	1844	213	38	9	30	0	3	272	0	4	5	7	7	0	3	5.7	4.3	0.75	34.5	56.5
Talisman	1867	214	5	53	13	6	4	218	0	2	3	4	6	0	1	7.4	3.6	0.49	26.9	54.7
Tettnanger	4471	5	13	4	49	0	13	258	63	8	4	6	9	0	8	2.4	2.4	1.02	25.4	42.7
Vital	2868	186	10	30	32	1	8	7	12	3	61	65	2	0	3	14.1	7.1	0.50	24.4	46.4
Vojvodina	2967	287	8	31	18	0	10	224	5	13	2	4	6	0	4	4.7	2.4	0.51	29.8	56.2

Variety	Myr-cene	2-m.-iso-butyrate	Sub. 14 b	Sub. 15	Lina-lool	Aroma-dendren	Unde-canone	Humu-lene	Farne-sene	γ-muu-rolene	ß-seli-nene	α-seli-nene	Cadi-nene	Seli-nadie-ne	Gera-niol	α-acids	ß-acids	ß/a	Cohu-mulone	Colu-pulone
WFG	4224	7	18	2	50	0	11	260	44	7	4	7	8	0	5	3.8	2.9	0.77	17.9	42.0
Willamette	1201	160	3	5	21	1	4	250	13	12	2	5	7	0	0	2.9	3.2	1.11	35.1	54.2
Wye Challenger	3372	597	12	26	37	13	11	235	7	5	46	53	6	0	0	4.2	3.8	0.91	26.7	45.9
Wye Northdown	2371	240	9	38	19	2	6	199	0	8	6	8	7	7	1	6.9	3.4	0.49	25.1	53.1
Wye Target	2820	365	13	24	37	0	6	146	0	21	6	9	9	9	1	10.4	4.3	0.42	34.9	66.0
Wye Viking	4105	232	14	63	32	0	4	170	86	4	22	25	5	0	3	7.9	3.6	0.46	22.0	49.4
Yeoman	2483	560	29	36	13	0	7	194	0	2	32	39	5	0	2	11.7	3.9	0.33	27.9	52.9
Zatecki	3059	244	6	13	45	0	17	275	19	3	4	7	7	0	1	1.8	1.8	0.99	22.4	51.4
Zenith	2610	170	10	21	38	0	10	251	0	3	71	79	6	0	1	5.5	2.5	0.46	23.9	59.6
Zeus	2706	164	19	13	10	0	8	152	0	10	11	14	14	16	1	12.9	4.7	0.36	36.6	58.0
Zitic	1992	20	5	17	15	0	5	268	3	3	3	5	6	0	4	4.2	3.4	0.81	22.4	47.2

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

Sub. 14b = methyl heptanoate, Sub. 15 = trans-(ß)-ocimene

7.4 Setup and commissioning of the new gas chromatography-mass spectrometry system

Thanks to the generous financial support of the Society of Hop Research, a gas chromatography-mass spectrometer was purchased for the laboratory. It was installed and commissioned in April 2014. *Fig. 7.5* shows the new instrument and, from L to R, Messrs Sichelstiel (Coordinator of the Hüll Hop Research Centre), Dr. K. Kammhuber (Head of IPZ 5d, Hop Quality and Analytics) and Dr. M. Möller (Chairman of the Managing Committee of the Society of Hop Research).

Fig. 7.5: New gas chromatography-mass spectrometer

With the help of this new system, the Hüll laboratory is now also in a position to identify aroma substances and thus describe hop varieties in much greater depth and detail.
The first step that had to be taken was to design optimum separation conditions; work then commenced on identifying the different substances in all common hop varieties. *Tab. 7.2* shows the substances identified to date.

Tab. 7.2: Substances identified with the GC-MS system

Substance	RT	Substance	RT	Substance	RT	Substance	RT
4-Methyl-3-pentanone	10.01	Methyl isoheptanoate	26.85	1-Heptanol	44.90	Isovaleric acid	59.73
2-Methyl-4-pentanone	10.41	2-Methyl-1-penten-3-ol	27.25	Methyl-6-methyl-octanoate	45.06	γ-Muurolene	60.48
3-Methyl-2-pentanone	10.83	trans-ß-Ocimene	27.56	Acetic acid	45.19	Methyl-7,8-octadecadienoate	60.73
α-Pinene	10.96	Methyl heptanoate	28.20	Ylangene	46.65	Viridiflorene	60.85
α-Thujene	11.11	p-Cymene	29.31	Citronellal	46.80	Methyl-geranate	60.90
2-Methyl-3-buten-2-ol	11.75	Hexyl acetate	29.70	alpha-Copaene	47.30	2-Dodecanone 1	61.46
2-Methylpropyl propanate	12.31	ß-Terpineol	30.25	Methyl pelargonate	47.71	Valencene/Epizonarene ?	61.75
Campfene	12.79	2-Methybutyl-2-methyl butyrate	30.36	2-Decanone	47.80	ß-Selinene	62.36
Dimethyl disulphide	13.51	Methyl heptanoate	31.18	S-Methyl-heptanethioate	48.55	Zingiberene	62.46
Isobutyl propionate	13.70	Amyl isovalerate	31.84	2-Nonanol	49.50	α-Selinene	62.66
Isobutyl isobutyrate	14.20	2-Octene-4-one	32.27	α-Gurjuene 1	49.90	α-Gurjuene 2	63.10
ß-Pinene	14.76	Acetol	32.64	Benzaldehyde	49.90	Citral	63.15
Isobutanol	14.97	Prenyl isobutyrate	33.64	Methyl-4-nonenoate	50.10	Geranyl acetate	64.55
Isoamyl acetate	16.27	3-Methyl-2-buten-1-ol	34.24	Octyl isobutyrate	51.20	ß-Cadinene	64.58
3-Pentene-2-one	17.15	Int. standard	35.28	Linalool	51.55	y-Cadinene	64.69
S-Methyl-thiobutyrate	17.30	6-Methyl-5-hepten-2-one	35.67	2-Undecanone	51.70	3,7-Selinadiene	64.90

Substance	RT	Substance	RT	Substance	RT	Substance	RT
Butylisobutyrate	18.00	Methyl 6-methylheptanoate	36.02	ß-Citral	53.10	Citronellol	64.98
Myrcene	19.32	S-Methyl hexanethioate 2	36.69	Isocaryophyllene	53.29	Curcumene	65.62
1-Hexene-3-ol	19.61	1-Hexanol	36.87	Isobutyric acid	53.31	α-Cadinene	66.74
α-Terpinene	20.28	Unknown	37.75	2-Methyl-3-pentanol	53.41	Tridecanone	67.81
Isobutyl-2-methyl butyrate	20.50	Isocyclocitral	38.26	α-Bergamotene	53.99	Geranyl isobutyrate	67.97
Methyl hexanoate	21.55	Heptyl acetate	38.65	ß-Cubebene	54.26	Elixene	69.00
Methylbutyl propionate	21.69	2-Nonanone	39.80	ß-Caryophyllene	54.68	Calamenene	69.23
2,3-Dimethyl-3-buten-2-ol	21.84	Methyl caprylate	39.96	Undecanone	54.92	Geraniol	70.10
Limonene	22.14	Nonanal	40.27	Aromadendrene	55.28	Methyl 3,6-dodecadienoate	73.36
2-Methylbutyl isobutyrate	22.36	S-butyl-hexanethioate	40.80	5,5-Dimethyl furanone	55.62	Tetradecanone	74.61
Prenal	23.08	Perrilene	42.33	Methyl-4-decenoate	56.64	α-Calacorene	74.70
2-Methylbutanol	23.61	Ethyl caprylate	43.40	Methyl geranate	57.11	2-Pentadecanone	76.90
S-Methyl thioisovalerate 1	24.33	Heptyl propionate	43.80	Methyl undecanoate	58.24	Heptanoic acid	77.50
S-Methyl thioisovalerate 2	25.17	HeptyI isobutyrate	44.00	2-Dodecanone 2	58.46	Caryophyllene oxide 1	78.53
Pentylfurane	25.67	Methyl pelargonate	44.25	Farnesene	59.10	ß-Santalole	80.21
Ethyl hexanoate	25.98	1-Octene-3-ol	44.64	Humulene	59.40	Humulene-2-epoxide	81.38
γ-Terpinene	26.58	α-Cubebene	44.80	4,7-Selinadiene	59.60		

RT = retention time

The identity of the substances was ascertained by comparing the mass spectra with the MS library, although 100% certainty is impossible.

7.5 Ring analyses of 2014 crop

Since 2000, hop supply contracts have included a supplementary agreement concerning α-acid content. The contractually agreed price applies if α-acid content is within what is termed a 'neutral' range. If it is above or below this range, the price is marked up or down, respectively. The specification compiled by the working group for hop analysis (AHA) describes precisely how samples are to be treated (sample division and storage), lays down which laboratories carry out post-analyses and defines the tolerance ranges permissible for the analysis results. In 2014, the IPZ 5d Work Group once again assumed responsibility for organizing and evaluating the ring analyses used to verify the quality of the alpha-acid analyses.

The following laboratories took part in the 2014 ring analyses:

Hallertauer Hopfenveredelungsgesellschaft (HHV), plant Au/Hallertau
NATECO$_2$ GmbH & Co. KG, Wolnzach
Hopfenveredlung St. Johann GmbH & Co. KG, St. Johann
Hallertauer Hopfenveredelungsgesellschaft (HHV), plant Mainburg
Hallertauer Hopfenverwertungsgenossenschaft (HVG), Mainburg
Agrolab GmbH, Oberhummel
Hops Dept. of the Bavarian State Research Centre for Agriculture, Hüll

The ring analyses commenced on 8th September 2014 and ended on 7th November 2014, as most of the hop lots had been examined in the laboratories during this period. In all, the ring test was performed nine times (nine weeks). The sample material was kindly provided by Mr. Hörmansperger (Hopfenring, Hallertau). To ensure maximum homogeneity, each sample was drawn from a single bale. Every Monday, the samples were ground with a hammer mill in Hüll, divided up with a sample divider, vacuum-packed and taken to the various laboratories. The laboratories analysed one sample per day on each of the following weekdays. One week later, the results were sent back to Hüll for evaluation. A total of 35 samples were analysed in 2014.

The evaluations were passed on to the individual laboratories without delay. A sample evaluation, serving as a model example of a ring analysis, can be seen in *Fig. 7.6*. The laboratory numbers (1-7) do not correspond to the above list. The outlier test was calculated as per ISO 5725. Cochran's test was applied for intra-laboratory assessment and Grubb's test for inter-laboratory assessment.

Nr. 1: HHA (09.09.2014)

Labor	KW		mittel	s	cvr
1	3,49	3,49	3,49	0,000	0,0
2	3,39	3,40	3,40	0,007	0,2
3	3,54	3,57	3,56	0,021	0,6
4	3,58	3,48	3,53	0,071	2,0
5	3,45	3,48	3,47	0,021	0,6
6	3,36	3,34	3,35	0,014	0,4
7	3,48	3,54	3,51	0,042	1,2

mean	3,47
sr	0,034
sL	0,070
sR	0,078
vkr	0,97
vkR	2,24
r	0,09
R	0,22
Min	3,34
Max	3,58

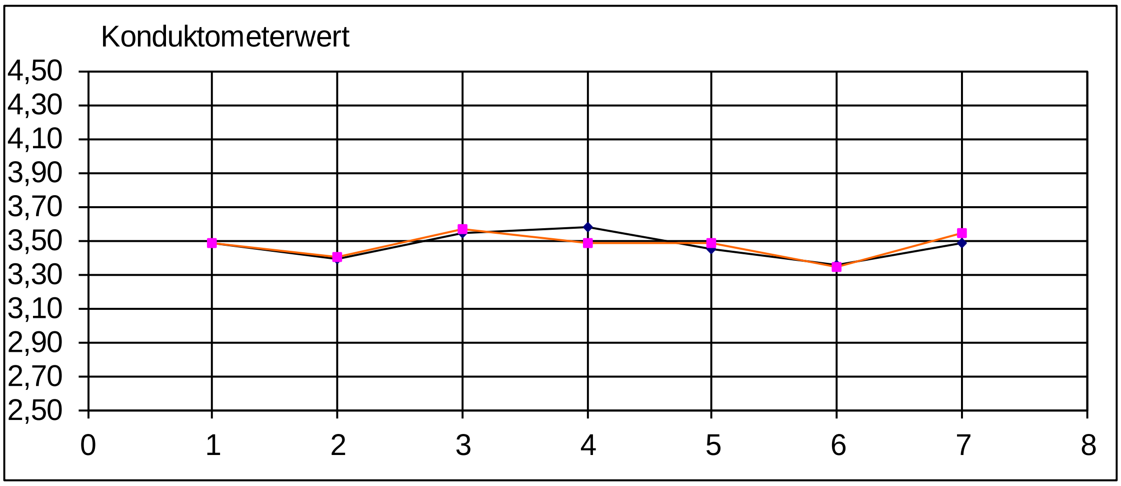


Fig. 7.6: Evaluation of a ring analysis

The outliers in 2014 are compiled in *Tab. 7.3.*

Tab. 7.3: Outliers in 2014

	Cochran			
Sample	α = 0.01	α = 0.05	α = 0.01	α = 0.05
31	0	0	0	5
Total:	**0**	**0**	**0**	**1**

Since 2013 there have been 5 alpha-acid classes and newly calculated tolerance limits. The new classes and the outliers in 2014 are shown in *Tab. 7.4*

Tab. 7.4: update dalpha-and tolerance acid classes limits and outliers in 2014

	< 5.0 %	5.0 % - 8.0 %	8.1 % - 11.0 %	11.1 % - 14 %	> 14.0 %
Critical difference Range	+/-0.3 0.6	+/-0.4 0.8	+/-0.5 1.0	+/-0.6 1.2	+/- 0.7 1.4
Outliers in 2014	0	0	0	0	1

In 2014, one outlier was observed in a sample with an alpha-acid content of over 14%.

Fig. 7.7 shows all analytical results for each laboratory as relative deviations from the mean (= 100 %), differentiated according to α-acid levels of <5 %. >=5 % and <10 % as well as >=10 %. Whether a laboratory tends to arrive at values that are too high or too low can be clearly seen from this graph.

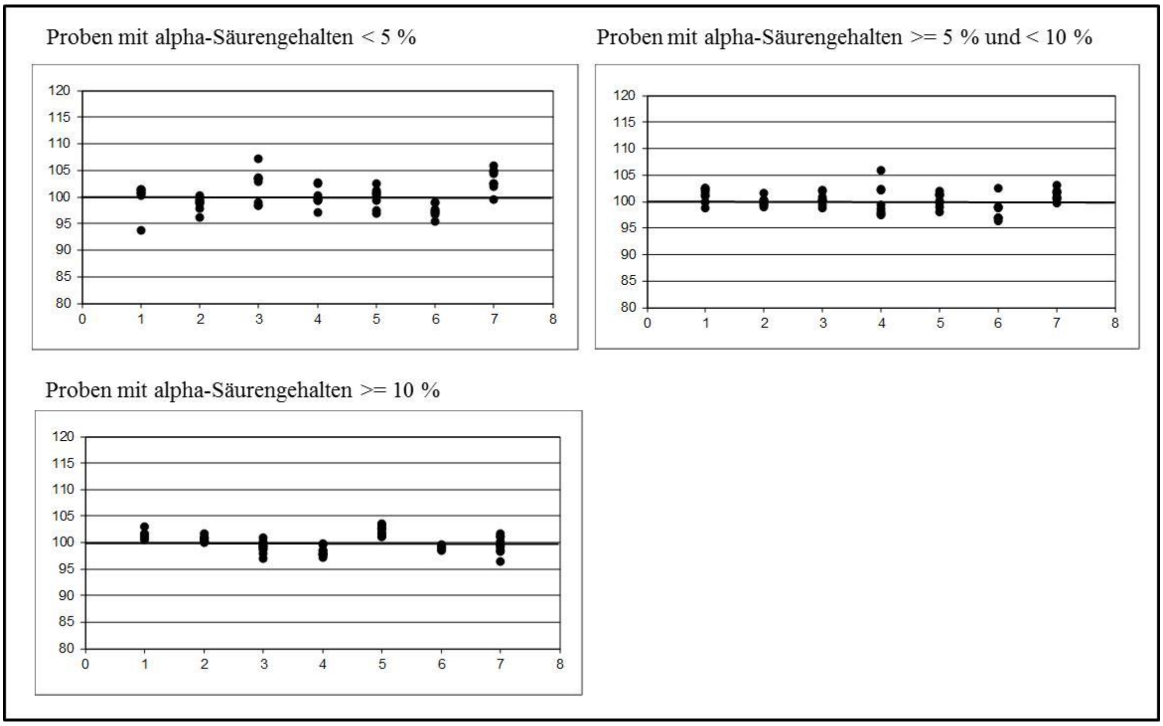


Fig. 7.7: Analysis results of the laboratories relative to the mean

The Hüll laboratory is number 5.

7.5.1 Evaluation of post-analyses

Since 2005, post-analyses have been performed in addition to the ring tests. The post-analyses are evaluated by the IPZ 5d Work Group, which passes on the results to the participating laboratories, the German Hop Growers' Association and the German Hop Trading Association. Three samples per week are selected by an initial test laboratory and these samples are subsequently analysed by three other laboratories according to the AHA specification. The result of the initial test is confirmed if the post-analysis mean and the initial test result are within the tolerance limits (Tab. 7.5). The 2014 results are shown in Tab. 7.7. Since 2005, all initial test results have been confirmed.

Tab. 7.5: 2014 post-analyses

Sample designation	Initial test laboratory	Initial test	Post-analysis			Mean value	Result confirmed
			1	2	3		
KW 37 HHT	HHV Au	5.6	5.5	5.5	5.7	5.57	yes
KW 37 HPE	HHV Au	6.9	6.8	6.8	7.1	6.90	yes
KW 37 HNB	HHV Au	10.6	10.2	10.3	10.3	10.27	yes
KW 38 QK 1402 HNB	NATECO2 Wolnzach	8.0	8.5	8.7	8.7	8.63	yes
KW 38 QK 1408 HHM	NATECO2 Wolnzach	12.1	12.0	12.0	12.1	12.03	yes
KW 38 QK 1412 HTU	NATECO2 Wolnzach	15.4	15.4	15.4	15.6	15.47	yes
KW 39 HHP 25347	HVG Mainburg	8.2	8.3	8.5	8.6	8.47	yes
KW 39 HHT 26038	HVG Mainburg	6.1	6.1	6.3	6.3	6.23	yes
KW 39 HNB 25326	HVG Mainburg	9.5	9.7	10.0	10.0	9.90	yes
KW 40 HMR	HHV Au	13.4	13.1	13.3	13.4	13.27	yes
KW 40 HHM	HHV Au	11.4	11.2	11.2	11.5	11.30	yes
KW 40 HHS	HHV Au	17.9	17.2	17.3	17.6	17.37	yes
KW 41 QK 3182 HHS1	NATECO2 Wolnzach	17.7	17.9	18.1	18.3	18.10	yes
KW 41 QK 3184 HHS2	NATECO2 Wolnzach	19.5	19.5	19.7	19.8	19.67	yes
KW 41 QK 3185 HHS3	NATECO2 Wolnzach	16.5	16.3	16.6	16.7	16.53	yes
KW 42 HPE	HVG Mainburg	7.9	8.0	8.2	8.2	8.13	yes
KW 42 HHS	HVG Mainburg	19.0	18.9	19.3	19.5	19.23	yes
KW 42 HTU	HVG Mainburg	17.3	17.3	17.8	17.9	17.67	yes
KW 43 HPE	HHV Au	8.4	8.4	8.4	8.5	8.43	yes
KW 43 HPE	HHV Au	9.4	9.2	9.2	9.5	9.30	yes
KW 43 HHS	HHV Au	17.5	17.4	17.4	17.5	17.43	yes
KW 44 QK 4394 HHS1	NATECO2 Wolnzach	15.0	14.8	15.1	15.2	15.03	yes
KW 44 QK 4393 HHS2	NATECO2 Wolnzach	14.0	13.5	13.8	14.0	13.77	yes
KW 44 QK 4403 HHS3	NATECO2 Wolnzach	13.6	13.2	13.5	13.6	13.43	yes
KW 45 33859 HHS1	HVG Mainburg	16.3	16.3	16.5	16.5	16.43	yes
KW 45 33990 HHS2	HVG Mainburg	18.1	18.1	18.4	18.4	18.30	yes
KW 45 33960 HHS3	HVG Mainburg	17.3	17.3	17.3	17.6	17.40	yes

7.6 Production of pure alpha acids and their orthophenylendiamine complexes for monitoring and calibrating the HPLC standard

In the autumn of 2010, the AHA working group introduced the international calibration extract ICE 3. It was the task of the Hüll laboratory to produce the ultra-pure α-acids (>98 %) required for calibrating and monitoring the extract as a standard. The stability of the calibration extract is checked twice a year by the AHA laboratories. The orthophenylene-diamine complex is first prepared from a CO_2 hop extract with a high α-acid content by reaction with orthophenylenediamine (*Fig. 7.8*).

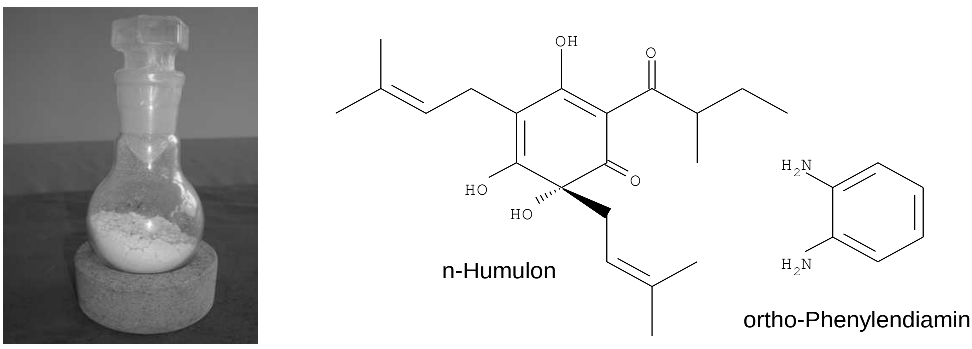


Fig. 7.8: Orthophenylenediamine complex and its chemical structure

This complex can be purified by multiple re-crystallization. The pure α-acids are then released from the complex. The complex itself has been found to be very stable and to be suitable for use as a standard for ICE calibration.

7.7 Findings with respect to the biogenesis of the total oil content of the new Hüll Special-Flavor Hops in 2012, 2013 and 2014

Research into the biogenesis of the alpha-acids of the most important hop varieties is performed in Hüll every year. As far as the Special-Flavor Hops are concerned, the aroma substances are, however, of major importance. In 2012-2014, the total-oil content and composition of the four new Hüll Special-Flavor Hops were also analysed alongside the alpha-acids. Tab. 7.6 shows the harvesting dates and *Fig. 7.9* to *Fig. 7.12* the results.

Tab. 7.6: *Harvesting dates*

Harvest year	T0	T1	T2	T3	T4	T5	T6
2012	16.08.2012	21.08.2012	28.08.2012	04.09.2012	11.09.2012	18.09.2012	25.09.2012
2013	14.08.2013	20.08.2013	27.08.2013	03.09.2013	10.09.2013	17.09.2013	24.09.2013
2014	13.08.2014	19.08.2014	26.08.2014	03.09.2014	09.09.2014	16.09.2014	23.09.2014

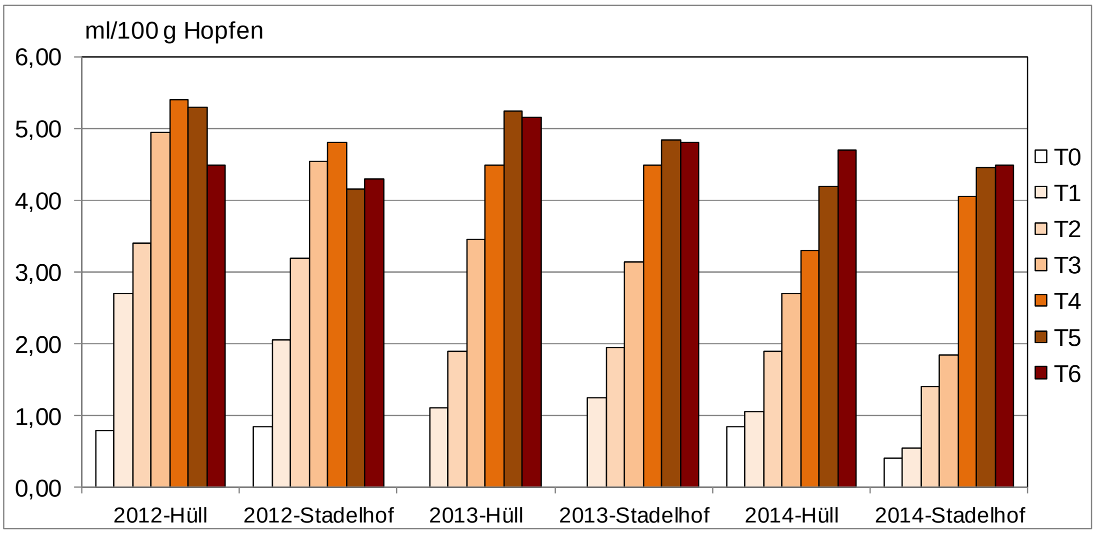


Fig. 7.9: Biogenesis of total oil content of Polaris from 2012 – 2014

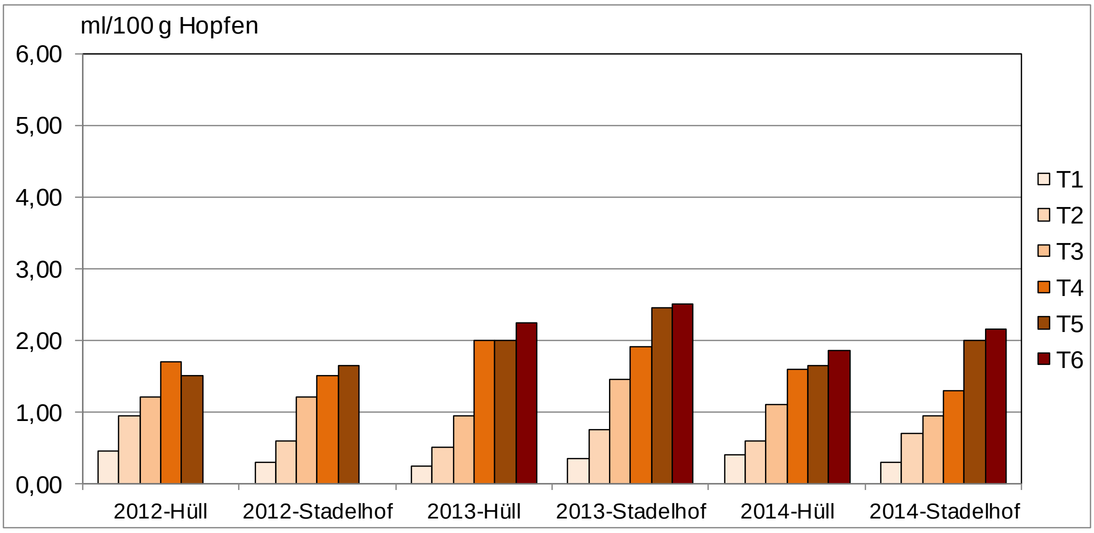


Fig. 7.10: Biogenesis of total oil content of Mandarina Bavaria from 2012 – 2014

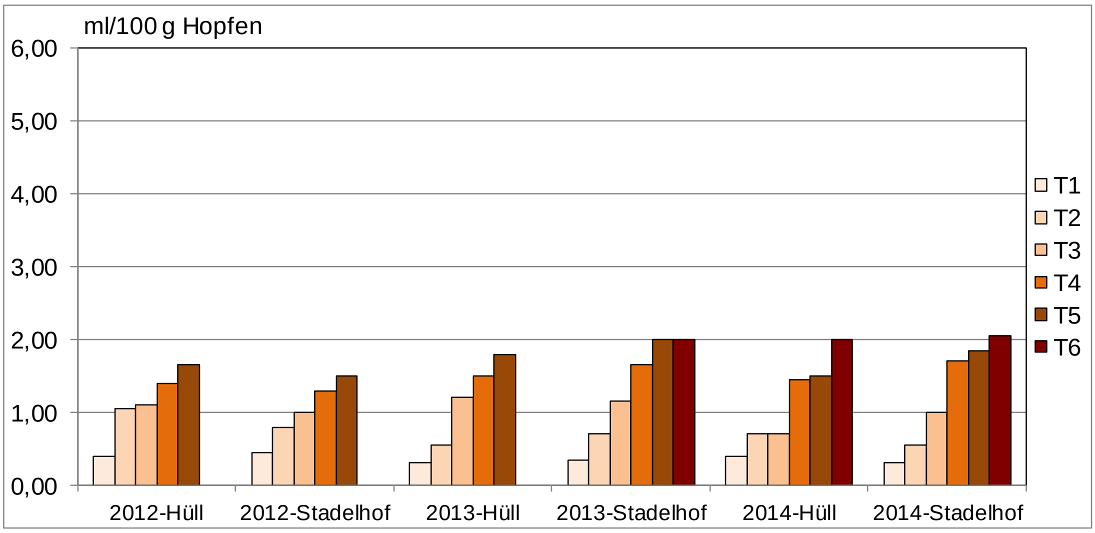


Fig. 7.11: Biogenesis of total oil content of Hallertau Blanc from 2012 - 2014

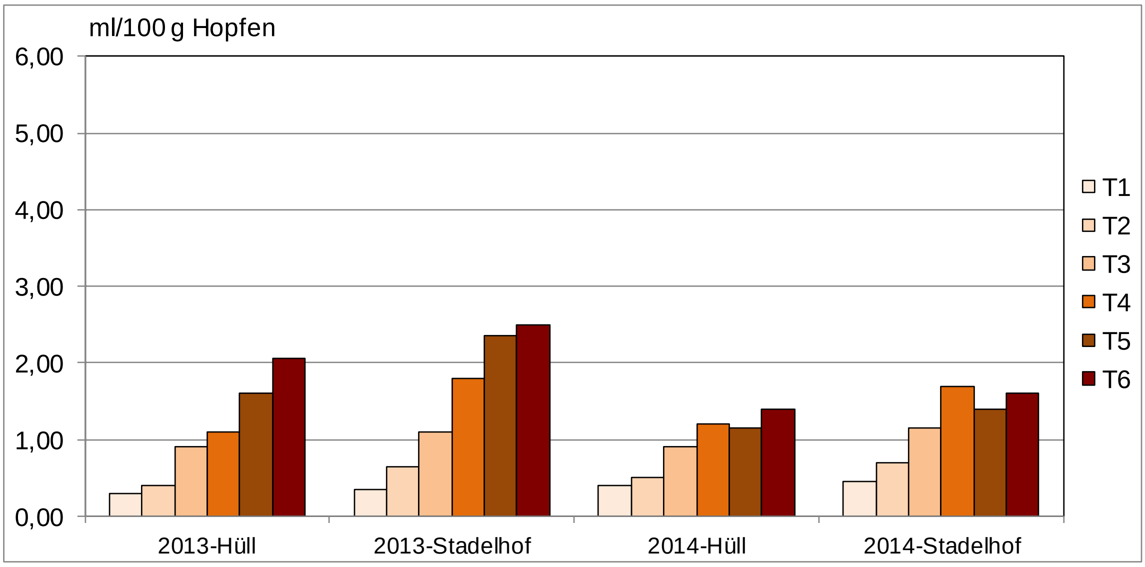


Fig. 7.12: Biogenesis of total oil content of Hüll Melon from 2013 – 2014

As can be seen, the oil content of the Polaris variety, with more than 5ml/100g hops, is very high; currently no other hop variety in the world has such a high oil content. The findings were nevertheless quite astonishing. Oil content levels in 2013 were even higher than in 2012 and 2014, although 2013 saw a very hot July with almost no rainfall, which led to much lower yields and alpha-acid levels. The biosynthesis of aroma substances, however, does not commence until very late, i.e. on about 20th August, by which time the weather situation in 2013 was, in fact, very favourable (*Fig. 7.13* and *Fig. 7.14*). It was warm enough and there was sufficient rain, which led to a further strong increase in aro-ma- substance content.

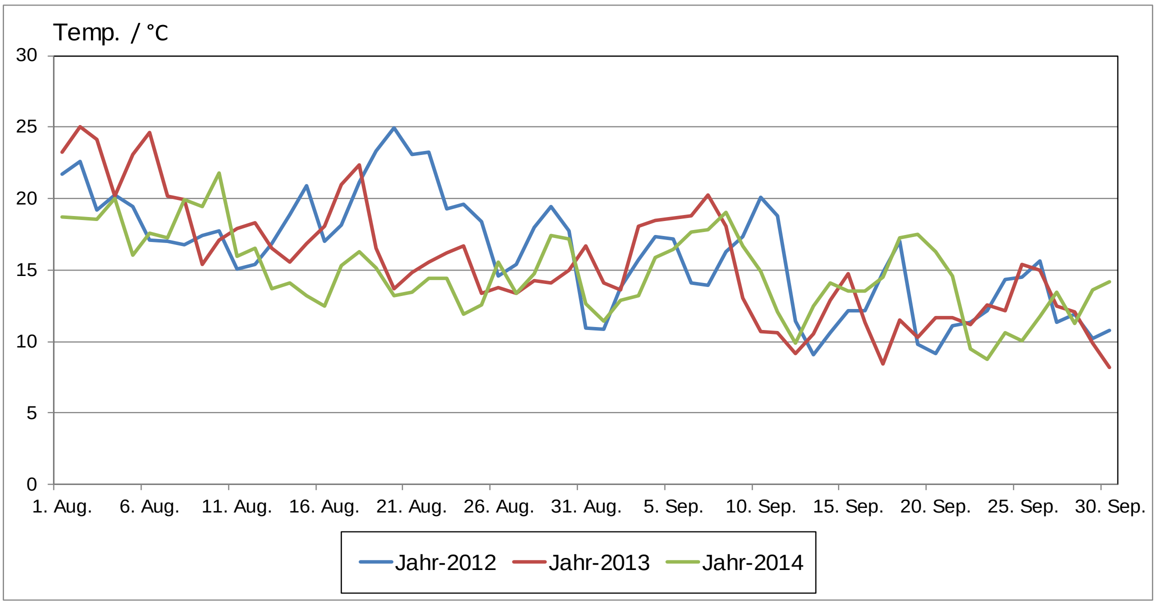


Fig. 7.13: Temperature trend in August-September, 2012-2014

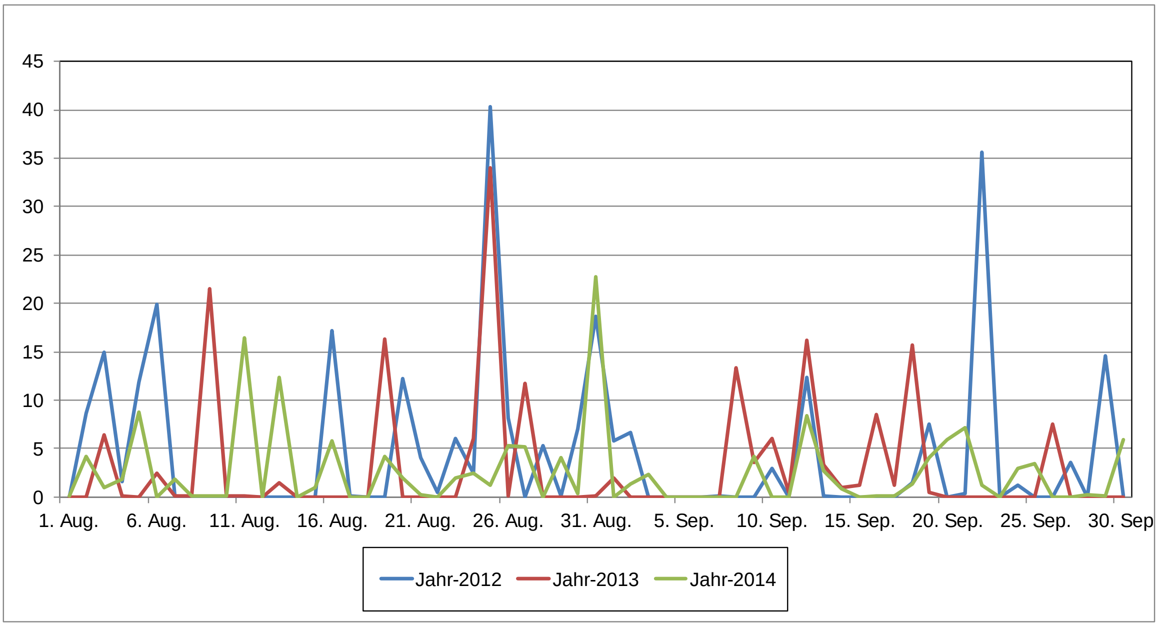


Fig. 7.14: Rainfall in August-September, 2012-2014

The last few weeks before harvesting are decisive for aroma profiles. Total-oil content and composition are much more dependent on the time of harvesting than is the case with the bitter substances. The share of myrcene in oil composition, in particular, rises more strongly than that of the other oil components, which also affects sensory perception

7.8 Analyses for Work Group IPZ 3d, Medicinal and Aromatic Plants

The following special analyses were performed for Work Group 3d, Medicinal and Aromatic Plants:

Salvia miltiorrhiza: 30 duplicate determinations of tanshinone

7.9 Monitoring for varietal authenticity

IPZ 5d has a statutory duty to provide administrative assistance to the German food control authorities by monitoring varietal authenticity.

Varietal authenticity checks for German food authorities (District Administrator's Offices)	27
of which complaints	0

8 Publications and specialist information

8.1 Overview of PR activities

	Number		Number
Practice-relevant information and scientific articles	40	Guided tours	49
LfL publications	2	Exhibitions and posters	3
Press releases	-	Basic and advanced training sessions	8
Radio and TV broadcasts	4	Final-year university degree theses	
Conferences, trade events and seminars	18	Participation in working groups	28
Talks	101	Foreign guests	149

8.2 Publications

8.2.1 Practice-relevant information and scientific papers

Graf, T. (2014): Hopfenpflanzer informieren sich über Bewässerung. Hopfen-Rundschau, 65; Nr. 9, Edit.: Verband Deutscher Hopfenpflanzer e.V., 303 – 304

Graf, T., Beck, M.; Mauermeier, M.; Ismann D.; Portner, J.; Doleschel, P.; Schmidhalter U. (2014): Humulus lupulus – The Hidden Half. Brewing Science, 161, 67

Jereb, M., Schwarz, J.; Weihrauch, F. (2014): Einsatz und Etablierung von Raubmilben zur nachhaltigen Spinnmilbenkontrolle in der Sonderkultur Hopfen. LfL-Schriftenreihe, Angewandte Forschung und Beratung für den ökologischen Landbau in Bayern; Öko-Landbau-Tag 2014, Edit.: Bayerische Landesanstalt für Landwirtschaft (LfL), 181 – 184

Jereb, M., Schwarz, J.; Weihrauch, F. (2014): Use and establishment of predatory mites for sustainable control of two-spotted spider mite (Tetranychus urticae) in hop. DgaaE-Nachrichten, 28(1), Edit.: Deutsche Gesellschaft für allgemeine und angewandte Entomologie, 47 – 48

Jereb, M., Schwarz, J.; Weihrauch, F. (2014): Einsatz und Etablierung von Raubmilben zur nachhaltigen Spinnmilbenkontrolle in der Sonderkultur Hopfen. Julius-Kühn-Archiv, 447, 59. Deutsche Pflanzenschutztagung, 23.-26. September 2014, Albert-Ludwigs-Universität Freiburg – Kurzfassungen der Beiträge -, Edit.: Julius Kühn-Institut, 114 – 115

Kammhuber, K. (2014): Ergebnisse von Kontroll- und Nachuntersuchungen für Alphaverträge der Ernte 2013. Hopfen-Rundschau 65 (08), Edit.: Verband Deutscher Hopfenpflanzer e.V., 266 – 267

Kammhuber, K. (2014): Aktualisierte Alpha-Bereiche und Analysentoleranzen bei Alpha-Verträge. Hopfen-Rundschau 65 (09), Edit.: Verband Deutscher Hopfenpflanzer e.V., 300 – 301

Kammhuber, K. (2014): Mit Hightech dem Hopfenaroma auf der Spur. Hopfenrundschau International, 2014/2015, Edit.: Verband Deutscher Hopfenpflanzer, 22 – 22

Kammhuber, K.; Graf, T.; Seefelder, S. (2014): Hopfenbauversammlungen der LfL. Hopfen-Rundschau 65 (03), Edit.: Verband Deutscher Hopfenpflanzer e.V., 79 – 81

Lutz, A., Seigner, E., Kneidl, J. (2014): Hüller Special Flavor-Hopfen – Hüll Special Flavor Hops. Hopfenrundschau International 2014/2015, Edit.: Deutscher Hopfenpflanzerverband, 20 – 21

Lutz, M., Portner, J. (2014): Start des neuen Modellvorhabens „Demonstrationsbetriebe integrierter Pflanzenschutz“. Hopfen-Rundschau 65 (05), Edit.: Verband Deutscher Hopfenpflanzer e.V., 151

Münsterer, J. (2014): Neue EDV-Version 7.0 der Bayerischen Hopfenschlagkartei (HSK). Hopfen-Rundschau 65 (01), Edit.: Verband Deutscher Hopfenpflanzer e.V., 7 – 7

Münsterer, J. (2014): Qualitätserhaltung durch Optimierung der Luftgeschwindigkeit beim Bandtrockner. Hopfenrundschau 65 (08), Edit.: Verband Deutscher Hopfenpflanzer e.V., 253 – 254

Portner, J. (2014): Hopfen. Bayerischer Agrarbericht

Portner, J. (2014): Modellvorhaben „Demonstrationsbetriebe integrierter Pflanzenschutz – Teilprojekt Hopfen“. Hopfen-Rundschau 65 (01), Edit.: Verband deutscher Hopfenpflanzer, 6

Portner, J. (2014): Gezielte Stickstoffdüngung des Hopfens nach DSN (Nmin). Hopfen-Rundschau 65 (04), Edit.: Verband Deutscher Hopfenpflanzer e.V., 118

Portner, J. (2014): Übermittlung von Angaben im Hopfensektor. Hopfen-Rundschau 65 (05), Edit.: Verband Deutscher Hopfenpflanzer e.V., 148 – 149

Portner, J. (2014): Nmin-Untersuchung ´14. Hopfen-Rundschau 65 (05), Edit.: Verband Deutscher Hopfenpflanzer e.V., 150

Portner, J. (2014): Peronosporabekämpfung. Hopfen-Rundschau 65 (06), Edit.: Verband Deutscher Hopfenpflanzer e.V., 189

Portner, J. (2014): Zwischenfruchteinsaat im Hopfen für KuLaP-Betriebe (A33) spätestens bis 30. Juni vornehmen!. Hopfenrundschau International 65 (06), Edit.: Verband Deutscher Hopfenpflanzer e.V., 189

Portner, J. (2014): Kostenfreie Rücknahme von Pflanzenschutzverpackungen PAMIRA 2014. Hopfen-Rundschau 65 (08), Edit.: Verband Deutscher Hopfenpflanzer e.V., 252

Portner, J. (2014): Rebenhäcksel baldmöglichst ausbringen!. Hopfen-Rundschau 65 (08), Edit.: Verband Deutscher Hopfenpflanzer e.V., 253

Portner, J. (2014): LfL-Hopfenbaulehrfahrten 2014. Hopfen-Rundschau 65 (09), Edit.: Verband Deutscher Hopfenpflanzer e.V., 302

Portner, J. (2014): Hallertauer Modell zum ressourcenschonenden Hopfenanbau. Hopfen-Rundschau 65 (09), Edit.: Verband Deutscher Hopfenpflanzer e.V., 302 – 303

Portner, J., Kammhuber, K. (2014): Fachkritik zur Moosburger Hopfenschau 2014. Hopfen-Rundschau 65 (10), Edit.: Verband Deutscher Hopfenpflanzer e.V., 331 – 335

Portner, J. (2014): Hopfen 2014 – Grünes Heft. LfL-Information, Edit.: Bayerische Landesanstalt für Landwirtschaft (LfL)

Schätzl, J. (2014): Pflanzenstandsbericht April 2014. Hopfen-Rundschau 65 (05), Edit.: Verband Deutscher Hopfenpflanzer e.V., 155

Schätzl, J. (2014): Pflanzenstandsbericht Mai 2014. Hopfen-Rundschau 65 (06), Edit.: Verband Deutscher Hopfenpflanzer e.V., 192

Schätzl, J. (2014): Pflanzenstandsbericht Juni 2014. Hopfen-Rundschau 65 (07), Edit.: Verband Deutscher Hopfenpflanzer e.V., 216

Schätzl, J. (2014): Pflanzenstandsbericht Juli 2014. Hopfen-Rundschau 65 (08), Edit.: Verband Deutscher Hopfenpflanzer e.V., 255

Schätzl, J. (2014): Pflanzenstandsbericht August 2014. Hopfenrundschau 65 (09), Edit.: Verband Deutscher Hopfenpflanzer e.V., 301

Seigner, E. (2014): Sortenliste des Internationalen Hopfenbaubüros. Hopfen-Rundschau 65 (01), Edit.: Verband Deutscher Hopfenpflanzer, 14 – 23

Seigner, E., Portner, J. (2014): Hop Stunt Viroid- und Zitrusviroid-Monitoring der LfL. Hopfen-Rundschau 65 (05), Edit.: Verband Deutscher Hopfenpflanzer e.V., 153

Seigner, L., Lutz, A. and Seigner, E. (2014): Monitoring of Important Virus and Viroid Infections in German Hop (Humulus lupulus L.) Yards. Brewing Science 67 (5/6), 81-87.

Sichelstiel, W.; Portner, J. (2014): Hopfenbauversammlungen der LfL. Hopfen-Rundschau 65 (04), Edit.: Verband Deutscher Hopfenpflanzer e.V., 116 – 117

Sichelstiel, W., Weihrauch, F.; Schwarz, J. (2014): Internationale Harmonisierung des Pflanzenschutzes im Hopfenbau durch die Commodity Expert Group Minor Uses Hops. Julius Kühn Archiv, 447, 59. Deutsche Pflanzenschutztagung, 23. – 26. September 2014, Albrecht-Ludwigs-Universität Freiburg, -Kurzfassung der Beiträge-, Edit.: Julius-Kühn-Institut, 113 – 114

Weihrauch, F., Jereb, M. (2014): Einsatz und Etablierung von Raubmilben zur nachhaltigen Spinnmilben-kontrolle in der Sonderkultur Hopfen – BÖLN-Projekt 2812NA014; 1. Zwischenbericht 2013

Weihrauch, F., Schwarz, J. (2014): Versuche zur Minimierung des Einsatzes kupferhaltiger Pflanzenschutz-mittel im ökologischen Hopfenbau. LfL-Schriftenreihe, 2/2014, Angewandte Forschung und Beratung für den ökologischen Landbau in Bayern; Öko-Landbau-Tag 2014, Edit.: Bayerische Landesanstalt für Land-wirtschaft (LfL), 174 – 180

Weihrauch, F., Schwarz, J. (2014): Reduzierung oder Ersatz kupferhaltiger Pflanzenschutzmittel im ökologi-schen Hopfenbau – BLE-Projekt 2809OE058; Projektbericht 2014

Weihrauch, F., Schwarz, J. (2014): Minimierung des Einsatzes kupferhaltiger Fungizide im ökologischen Hopfenbau: Wo stehen wir heute? Julius-Kühn-Archiv, 447, 59. Deutsche Pflanzenschutztagung, 23.-26. September 2014, Albert-Ludwigs-Universität Freiburg – Kurzfassungen der Beiträge -, Edit.: Julius Kühn-Institut, 112 – 113

8.2.2 LfL publications

Name	Work Group	LfL publications	Title
Hops Department IPZ 5	IPZ 5	LfL Information (LfL publication)	Annual Report 2013 – Special Crop: Hops
Portner, J.	IPZ 5a	LfL Information (LfL-publication)	Hopfen 2014 – Grünes Heft (Hops 2014 – "Green Leaflet")

8.2.3 Radio and TV broadcasts

Name/WG	Date of broadcast	Topic	Title of pro-gramme	Station
Lutz, A., Weiher, J. Kneidl, J., Presl, I. IPZ 5	18.07.2014	Sexing – Hop breeding in the Hallertau area	Unser Land	BR (Bavarian Broadcas-ting)
Portner, J., Lutz, M. IPZ 5a and Jereb, M., IPZ 5b	29.08.2014	Any chance without chemistry? Plant protection in hop growing	UNSER LAND	BR
Lutz, A., IPZ 5c Zarnkow, M. Plank, M.	22.09.2014	"Beer: The unknown essence"	Faszination Wissen	BR
Lutz, A., IPZ 5 c Eric Toft	02.07.2014	Who brews the best beer?	Galileo	ProSieben

8.3 Conferences, talks, guided tours and exhibitions

8.3.1 Conferences, trade events and seminars

Organised by	Topic	Participants	Date/Venue
Graf, T., IPZ 5a	Optimising irrigation management in hop growing	Project managers and staff involved in projects dealing with irrigation issues in Bavarian agriculture	Wolnzach 24.02.2014
Graf, T., IPZ 5a	Irrigation in hop growing	Farmers	Karpfenstein 05.08.2014
Graf, T., IPZ 5a	Irrigation in hop growing	Farmers	Karpfenstein 07.08.2014
Münsterer, J., IPZ 5a	Optimal hop conditioning	Hop farmers from all German hop-growing areas	Wolnzach 17.01.2014
Münsterer, J., IPZ 5a	Workshop: "Optimising kiln drying"	Hop growers with measuring and control equipment in floor kilns	Wolnzach 22.01.2014
Münsterer, J., IPZ 5a	Workshop: "Optimising belt dryers"	Hop growers with belt dryers	Wolnzach 23.01.2014
Münsterer, J., IPZ 5a	New measuring techniques for controlling belt dryers	Elbe-Saale hop growers	Ostrau, Elbe-Saale 29.01.2014
Münsterer, J., IPZ 5a	Seminar: "Fundamentals of hop drying"	Hop growers from all German hop-growing areas	Wolnzach 08.12.2014
Münsterer, J., IPZ 5a	Seminar: "Using alternative energy sources for hop drying"	Hop farmers from all German hop-growing areas	Wolnzach 10.12.2014
Münsterer, J., IPZ 5a	Optimal hop conditioning	Hop farmers from all German hop-growing areas	Wolnzach 12.12.2014
Portner, J., IPZ 5a	The Hallertauer model for resource-saving hop growing	Water suppliers and project participants	Mainburg 20.11.2014
Lutz, A., Seigner, E., IPZ 5c	Hop advisory committee	Hop aroma experts	Hüll 28.01.2014
Lutz, A., Seigner, E., IPZ 5c	Hop advisory committee	Hop aroma experts	Hüll 19.05.2014
Lutz, A., Seigner, E., IPZ 5c	Hop advisory committee	Hop aroma experts	Hüll 30.06.2014
Lutz, A., Seigner, E., IPZ 5c	Hop advisory committee	Hop aroma experts	Hüll 06.10.2014
Sichelstiel, W., IPZ 5b	Current plant protection problems and possible solutions in hop growing	Plant protection experts	Mainburg 29.08.2014
Sichelstiel, W., IPZ 5b	The Commodity Expert Group (CEG) Minor Uses Hops – Work on lack of authorised PPPs at European level	Plant protection experts	Mainburg 29.08.2014
Kammhuber, K., IPZ 5d, Lutz, A., Kneidl, J., IPZ 5c	Assessment of hop samples from German hop-growing areas	Hop experts, Hop growers, hop traders, brewers	Hüll, 16.10.2014

8.3.2 Talks

WG	Name	Topic	Organiser Attendees	Date	Venue
IPZ 5	Doleschel, P.	The LfL-Hop research and consultancy in Bavaria	GfH 125 members and GfH guests	08.04.14	Wolnzach
IPZ 5	Graf, T.	DBU – Project	LfL 30 IPZ 5 employees	03.04.14	Hüll
IPZ 5a	Graf, T.	Optimising irrigation manangement in hop growing	LfL+BayWa 30 BayWa employees	13.02.14	Wolnzach
IPZ 5a	Graf, T.	Optimising irrigation management in hop growing	LfL + AELF Roth 20 representatives from agriculture and industry	17.02.14	Hedersdorf
IPZ 5a	Graf, T.	Optimising irrigation management in hop growing	LfL + AELF Roth 35 representatives from agriculture and industry	17.02.14	Spalt
IPZ 5a	Graf, T.	Optimising irrigation management in hop growing	LfL + AELF Pfaffenhofen 50 representatives from agriculture and industry	18.02.14	Lindach
IPZ 5a	Graf, T.	Optimising irrigation management in hop growing	LfL + AELF Kelheim 85 representatives from agriculture and industry	19.02.14	Mainburg
IPZ 5a	Graf, T.	Optimising irrigation management in hop growing	LfL + AELF Erding 35 representatives from agriculture and industry	20.02.14	Osseltshau-sen
IPZ 5a	Graf, T.	Optimising irrigation management in hop growing	LfL + AELF Landshut 45 representatives from agriculture and industry	21.02.14	Oberhatz-kofen
IPZ 5a	Graf, T.	Optimising irrigation management in hop growing	LfL 30 representatives from agriculture and industry	25.02.14	Biburg
IPZ 5a	Graf, T.	Optimising irrigation management in hop growing	LfL 100 representatives from agriculture and industry	26.02.14	Niederlauter-bach
IPZ 5a	Graf, T.	Optimising irrigation management in hop growing	LfL 25 representatives from agriculture and industry	28.02.14	Lobsing
IPZ 5a	Graf, T.	Optimising irrigation management in hop growing	HVG eG 25 attendees, Supervisory Board mem-bers of the HVG eG	20.03.14	Wolnzach
IPZ 5a	Graf, T.	Optimising irrigation management in hop growing	GfH 35 attendees GfH tech. + scientific committee	08.04.14	Wolnzach
IPZ 5a	Graf, T.	Irrigation in hop gro-wing	LfL 20 farmers	05.08.14	Karpfenstein
IPZ 5a	Graf, T.	Irrigation in hop gro-wing	LfL 25 farmers	05.08.14	Karpfenstein
IPZ 5a	Graf, T.	Irrigation in hop gro-wing	LfL 25 farmers	07.08.14	Karpfenstein
IPZ 5a	Lutz, M.	Initial findings with the model project “Demonstration Farms for Integrated Plant Protection in Hop Growing”	Hallertau Hop Growers’ Association 35 members of the Hal-lertau Hop Growers’ Asso-ciation	18.11.14	Niederlauter-bach

WG	Name	Topic	Organiser Attendees	Date	Venue
IPZ 5a	Lutz, M.	Initial findings with the model project “Demonstration farms for integrated plant protection in hop growing”	LfL 30 employees from the Institute for Plant Protection, ÄELF and Expert Centre L 3.1 – Crop Science	02.12.14	Freising
IPZ 5a	Münsterer, J.	New measuring techniques for controlling belt dryers	Elbe-Saale Hop Growers' Association 60 hop growers	29.01.14	Ostrau, Elbe-Saale
IPZ 5a	Münsterer, J.	Field record evaluation with the hop-card index (HSK)	LfL 17 members of the HSK working group	17.03.14	Wolnzach, House of Hops
IPZ 5a	Münsterer, J.	Drying performance and dimensioning of dryers	IGN Niederlauterbach 150 members	21.09.14	Niederlauterbach
IPZ 5a	Münsterer, J.	Efficient use of alternative energy sources for hop drying	AELF Ingolstadt and AELF Pfaffenhofen 70 “Holzheizung aktuell” participants	23.10.14	Niederlauterbach
IPZ 5a	Münsterer, J.	Production techniques to improve and uphold crop performance	Elbe-Saale Hop Growers' Association, 60 hop growers, 80 members	03.12.14	Höfgen/ Grimma
IPZ 5a	Portner, J.	Latest update on hop growing	LfL and BayWa 30 BayWa employees	13.02.14	Wolnzach
IPZ 5a	Portner, J.	Latest update on hop growing	LfL and Beiselen GmbH 25 employees of the rural trading company	14.02.14	Hebrontshausen
IPZ 5a	Portner, J.	Latest update on hop growing	LfL+AELF Roth 20 hop growers	17.02.14	Hedersdorf
IPZ 5a	Portner, J.	Latest update on hop growing	LfL+AELF Roth 35 hop growers	17.02.14	Spalt
IPZ 5a	Portner, J.	Latest update on hop growing	LfL+AELF PAF 50 hop growersr	18.02.14	Lindach
IPZ 5a	Portner, J.	Latest update on hop growing	LfL+AELF Abensberg 85 hop growers	19.02.14	Mainburg
IPZ 5a	Portner, J.	Latest update on hop growing	LfL+AELF Erding 35 hop growers	20.02.14	Osseltshausen
IPZ 5a	Portner, J.	Latest update on hop growing	LfL 45 hop growers	21.02.14	Oberhatzkofen
IPZ 5a	Portner, J.	Latest update on hop growing	LfL + AELF Abensberg 30 hop growers	25.02.14	Biburg
IPZ 5a	Portner, J.	Latest update on hop growing	LfL + AELF Pfaffenhofen 100 hop growers	26.02.14	Niederlauterbach
IPZ 5a	Portner, J.	Latest update on hop growing	LfL, 25 hop growers	28.02.14	Lobsing
IPZ 5a	Portner, J.	Infos and facts about hop growing	AELF Ingolstadt 15 hop ambassadresses	15.07.14	Wolnzach
IPZ 5a	Portner, J.	Infos and facts about hop growing	Hallertau Hop Growers' Association, 5 hop-queen aspirants	07.08.14	Wolnzach
IPZ 5a	Portner, J.	Expert hop critics 2014	Town of Moosburg a.d. Isar 80 visitors and guests of the Moosburger Hop Show	18.09.14	Moosburg a.d. Isar
IPZ 5a	Portner, J.	Hallertauer model for resource-saving hop farming	Hallertau joint water-supply management authority, 20 public water suppliers and project participants	20.11.14	Mainburg

WG	Name	Topic	Organiser Attendees	Date	Venue
IPZ 5a	Schätzl, J.	Hop growing in the Hallertau region	Weihenstephan university 32 students of brewing and agriculture	19.05.14	Freising
IPZ 5a	Schätzl, J.	Latest update on fertilisation and plant protection/Alternativesto chemical hop stripping	Hopfenring + LfL 9 Ring consultants	23.05.14	Wolnzach
IPZ 5a	Schätzl, J.	Latest update on plant protection in 2014	LfL and AELF Roth 43 hop growers and guests from Spalt	28.05.14	Spalt
IPZ 5a	Schätzl, J.	Rosy Rustic infestation – direct and indirect control methods/ Herbicide damage	Hopfenring + LfL 9 Ring consultants	11.06.14	Hüll and Eschelbach
IPZ 5a	Schätzl, J.	Pests and diseases	Hopfenring + LfL 9 Ring consultants	07.07.14	Walkersbach
IPZ 5a	Schätzl, J.	Final plant protection measures and anticipated harvest dates	Hopfenring + LfL 8 Ring consultants	13.08.14	Hüll
IPZ 5a	Schätzl, J.	Consultancy in 2014 – the year in review	Hopfenring + LfL 9 Ring consultants	03.12.14	Wolnzach
IPZ 5b	Jereb, M.	Release and establishment of predatory mites for sustainable spider-mite control in hops	LfL 20 representatives from organic-farming associations and research and consultancy organisations	09.04.14	Triesdorf
IPZ 5b	Jereb, M.	Release and establishment of predatory mites for sustainable spider-mite control in hops	JKI, Baden-Württemberg plant protection service and German Phytomedical Society 120 scientists and consultants, representatives of the crop protection industry	23.09.14	Freiburg im Breisgau
IPZ 5b	Jereb, M.	Release and establishment of predatory mites for sustainable spider-mite control in hops	German Phytomedical Society & German Soc. for General and Applied Entomology 42 scientists and plant protection consultants	25.11.14	Veitshöchheim
IPZ 5b	Schwarz, J.	Quassia – quo vadis?	Bioland (Bavaria) 30 attendees	04.02.14	Plankstetten
IPZ 5b	Schwarz, J.	Authorised PPP situation in 2014	LfL 30 attendees	25.02.14	Biburg
IPZ 5b	Schwarz, J.	Authorised PPP situation in 2014	LfL 100 attendees	26.02.14	Niederlauterbach
IPZ 5b	Schwarz, J.	Authorised PPP situation in 2014	LfL 25 attendees	28.02.14	Lobsing
IPZ 5b	Schwarz, J.	Authorised PPP situation in 2014	LfL 10 attendees	12.03.14	Haunsbach
IPZ 5b	Schwarz, J.	Trials to minimise the use of copper in organic hop farming	LfL 20 representatives from organic-farming associations and research and consultancy organisations	09.04.14	Triesdorf
IPZ 5b	Schwarz, J.	CEG meeting Minor Uses Hops – Trials in 2014	Commodity Expert Group 12 attendees	07.10.14	Brussels

WG	Name	Topic	Organiser Attendees	Date	Venue
IPZ 5b	Sichelstiel, W.	Possible solutions to current plant protection problems in hop growing	Fed. Ministry of Food & Agriculture 14 hop growers and representatives from hop- industry associations	30.01.14	Bonn
IPZ 5b	Sichelstiel, W.	Plant-protection research in hop cultivation	Fed. Ministry of Food & Agriculture 14 hop growers and representatives from hop- industry associations	30.01.14	Bonn
IPZ 5b	Sichelstiel, W.	Authorised PPP situation in 2014	LfL + BayWa 30 employees	13.02.14	Wolnzach
IPZ 5b	Sichelstiel, W.	Authorised PPP situation in 2014	LfL + Beiselen 25 employees and rural traders	14.02.14	Hebrontshausen
IPZ 5b	Sichelstiel, W.	Authorised PPP situation in 2014	LfL + AELF Roth 20 hop growers	17.02.14	Hedersdorf
IPZ 5b	Sichelstiel, W.	Authorised PPP situation in 2014	LfL + AELF Pfaffenhofen 50 hop growers	18.02.14	Lindach
IPZ 5b	Sichelstiel, W.	Authorised PPP situation in 2014	LfL + AELF Abensberg 85 hop growers	19.02.14	Mainburg
IPZ 5b	Sichelstiel, W.	Authorised PPP situation in 2014	LfL + AELF Erding 35 hop growers	20.02.14	Osseltshausen
IPZ 5b	Sichelstiel, W.	Authorised PPP situation in 2014	LfL + AELF Landshut 45 hop growers	22.02.14	Oberhatzkofen
IPZ 5b	Sichelstiel, W.	Authorised PPP situation in 2014	Lake Constance district office 150 hop growers	10.03.14	Laimnau
IPZ 5b	Sichelstiel, W.	Authorised PPP situation in 2014	LfL + AELF Roth 35 Hopfenpflanzer	17.03.14	Spalt
IPZ 5b	Sichelstiel, W.	The Rosy Rustic – a minor pest in hop growing	Hopfenring 80 hop growers	05.08.14	Forchheim
IPZ 5b	Sichelstiel, W.	The Rosy Rustic – a minor pest in hop growing	VLF Kelheim 45 hop growers	07.08.14	Forchheim
IPZ 5b	Sichelstiel, W.	The Commodity Expert Group (CEG) Minor Uses Hops – Europe-wide endeavours to address issues concerning the lack of authorised PPPs	Assoc. of German Hop Growers 70 trade visitors from the agrochemical industry	29.08.14	Mainburg
IPZ 5b	Sichelstiel, W.	Current plant protection problems and possible solutions in hop growing	Assoc. of German Hop Growers 70 trade visitors from the agrochemical industry	29.08.14	Mainburg
IPZ 5b	Sichelstiel, W.	International harmonisation of plant protection in hop growing by the Commodity Expert Group Minor Uses Hops	JKI, Baden-Württemberg pest-control office and German Phytomedical Soc. 150 scientists and representatives from the pest-control offices of the German Länder, licensing authorities and the agrochemical industry	23.09.14	Freiburg im Breisgau

WG	Name	Topic	Organiser Attendees	Date	Venue
IPZ 5b	Sichelstiel, W.	Pests and diseases in hops – situation in Germany 2014	Commodity Expert Group Minor Uses 12 attendees	06.10.14	Brussels
IPZ 5b	Weihrauch, F.	2013 trials to minimise the use of copper in organic hop farming and outlook for the future	Bioland 30 farmers and organic hop-farming consultants	04.02.14	Plankstetten monastery
IPZ 5b	Weihrauch, F.	Trials to minimse the use of copper-containing PPPs in organic hop farming	Society of Hop Research 32 representatives from various associations and breweries	08.04.14	Wolnzach
IPZ 5b	Weihrauch, F.	Minimising the use of copper-containing fungicides in organic hop farming: What progress have we made?	JKI, Baden-Württemberg pest-control office and German Phytomedical Soc. 150 scientists and representatives from the pest-control offices of the German Länder, licensing authorities and the agrochemical industry	23.09.14	Freiburg im Breisgau
IPZ 5b	Weihrauch, F.	Minimising the use of copper-containing fungicides in organic hop farming: update on 2014 trial results	JKI and the German Organic Food Industry Federation (BÖLW) 75 scientists and consultants plus representatives from the agrochemicals industry (integrated and ecological plant protection) and from the authorities	21.11.14	Berlin
IPZ 5b	Weihrauch, F.	Minimising the use of copper-containing fungicides in organic hop farming: update on 2014 trial results	HVG hop producer group 22 attendees including the HVG supervisory board	11.12.14	Wolnzach
IPZ 5c	Lutz, A.	Hüll special-flavor hops	Barth Haas Group 45 hop growers	19.08.14	Reicherts-hausen
IPZ 5c	Lutz, A.	Hüll special-flavor hops	Hopfenring 60 ISO-certified hop farmers	20.08.14	Hüll
IPZ 5c	Lutz, A.	Hüll special-flavor hops – large-area trial plantings and current breeding lines	Assoc. of German Hop Growers, 180 representatives from the hop and brewing industries, ministries, authorities and politics	28.08.14	Hüll
IPZ 5c	Lutz, A.	Innovative devlopment of new Hüll cultivars	Private Bavarian breweries and Bavarian Brewers' Federation; 90 representatives from the brewing industry	14.10.14	Spalt
IPZ 5c	Lutz, A.	The importance of US craft brewers for the global hop market – Hüll cultivars	Alt-Weihenstephaner Brauerbund 45 student brewers	03.11.14	Freising

WG	Name	Topic	Organiser Attendees	Date	Venue
IPZ 5c	Seigner, E.	Cross-breeding with the Tettnanger land-race variety	Baden-Württemberg Ministry of Land and Resources (MLR) 15 attendees – MLR head, Profs. Wünsche und Weber from Hohenheim university plus representatives from Tettnang Hop Growers' Association	19.02.14	Stuttgart
IPZ 5c	Seigner, E.	Research projects and main research areas of the WG Hop Breeding Research	LfL 30 attendees from IPZ 5	03.04.14	Hüll
IPZ 5c	Seigner, E.	Assessment of breeding lines by the GfH's newly appointed advisory committee and large-area trial plantings of selected lines	GfH (Gesellschaft für Hopfenforschung) 35 members of the GfH's technical and scientific committee	08.04.14	Wolnzach
IPZ 5c	Seigner, E.	Hüll special-flavor hops and innovations in cultivar breeding	LfL 90 Hopfenring members	05.08.14	Forchheim
IPZ 5c	Seigner, E.	Hüll special-flavor hops and innovations in cultivar breeding	LfL 45 VLF members (Assoc. of agricultural-college graduates.	07.08.14	Forchheim
IPZ 5c	Seigner, E.	Hüll special-flavor hops – current status and innovations in cultivar breeding	Assoc. Of German Hop Growers, 180 representatives from the hop and brewing industries, ministries, authorities and politics	28.08.14	Hüll
IPZ 5c	Seigner, E.	Innovations concerning the development of new Hüll hop cultivars	GfH 25 representatives from the brewing industry plus members of the GfH's Advisory Board	10.11.14	Spalt
IPZ 5d	Kammhuber, K.	Analytical characterisation of the new Hüll special-flavor hops	LfL+AELF Roth 20 hop growers	17.02.14	Hedersdorf
IPZ 5d	Kammhuber, K.	Analytical characterisation of the new Hüll special-flavor hops	LfL+AELF Roth 35 hop growers	17.02.14	Spalt
IPZ 5d	Kammhuber, K.	Analytical characterisation of the new Hüll special-flavor hops	LfL+AELF Pfaffenhofen 50 hop growers	18.02.14	Lindach
IPZ 5d	Kammhuber, K.	Analytical characterisation of the new Hüll special-flavor hops	LfL+AELF Abensberg 85 hop growers	19.02.14	Mainburg
IPZ 5d	Kammhuber, K.	Analytical characterisation of the new Hüll special-flavor hops	LfL+AELF Erding 35 hop growers	20.02.14	Osseltshausen
IPZ 5d	Kammhuber, K.	Analytical characterisation of the new Hüll special-flavor hops	LfL + AELF Landshut 45 hop growers	21.02.14	Oberhatzkofen
IPZ 5d	Kammhuber, K.	Analytical characterisation of the new Hüll special-flavor hops	LfL+AELF AB 30 hop growers	25.02.14	Biburg

WG	Name	Topic	Organiser Attendees	Date	Venue
IPZ 5d	Kammhuber, K.	Analytical characterisation of the new Hüll special-flavor hops	LfL+AELF Pfaffenhofen 100 hop growers	26.02.14	Niederlauterbach
IPZ 5d	Kammhuber, K.	Analytical characterisation of the new Hüll special-flavor hops	LfL 25 hop growers	28.02.14	Lobsing
IPZ 5d	Kammhuber, K.	Improvement of aroma characterisation of the new Hüll special-flavor hops	GfH 35 members of the GfH Managing Committee and of the GfH's technical and scientific committee	08.04.14	Wolnzach
IPZ 5d	Kammhuber, K.	Tracking hop aroma with high tech	Assoc. of German Hop Growers 180 representatives from the hop and brewing industries, ministries, authorities and politics	28.08.14	Hüll

8.3.3 Guided tours

WG	Guided by	Topic	Guests	Datem	NP
IPZ 5	Doleschel, P. Sichelstiel, W. Weihrauch, F. Kammhuber, K. Lutz, A. Seigner, E.	Hüll Hop Research Centre – Work organisation and network, research projects: plant protection in organic hop farming, hop components analysis, flavor-hop breeding, breeding for resistance, Verticillium studies	Delegation – Agriculture Committee of the European Parliament, president and representatives of the Assoc. of German Hop Growers	27.03.14	19
IPZ 5	Doleschel, P. Lutz, A. Kammhuber, K.	LfL hop research, hop breeding, special-flavor hops, aroma analysis	Crop husbandry trainees (administrative grade 4) for a Civil Service career in natural sciences and engineering	15.04.14	5
IPZ 5	Lutz, A. Kammhuber, K.	Hop research at the LfL, hop breeding, special-flavor hops, aroma analysis	A Japanese journalist	06.05.14	1
IPZ 5	Sichelstiel. W. Lutz, A. Portner, J. Seigner, E.	LfL hop research, hop growing, hop consultancy, plant protection, breeding, trial planting of breeding lines	HVG Spalt, Dr. Braun	12.05.14	1
IPZ 5	Sichelstiel, W. Lutz, A. Kammhuber, K.	LfL hop research , hop breeding, plant protection, hop analysis	VBBLE (Assoc. of civil servants for rural development)	20.05.14	80
IPZ 5	Seigner, E. Lutz, A. Kammhuber, K.	LfL hop research, hop breeding, hop growing, plant protection, hop analysis	Guests from Mondelez	21.05.14	2
IPZ 5	Kammhuber, K. Kneidl, J.	Chemische analysis of hop components, hop breeding	Teacher from Schyren high school in Pfaffenhofen	21.05.14	1
IPZ 5	Seigner, E. Lutz, A. Kammhuber, K. Sichelstiel, W.	Hop breeding and analysis	Hohenheim university, Tettnang Assoc.of Hop Growers	03.06.14	5

WG	Guided by	Topic	Guests	Datem	NP
IPZ 5	Lutz, A. Schätzl, J.	LfL hop research, hop research and hop growing	Pfaffenhofen vocational school	06.06.14	12
IPZ 5	Sichelstiel, W. Schwarz, J.	Hüll Hop Research Centre, plant protection in hop growing, hop breeding	Dow AgroSciences	11.06.14	2
IPZ 5	Sichelstiel, W.	Hüll Hop Research Centre, hop breeding	US Craft Brewers	12.06.14	2
IPZ 5	Lutz, A. Seigner, E. Kammhuber, K. Sichelstiel, W.	Hop breeding and analysis	Max-Planck Institute, Hohenheim university	27.06.14	4
IPZ 5	Sichelstiel, W. Lutz, A.	LfL hop breeding	Bavarian Ministry for Food, Agric. and Forestry, Dept. P	03.07.14	45
IPZ 5	Sichelstiel, W. Seigner, E.	LfL hop research, plant protection, hop breeding, special-flavor hops, hop analysis	Students from Munich Technical University (TUM), Faculty of Brewing Science and Food Technology	08.07.14	15
IPZ 5	Lutz, A. Sichelstiel, W.	In-row cultivation of Hüll breeding lines	Hop farmers conducting trials	09.07.14	4
IPZ 5	Sichelstiel, W. Kammhuber, K. Seigner, E.	LfL hop research, plant protection, hop analysis, hop breeding	Instit.for Agric. Eng. and Animal Husbandry, annual outing	16.07.14	65
IPZ 5	Sichelstiel, W. Lutz, A.	LfL hop research, hop breeding, plant protection	AB InBev Brauer	18.07.14	2
IPZ 5	Lutz, A. Sichelstiel, W. Kammhuber, K.	Hop breeding, special-flavor hops, hop analysis	Schneider Weisse	21.07.14	3
IPZ 5	Lutz, A. Schätzl, J.	LfL hop research, hop breeding, hop growing	Students from the Pfaffenhofen School of Agriculture	25.07.14	15
IPZ 5	Sichelstiel, W. Kammhuber, K. Seigner, E.	Hop research, hop breeding, plant protection, chemical analysis	Barth-Haas Group, hop purchasers, growers	13.08.14	7
IPZ 5	Seigner, E. Kammhuber, K.	Hop research, hop breeding, plant protection, chemical analysis	US hop traders, HVG Hop Processing Cooperative	13.08.14	4
IPZ 5	Sichelstiel, W. Kammhuber, K. Seigner, E.	LfL hop research, hop breeding, plant protection, hop growing, chemical analysis	Thüringia medicinal-, aromatic- and spice-plant association	22.08.14	30
IPZ 5	Seigner, E. Sichelstiel, W.	LfL hop research, aroma analysis, hop breeding, special-flavor hops	Brewers from AB-InBev, Beck's Bremen	22.08.14	5
IPZ 5	Lutz, A. Seigner, E. Sichelstiel, W.	Hop research, hop breeding, special-flavor hops	Three Floyds Brewing Company	27.08.14	5
IPZ 5	Seigner, E. Kammhuber, K.	Lfl hop research, hop breeding, special-flavor hops, plant protection, hop analysis	Trip Kloser, craft brewers, a beer journalist	05.09.14	5
IPZ 5	Seefelder, S. Kammhuber, K.	LfL hop research, *Verticillium* research in hops, hop analysis	Phytomedical Society	08.09.14	10

WG	Guided by	Topic	Guests	Datem	NP
IPZ 5	Seigner, E. Kammhuber, K.	LfL hop research, hop breeding, special-flavor hops, aroma analysis	Brewers and beer sommeliers	09.09.14	15
IPZ 5	Seigner, E. Kammhuber, K.	LfL hop research, hop breeding, plant protection, chem. analysis	Hop grower	11.09.14	1
IPZ 5	Seigner, E.	LfL hop research, hop breeding, special-flavor hops, hop analysis	Beer sommeliers	16.09.14	10
IPZ 5	Sichelstiel, W. Kammhuber, K. Seigner, E.	Hop research, hop breeding, special-flavor hops, plant protection, chemical analysis	Scandinavian Brewing School	29.09.14	8
IPZ 5	Sichelstiel, W. Kammhuber, K. Lutz, A. Seigner, E.	Hop research, innovations	AB InBev, Innovation & Technical Development	01.10.14	5
IPZ 5	Lutz, A. Kammhuber, K.	LfL hop research, hop breeding, hop analysis	Kalsec	19.11.14	2
IPZ 5c	Lutz, A.	Special-flavor hops and brewing trials	German craft brewers	29.01.14	3
IPZ 5c	Lutz, A.	Wild hops from Patagonia	Hop growers	29.01.14	1
IPZ 5c	Seigner, E. Lutz, A.	Special-flavor hops, breeding, hop aroma and beer aroma, craft brewers	A journalist	05.02.14	1
IPZ 5c	Lutz, A.	Special-flavor hops	August Schell Brewing Company	14.02.14	3
IPZ 5c	Lutz, A. Seigner, E. Kneidl, J.	Hop breeding, special-flavor hops, breeding for mildew resistance, downy-mildew-tolerance selection	A journalist from the Donaukurier newspaper	16.04.14	1
IPZ 5c	Lutz, A.	LfL hop research, hop breeding research	AB InBev, Director of Brewing Quality and Innovation	23.05.14	2
IPZ 5c	Lutz, A.	LfL hop research, hop breeding, aroma- and special-flavor hops	University brewing students	26.05.14	15
IPZ 5c	Lutz, A. Kneidl, J. Presl, A.	Hop research, male hops	Bavarian Broadcasting Corp., M. Düchs	24.06.14	4
IPZ 5c	Lutz, A.	DUS testing in the EU - hops	Federal Plant Variety Office	08.07.14	2
IPZ 5c	Lutz, A.	Hop research, breeding	AB InBev brewers	03.09.14	2
IPZ 5c	Lutz, A.	Hop breeding, Hüll special-flavor hops	Firestone Walker and Surly Brewing Co.	04.09.14	1
IPZ 5c	Seigner, E.	LfL hop research, hop breeding, plant protection, hop analysis	Interested guests (guided hop tour open to the public)	05.09.14	8
IPZ 5c	Lutz, A.	Hop breeding, special-flavor hops	Victory Brewery, Ron Barchet and team	09.09.14	3
IPZ 5c	Seigner, E.	Hop research, hop breeding, plant protection, chemical analysis	AB InBev	21.09.14	46
IPZ 5c	Lutz, A.	Hop breeding, special-flavor hops	Brewers from the Schönram and Störtebeker Braumanufaktur breweries	23.09.14	4

WG	Guided by	Topic	Guests	Datem	NP
IPZ 5c	Lutz, A.	2014 harvest samples of Hüll cultivars and breeding lines	Schönram brewery	23.09.14	1
IPZ 5c	Lutz, A.	Special-flavor hops	New Glarus Brewing Company	30.09.14	2

8.3.4 Exhibitions and posters

Event	Exhibition objects and topics/posters	Organised by	Duration	WG
Guided hop tour	Large-area plantings of breeding lines 2010/08/33 and 2010/72/20	Assoc. of German Hop Growers	28.08.2014	IPZ 5c and IPZ 5d
Guided hop tour	Development of a new hop variety	Assoc. of German Hop Growers	28.08.2014	IPZ 5c and IPZ 5d
Guided hop tour	Tracking hop aroma with high tech	Assoc. of German Hop Growers	28.08.2014	IPZ 5c and IPZ 5d

8.4 Basic and advanced training

Name, Work Group	Topic	Target group
Portner, J., IPZ 5a	14.01.2014 – Haunsbach hop working group	15 farmers
Portner, J., IPZ 5a	23.05.2014 – Masters' examination – work-project orals, Wolnzach	4 candidates
Portner, J., IPZ 5a	13. – 17.10.2014 – Instruction in hop production, Pfaffenhofen School of Agriculture	16 farmers
Schätzl, J., IPZ 5a	06.06.2014 – Info session for vocational-school students	15 students
Schätzl, J., IPZ 5a	10.07.2014 – Final professional-farming examination, Attenhofen	4 candidates
Schätzl, J., IPZ 5a	25.07.2014 – Hop-instruction day, Hüll	15 farmers
Schätzl, J., IPZ 5a	28.08.2014 – Final professional-farming examination, Thalhausen	2 candidates
Schätzl, J., IPZ 5a Lutz, A., IPZ 5c	25.07.2014 – Hop-instruction day, Hüll and Steinbach	15 farmers

8.5 Participation in work groups, memberships

Name	Capacity	Organisation
Fuß, S.	Member	Professional-farmer examination committee at the Landshut training centre
Kammhuber, K.	Member	Working group for hop analysis (AHA)
Kammhuber, K.	Member	Analysis Committee (Sub-Committee: Hops) of the European Brewery Convention
Münsterer, J.	Member	Professional-farmer examination committee at the Landshut training centre
Portner, J.	Member	WG Nachhaltigkeit im Hopfenbau (Sustainable hop cultivation)
Portner, J.	Member	Expert Committee on the Approval Procedure for Plant Protection Equipment , Julius Kühn Institute (JKI)

Name	Capacity	Organisation
Portner, J.	Member	JKI – EU Member States' work group "Kontrolle von Pflanzenschutzgeräten" (Monitoring of plant protection equipment)
Portner, J.	Member	Master-farmer exam. committees of Lower Bavaria, eastern Upper Bavaria and western Upper Bavaria
Schätzl, J.	Member	Professional-farmer examination committee at the Landshut training centre
Schätzl, J.	Member	Professional-farmer examination committee at the Erding/Freising training centre
Seefelder, S.	Member	Society of Hop Research
Seefelder, S.	Member	LfL's public relations team
Seigner, E.	Member	Society of Hop Research
Seigner, E.	Member	German Society for Plant Breeding (GPZ)
Seigner, E.	Member	International Society of Horticultural Science (ISHS)
Seigner, E.	Chairwoman and secretary	Scientific Commission of the International Hop Growers' Convention
Sichelstiel, W.	Member	German Phytomedical Society (DPG)
Sichelstiel, W.	Chairman	EU Commodity Expert Group "Minor Uses Hops"
Weihrauch, F.	Member	Arbeitsgemeinschaft Bayerischer Entomologen e.V.
Weihrauch, F.	Member	British Dragonfly Society
Weihrauch, F.	Responsible for bibliography	German Soc. for General and Applied Entomology (DgaaE), working group "Neuroptera"
Weihrauch, F.	Member	DgaaE working group "Useful Arthropods and Entomopathogenic Nematodes"
Weihrauch, F.	Member	German Soc. for General and Applied Entomology (DgaaE)
Weihrauch, F.	Member	German Society for Orpthopterology (DgfO)
Weihrauch, F.	Member	German Phytomedical Society (DPG)
Weihrauch, F.	Member	German Society for Tropical Ecology
Weihrauch, F.	Member	Münchner Entomologische Gesellschaft e.V.
Weihrauch, F.	Member des Editorial Boards	Worldwide Dragonfly Society

9 Current research projects financed by third parties

WG Project manager	Project	Dur-ation	Cooperation	Sponsor
IPZ 5a Portner, J.	Optimisation of irriga-tion management in hop growing (DBU)	2011-2014	Dr. Michael Beck – Wei-henstephan-Triesdorf Univ., Dept. of Hort; Prof. Urs Schmidhalter, Munich Technical Univ., Chair of Plant Nutrition; Christian Euringer - ATEF.ONE GmbH; Dr. Erich Lehmair, - HVG, Wolnzach	Deutsche Bundes-stiftung Umwelt (DBU)
IPZ 5a Portner, J.	Demonstration Farms Integrated Plant Protec-tion - hops	2014-2016	JKI; ZEPP; demonstration hop farms	Bundesanstalt für Landwirtschaft und Ernährung (BLE) *(Fe-deral Agency for Agri-culture and Food)*

WG Project manager	Project	Duration	Cooperation	Sponsor
IPZ 5a Graf, T.	Anatomic & morphological research on Humulus lupulus, Herkules cultivar	2013-2014	Munich Technical University	Deutsche Bundesstiftung Umwelt (DBU)
IPZ 5a Portner, J.	Development and optimisation of an automatic hop-picking machine	2011-2014		Bundesanstalt für Landwirtschaft und Ernährung (BLE), Project sponsor: Innovationsförderung
IPZ 5b Weihrauch, F.	Reducing or replacing copper-containing PPPs in organic hop farming	2010-2014	An organic hop farm	Bundesanstalt für Landwirtschaft und Ernährung (BLE)
IPZ 5b Weihrauch, F.	Release of predatory mites and establishment of PM populations for sustained spider-mite control in hop farming	2013-2016		Bundesanstalt für Landwirtschaft und Ernährung (BLE)
IPZ 5b Weihrauch, F.	Minimising the use of copper-containing PPPs in organic and integrated hop farming	2014-2015		HVG Erzeugergemeinschaft Hopfen *(HVG hop producer group*
IPZ 5c Seigner, E.; Lutz, A.	PM isolates and their use in breeding PM-resistant hops	2006-2016	EpiLogic GmbH, agrobiological research and consultancy, Freising	Society of Hop Research (GfH) (2013-2014); HVG Erzeugergemeinschaft Hopfen (2011-2012; 2015-2016); Wissenschaftl. Station f. Brauerei in München e.V. *(Scientific Station for Brewing in Munich)* (2006-2010)
IPZ 5c Seigner, E.; Seigner, L.; Lutz, A.	Monitoring for dangerous hop virus and viroid infections in Germany	2011-2015	Dr. K. Eastwell, WSU, Prosser, USA; Dr. S. Radišek, Slovenian Institute of Hop Research and Brewing, Slovenia; IPZ 5a (WG Hop Cultivation/Production Techniques), IPZ 5b (WG Plant Protection in Hop Growing);Local hop consultants;Hop Producers' Ring; hop farms; Eickelmann propagation facility, Geisenfeld; hop-growing consultants	Wissenschaftliche Station für Brauerei in München e.V.

WG Project manager	Project	Duration	Cooperation	Sponsor
IPZ 5c Lutz, A.; Seigner, E.	Cross breeding with the Tettnanger landrace	2011-2016	Straß experimental station, Franz Wöllhaf	Ministerium für ländlichen Raum und Verbraucherschutz, Baden Württemberg (MLR-BW), *(Ministry of Rural Affairs and Consumer Protection)*; Hopfenpflanzerverband Tettnang *(Tettnang Hop Growers' Assoc.)*; HVG Erzeugergemeinschaft Hopfen; Society of Hop Research
IPZ 5c Seigner, E.; Lutz, A.	Faster provision of virus-free planting stock via improved *in-vitro* tissue culture	2014-2015	IPS 2c, Dr. L. Seigner, virus diagnostics	Wissenschaftliche Station für Brauerei in München e.V.

10 Main research areas

WG	Project	Dur- ation	Cooperation
5a	Testing and establishing technical aids for optimising the drying and conditioning of hops	2003 - 2015	
5a	Various fertiliser tests aimed at optimising nutrient supply in hop growing	2003- 2015	
5a	Compilation of a data bank as a basis for cost accounting	2006- 2015	
5a	Hallertauer model for resource-saving hop cultivation	2010- 2014	Landesamt für Wald- und Forstwirtschaft; Bavariab´n Environment Agency; Ecozept,
5a	Reaction of various cultivars to reduced trellis height (6 m)	2012- 2014	
5a	Variation in cover-crop sowing and incorporation times in hop-growing	2012- 2014	Instit. Für Agricultural Ecology, Organic Farming + Soil Protection (IAB)
5a	Influence of nitrolime on *Verticillium* albo-atrum	2012- 2014	
5a	Evaluation of the specific water requirements of different hop varieties irrigated as a function of soil-moisture tension	2012- 2014	
5a	Anatomic & morphological research on Humulus lupulus, Herkules cultivar	2013- 2014	Munich Technical UNiversity
5a	Demonstration Farms Integrated Plant Protection - hops	2014- 2016	JKI; ZEPP; demonstration hop farms
5a	Harvesting-time trials for the MB, HC und PA flavor-hop varieties	2014- 2016	
5b	Documentation of the worldwide organic hop-growing situation	2011- 2022	Joh. Barth & Sohn GmbH & Co. KG, Nuremberg
5b	Click-beetle (Elateridae) monitoring and diagnosis in Hallertau hop yards	2010- 2015	Julius Kühn Institute, Braunschweig Syngenta Agro GmbH, Maintal
5c	In situ maintenance and expansion of the Bavarian hop gene pool	2001- 2025	
5c	Breeding of hops with special components	2006- 2022	EpiLogic GmbH, agrobiological research and consultancy; BayWa, Dr. Dietmar Kaltner; HVG Hop Processing Cooperative; Hopsteiner, Dr. Martin Biendl; Barth-Haas Group, Dr. Christina Schönberger
5c	"Special-flavor hops" breeding programme	2006- 2020	GfH's hop advisory committee; Munich Tech. Univ., Chair of Brewing and Beverage Technol., Dr. F. Schüll Bitburger experimental brewery, Dr. S. Hanke; partners from the hop and brewing industries

WG	Project	Dur-ation	Cooperation
5c	Promoting quality through the use of molecular techniques to differentiate between hop varieties	2007-2022	The GfH's propagation facility; hop trade
5c	Meristem cultures for producing healthy hop planting stock	2008-2022	IPS 2c - Seigner, L. and team IPZ 5b - Ehrenstraßer, O.
5c	Brewing trials with special-flavor hops – the LfL as brewers' cooperation partner	2011-2022	Hop-trading companies; Assoc. of German Hop Growers; Munich Technical University, Chair of Brewing and Beverage Technology; breweries worldwide
5c	Breeding of hop cuultivars particularly suited to low-trellis cultivation	2012-2020	
5c	Development and optimisation of screening systems for assessing hop tolerance towards downy mildew	2012-2015	Prof. Dr. Thomas Ebertseder, Weihenstephan-Triesdorf University, Department of Agriculture and Food Economy
5c	Testing planting stock for *Verticillium*	2013-2022	
5d	Performance of all analytical studies in support of the work groups, especially Hop Breeding Research, in the Hop Department	Ongoing	IPZ 5a, IPZ 5b, IPZ 5c
5d	Development of an HPLC-data-based NIRS calibration model for alpha-acid content	2000-open-ended	
5d	Development of HPLC-based analytical methods for hop polyphenols (total polyphenols, flavonoids and individual substances such as quercetin and kaempferol)	2007-open-ended	AHA working group
5d	Production of pure alpha acids and their ortho-phenylenediamine complexes for monitoring and calibrating the ICE 3 calibration extracts	Ongoing	AHA working group
5d	Organisation and evaluation of ring analyses for alpha-acid determination for the hop supply contracts	2000-open-ended	AHA working group
5d	Ringversuche zur Überprüfung und Standardisierung von wichtigen Analysenparametern innerhalb der AHA-Labors (z. B. Linalool, Nitrat, HSI)	Ongoing	AHA working group
5d	Varietal authenticity checks for the food control authorities	Ongoing	Landratsämter (Lebensmittelüberwachung) *(District food control authorities)*

11 Personnel at IPZ 5 – Hops Department

The following staff members were employed at the Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, at Hüll, Wolnzach and Freising in 2014 (WG = Work Group):

IPZ 5

Coordinator:
LD Sichelstiel Wolfgang

Hertwig Alexandra
Krenauer Birgit

IPZ 5a

WG Hop Cultivation/Production Techniques
LD Portner Johann

Fischer Elke
LA Fuß Stefan
Dipl.-Biol. (Univ.) Graf Tobias
LA Münsterer Jakob
Lutz Maria (as of 01.03.2014)
LR Schätzl Johann

IPZ 5b

WG Plant Protection in Hop Growing
LD Sichelstiel Wolfgang

LTA Ehrenstraßer Olga
Felsl Maria
Dipl.-Ing. (FH) Jereb Marina
LI Meyr Georg
Dipl.-Ing. (FH) Schwarz Johannes (until 31.12.14)
Weiher Johann
Dr. rer. nat. Weihrauch Florian
Wörner Laura, M.Sc. (as of 01.12.14)

IPZ 5c

WG Hop Breeding Research
RD Dr. Seigner Elisabeth

Dandl Maximilian
BTA Eisenbraun Daniel
CTA Forster Brigitte
CTA Hager Petra
LTA Haugg Brigitte
Hock Elfriede
Agr.-Techn. Ismann Daniel
LTA Kneidl Jutta
LAR Lutz Anton
Maier Margret
Mauermeier Michael
Pflügl Ursula
Presl Irmgard
ORR Dr. Seefelder Stefan
Suchostawski Christa

IPZ 5d

WG Hop Quality and Analytics
ORR Dr. Kammhuber Klaus

MTLA Hainzlmaier Magdalena
CL Neuhof-Buckl Evi
Dipl.-Ing. agr. (Univ.) Petzina Cornelia
CTA Weihrauch Silvia
CTA Wyschkon Birgit