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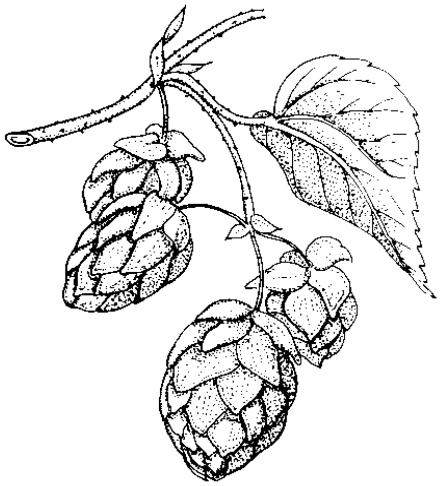
Gesellschaft für Hopfenforschung e.V.

Annual Report 2013

Special Crop: Hops



Bavarian State Research Center for Agriculture

- Institute for Crop Science and Plant Breeding -

and the

Society of Hop Research e.V.

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Foreword

Applied research is the only answer to many of the challenges associated with hop production. This was once again confirmed by the events of 2013, which left a deeper impression on hop growers, the hop industry and brewers than they would have liked. World hop stocks shrank as a result of the extreme weather conditions in the Hallertau and other European hop-growing regions, without leading to a significant rise in producer prices. Together with low yields, this situation resulted in what were in some cases huge revenue shortfalls for hop growers. Nevertheless, with global beer sales on the increase and a dynamic trend towards strongly hopped special and flavoured beers now underway, global demand for hops is steadily rising. Quality, production reliability, cost awareness and the ability to react to ever-faster market and production changes are the key to sustainable competitiveness for hop growers and the hop industry in Germany.

The mission of hop research is to address new challenges, develop cross-workgroup solutions and communicate the results to the field. The cooperation between the Hop Department of the Institute for Crop Science and Plant Breeding of the Bavarian State Research Center for Agriculture and the Society of Hop Research offers excellent structures for this purpose. Research issues are submitted to the Hüll research team via the committees of the Society of Hop Research, by our partners at the "Haus des Hopfens" competence centre in Wolnzach and by the hop industry via short communication paths. Excellent links between the various parties involved allow the results to be put into practice rapidly.

Within the framework of its advisory and training activities, the work group Hop Cultivation/Production Techniques passes on research results to hop growers without delay. It also processes a variety of queries relating to cultivation, technical innovations, optimisation of machinery, harvesting equipment, drying and conditioning right down to basic research on irrigation issues.

The activities of the work group Plant Protection in Hop-Growing focus on the search for solutions to disease and pest problems. Processes and instruments of integrated plant protection are researched under field conditions and further enhanced. At the European level, the "Minor Crops Working Group" is working on improvements to the registration situation with respect to plant protection products for hop cultivation. Practice-relevant solutions to ecological problems are also being developed.

Resistance breeding - particularly against wilt disease, among others - is a precondition for economically sustainable hop farming. Apart from the development of high-alpha varieties and classical aroma varieties, the breeding of special-flavor varieties has become a new key area of activity. In future, new breeds will be tested even more intensively in an enhanced process. Further new developments include an expert committee on aroma assessment and an extensive trial planting of selected lines aimed at obtaining more information prior to cultivar launch.

With the identification of aroma-active components, the work group Hop Quality and Analytics supplies data that is critical for improved aroma characterisation of new hop breeds and assessment of their potential in beer. Sophisticated equipment will allow a more thorough and detailed approach to these issues in future.

All tasks and projects are tackled by the employees engaged in hop research at Hüll, Wolnzach and Freising with great industry, commitment and creativity. We would like to express our special thanks for their proactive work.

Dr. Michael Möller	Dr. Peter Doleschel
Chairman of the Managing Committee	Head of the Institute for
of the Society of Hop Research	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

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.

Optimisation of irrigation management in hop growing

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, *(Bavarian State 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, J. Münsterer
Cooperation:	Dr. M. Beck, Weihenstephan-Triesdorf University of Applied Sciences A. Werner, Thuringia State Research Centre for Agriculture Prof. Urs Schmidhalter, Technical University of Munich/ Weihenstephan ATEF, Oberhartheim
Duration:	01.12.2011 – 30.11.2014

Objective

The trial plots selected for the project were equipped with the necessary water distribution and measuring systems in spring 2012. The aim of the project is to gain further insights into water metabolism in hops and thus be in a position to provide farmers with expert advice on irrigation issues. We want to throw more light on the role played by hop plant physiology in water metabolism and lay the foundation for future research work. The major field-related issues requiring clarification are:

- Definition of the ideal irrigation time
- Definition of the ideal water volume
- Definition of the ideal drip-system position relative to the row of plants
- Definition of control algorithms for irrigating hops

Material and methods

To minimise possible influencing factors and interactions, two soil types (sand and clay) typical of the growing area and planted with the most frequently cultivated Herkules variety were selected for the principal trials. Two trial fields for six variants with sixfold replications were pegged out, one on sand and one on clay. The drip-hose was positioned according to the three variants commonly used by hop farmers (AB = on top of the hilled row, NB = buried beside the hilled row, ZB = buried in the centre of the tractor aisles). Commencement of irrigation was scheduled as a function of soil moisture (water tension). Three tension levels were selected, 150 hPa, 300 hPa and 600 hPa. Commencement of irrigation was set at 300 hPa for all three drip-hose positions.

On 20th June 2013, a violent storm caused massive hail damage to the trial hop plants growing at the Karpfenstein sandy-soil location. Since the trial had already been completely set up, it was continued, using different irrigation times, in order to test its technical soundness. A normal trial harvest over all 36 plots was ruled out from the start, however, since with approx. 80 % of the plants having suffered head damage and being distributed very non-uniformly over the trial acreage, any evaluation of yields on such a large scale was impossible.

The clay-soil location escaped the hail storm. However, the trial hop plants grew feebly in comparison to the surrounding hop plants on the rest of the field. Structural damage, presumably due to untimely soil cultivation measures, is suspected of being the cause. Although the trial continued as planned, it became evident at least a month before harvesting that the plants were relatively poorly developed and that the anticipated harvest would not be representative of the location or the variety. Since the entire trial acreage showed uniform poor growth, however, it was still possible to calculate yields as a function of different irrigation regimes.

Results

The trial plots on the sandy-soil location were not harvested on account of the hail damage.
Differences in irrigation strategies had no significant influence on hop yields or alpha-acid content at the clay-soil location.

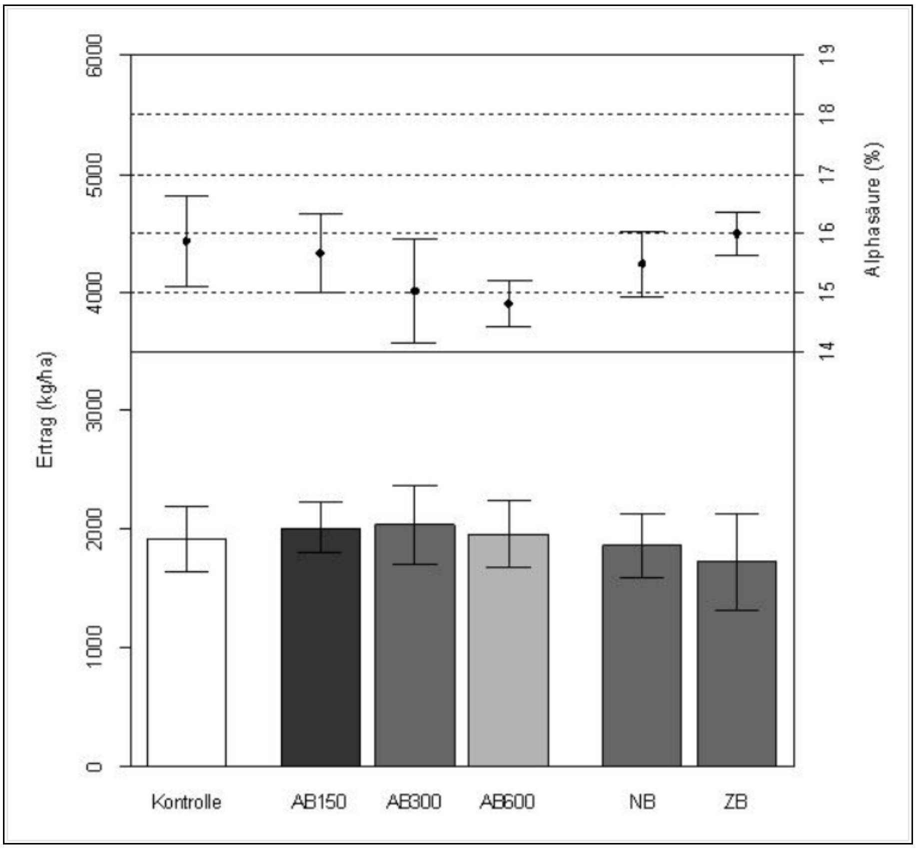


Fig. 1.1: Yield (kg/ha) and α-acid content (%) at the clay-soil location for the various irrigation strategies (control = no irrigation, AB = drip hose on top of the hilled row at soil moisture tensions of 150, 300 and 600 hPa), NB = drip hose buried beside the hilled row, ZB = drip hose buried in the tractor aisle; NB and ZB were irrigated simultaneously with the AB300 variant); n=6. Neither yields nor α-acid contents showed any significant differences. Tested with ANOVA (F: 0.839; p = 0.533).

Use and establishment of predatory-mite populations for sustained 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 common spider mite 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 crops. 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

Randomised-plot trials for three or four variants with fourfold replications were set up at five different locations (varieties: HT, PE, OL, SD and HS). The following predatory mites were investigated and compared in combination with the undersown crops: the autochthonous species (a) *Typhlodromus pyri* and (b) *Amblyseius andersoni*, and a mixture (c) of the allochthonous species *Phytoseiulus persimilis* and *Neoseiulus californicus.* The predatory mites were applied as follows at the beginning of July:

T. pyri on felt strips (unit: 5 gravid females); on every fourth training wire

A. andersoni in small packets (unit: 250 predatory mites); two packets per plot row

P. persimilis and *N. californicus* on bean leaves (unit: 5,000 predatory mites); 12 predatory mites per training wire

Following the release of the beneficial organisms, their numbers were monitored at fortnightly intervals (10 plants/plot, one leaf from the bottom, one from the middle and one from the top of each plant).

Results

The first season was used to establish the undersown crops and apply the predatory mites. The weather conditions in 2013 were such that no predatory-mite populations large enough to furnish conclusive results were established on any of the trial plots. The trials will be repeated unchanged in 2014.

Reducing or replacing copper-containing plant protectives in organic 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 managers:	B. Engelhard (until 03/2011), Dr. F. Weihrauch
Project staff:	J. Schwarz, D. Ismann, G. Meyr
Cooperation:	Naturland-Hof Pichlmaier, Haushausen
Duration:	19.04.2010 - 28.02.2014

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 experimental project was thus to test the extent to which the amount of copper used per season in hops 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.

Results

See detailed report under 6.4, page 79, Trials to minimise the use of copper-containing plant protectives in organic hop farming.

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
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 nation-wide, multi-year joint project aimed at remedying this situation, adult click-beetle monitoring commenced in the Hallertau in 2010. In the fourth project year, 2013, beetle catches from an organic hop yard near Haushausen (Pfaffenhofen district, 455 m a.s.l., soil: clay) were compared with those from a conventional yard on the edge of the Paar valley (Gambach, Pfaffenhofen district, 425 m a.s.l., soil: sand). In Gambach, soil traps for wireworms were positioned in a hilled row where apparent wireworm damage had been observed in 2012. The traps were baited with germinating wheat grains and emptied at fortnightly intervals.

Results

Over a 15-week period in 2013 (April 25th – August 1st), a total of 1,969 adult beetles (seven species, five of them *Agriotes* species) were caught in pheromone traps (Haushausen: 607 beetles, Gambach: 1,362 beetles). The striped click beetle, *A. Lineatus*, was the main species at Gambach, making up some 64 % of the catch. It was followed by the dusky click beetle, *A. obscurus,* (25.4 %) and the common click beetle, *A. sputator* (9.2 %). *A. obscurus* predominated in Haushausen (68.7 %), followed by *A. lineatus* (17.7 %) and *A. sputator* (8.1 %). In addition, small numbers (<5 %) of *A. ustulatus* were caught at both locations.

The mere 14 wireworms caught in the soil traps (the species were identified by Dr. J. Lehmhus, JKI Braunschweig) presented a completely different picture and one which differed even more from the adult-beetle catch than it had in 2012: *Agriotes lineatus*, *A. obscurus* and *A. sputator* were missing altogether in the 2013 catch, which consisted exclusively of the three species *Agrypnus murinus*, *Hemicrepidius hirtus and Selatosomus aeneus.* According to the literature, these tend to be considered as carnivorous beetles. Further research therefore remains essential in order to clarify what actually happens in the root zone of hop plants.

Cross breeding with the Tettnanger landrace

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtung und AG Hopfenqualität/Hopfenanalytik *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Breeding Research and WG Hop Analytics)*
Financed by:	Ministerium für Ländlichen Raum und Verbraucherschutz *(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 experimental station, F. Wöllhaf
Duration:	01.05.2011 - 31.12.2016

Objective

The aim of this breeding project is to significantly improve the yield and fungal resistance of the Tettnanger landrace while maintaining its original aroma as closely as possible. 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 aroma lines showing broad disease resistance and, thanks to their pedigree, good agronomic performance.

Results

Since commencement of the project, 730 female breeding lines stemming from 13 crosses fulfilling the above objective have been planted out in the Hüll breeding yard for the three-year seedling assessment. These seedlings had already shown promising disease resistance/tolerance, growth vigour and cone formation. In addition, approx. 100 male hop plants from this breeding programme are under observation in the Freising male-hops breeding yard.

Tab. 1.1: Seedling assessment – current situation

Seedling generation	Breeding programme	Female seedlings in Hüll	Male seedlings in Freising
S 2011/ 24 + 25	Aroma + resistance	242	30
S 2012/ 25-27 + 29	Aroma + resistance	282	33
S 2012/ 28 + 30-31	Aroma + flavor + resistance	61	19
S 2013/ 44	Aroma + resistance	2	1
S 2013/ 45-47	Aroma + flavor + resistance	144	14
Total		**731**	**97**

In autumn 2013, cones were harvested from seven of the first-generation seedlings (2011/24 and 2011/25 seedlings), these seven having been assessed as having a fine, hoppy aroma, and the cone contents chemically analysed (EBC 7.7).

Tab. 1.2: Overview of 2012 and 2013 harvest results

Properties	**Tettnanger 2013 yield (2012)**	**Seedlings (2011/24) 2012 yield**	**Seedlings (2011/24) 2013 yield**	**Seedlings (2011/25) 2013 yield**
Aroma	Fine, hoppy, spicy	Fine, hoppy, spicy	Fine, hoppy, spicy	Fine, hoppy, spicy
α-acids (%)[1]	1.9 (3.8)	4.3 - 5.8	2.0 - 3.7	2.9
β-acids (%)[1]	2.2 (4.0)	2.3 - 4.7	1.5 - 3.6	3.3
Cohumulone (%)[2]	24 (23)	20 - 23	22 - 30	21
Xanthohumol (%)[1]	0.2 (0.4)	0.2 - 0.4	0.2 - 0.3	0.4

[1]in % (w/w); [2]relative, in % of alpha-acids

The chemical data obtained for the first seedlings from this breeding programme, together with the 2012 yields, provide initial evidence that the breeding objective can be reached. Assessment of the 2013 results must take into account the fact that the extreme weather conditions prevented the seedlings from showing their full potential in respect of component content and aroma.

In the summer of 2013, five more crosses were performed between the Tettnanger landrace and pre-selected male lines showing disease resistance, good agronomic qualities and potential for traditional and fruity aroma.

The above shows that, with 10 crosses and 50 to 60 seedlings per cross, the project plan specifications have been exceeded by far.

Powdery mildew (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., *(Society of Hop Research)*
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 – 31.12.2014

Objective

PM-resistance breeding remains a top-priority objective. Optimised testing methods employing PM isolates with previously characterised virulence properties have been used for PM resistance-testing in the greenhouse and lab since 2000.

Results

In 2013, eleven previously characterised single-spore isolates of *Podosphaera macularis*, the fungus that causes powdery mildew in hops, were used in connection with 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. 100,000) from 95 crosses performed in 2012 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, 205 breeding lines, 22 cultivars and one wild hop previously 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 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 2013, 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 2013 with 11 previously characterised PM isolates

2013	Greenhouse tests		Laboratory tests	
	Plants	**Assessments**	**Plants**	**Assessments**
Seedlings from 95 crosses	Approx. 100,000 by mass screening		-	-
Breeding lines	205	461	191	1,439
Cultivars	22	42	12	77
Wild hops	1	3	1	10
Virulence properties of the PM isolates	-	-	11	462
Total (individual tests)	**228**	**506**	**215**	**1,988**

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

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)*
	Wissenschaftsförderung der Deutschen Brauwirtschaft (Wifö)
Project manager:	Dr. S. Seefelder
Project staff:	K. Maurer , P. Hager, H. Schmid (until 31.07.2013), E. Niedermeier (until 30.06.2013)
Cooperation:	Dr. S. Radišek, Slovenian Institute of Hop Research and Brewing, Slovenia
	Prof. B. Javornik, University of Lublijana, Slovenia
	Prof. G. Berg, University of Graz, Austria
	IPZ 5a (Work Group for Hop Cultivation/Production Techniques)
Duration:	01.03.2008 - 31.12.2013

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 is primarily intended to establish a reliable detection method that permits definitive diagnosis of the dangerous *Verticillium* wilt. A further intention is 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 examination to differentiate between *Verticillium albo-atrum* and *V. dahliae*
- Infection test to determine virulence
- Isolation of hereditary Verticillium material directly from hop bines
- Testing of specific bioantagonists as possible control measures

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* und *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 was clearly identifiable. 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-contamínated ground is currently unclear.

Outlook

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

Monitoring for dangerous viroid and viral hop 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 Pathogen Diagnostics, and 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. L. Seigner, Institute for Plant Protection (IPS 2c); Dr. E. Seigner, A. Lutz (both from IPZ 5c)
Project staff:	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 2013

Objective

For years, the LfL has been monitoring its hop breeding yards and field crops in all hop-growing areas for hop-typical viruses and hop stunt viroid. As these harmful organisms cause pronounced yield and alpha-acid losses in hops, particularly under stress-inducing conditions, the goal of the monitoring activities is to detect and eradicate infection centres as early as possible, first and foremost primary infection centres of the dreaded hop stunt viroid, in order to prevent this disease from spreading.

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) and immunologically (DAS-ELISA = Double Antibody Sandwich Enzyme Linked Immunosorbent Assay) in the LfL's pathogen diagnostics lab (IPS 2c) for the following pathogens:

Viroid/Virus German name	Viroid/Virus English name	Abbreviation	Detection method
Latentes Amerikanisches Hopfen-Carlavirus	American hop latent carlavirus	AHpLV	RT-PCR
Apfelmosaik-Ilarvirus	Apple mosaic ilarvirus	ApMV	DAS-ELISA
Arabis Mosaik-Nepovirus	Arabismosaic nepovirus	ArMV	DAS-ELISA
Hopfenmosaik-Carlavirus	Hop mosaic carlavirus	HpMV	DAS-ELISA
Hopfenstauche-Viroid	Hop stunt viroid	HpSVd	RT-PCR*
Zitrusviroid IV	Citrus viroid IV	CVd IV	RT-PCR#

* using primers from Eastwell und 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 backed up by an internal, hop-specific, mRNA-based RT-PCR control (Seigner et al. 2008). In 2013, individual samples were tested for the first time for citrus viroid as well.

Results

HpSVD was not detected in any of the 275 hop samples tested in 2013. Individual samples taken from hop farms fertilised for many years with compost were tested additionally for citrus viroid, since in Slovenia, composted citrus fruit had transported this viroid into hops and caused dramatic yield and quality losses (Radišek et al., 2013). However, citrus viroid was not detected in the samples tested. A very different picture emerges for the various virus infections, where incidence levels are massive. The situation appears worse than it actually is, however, because most of the samples from hop farms were taken from plants with a suspicious appearance.

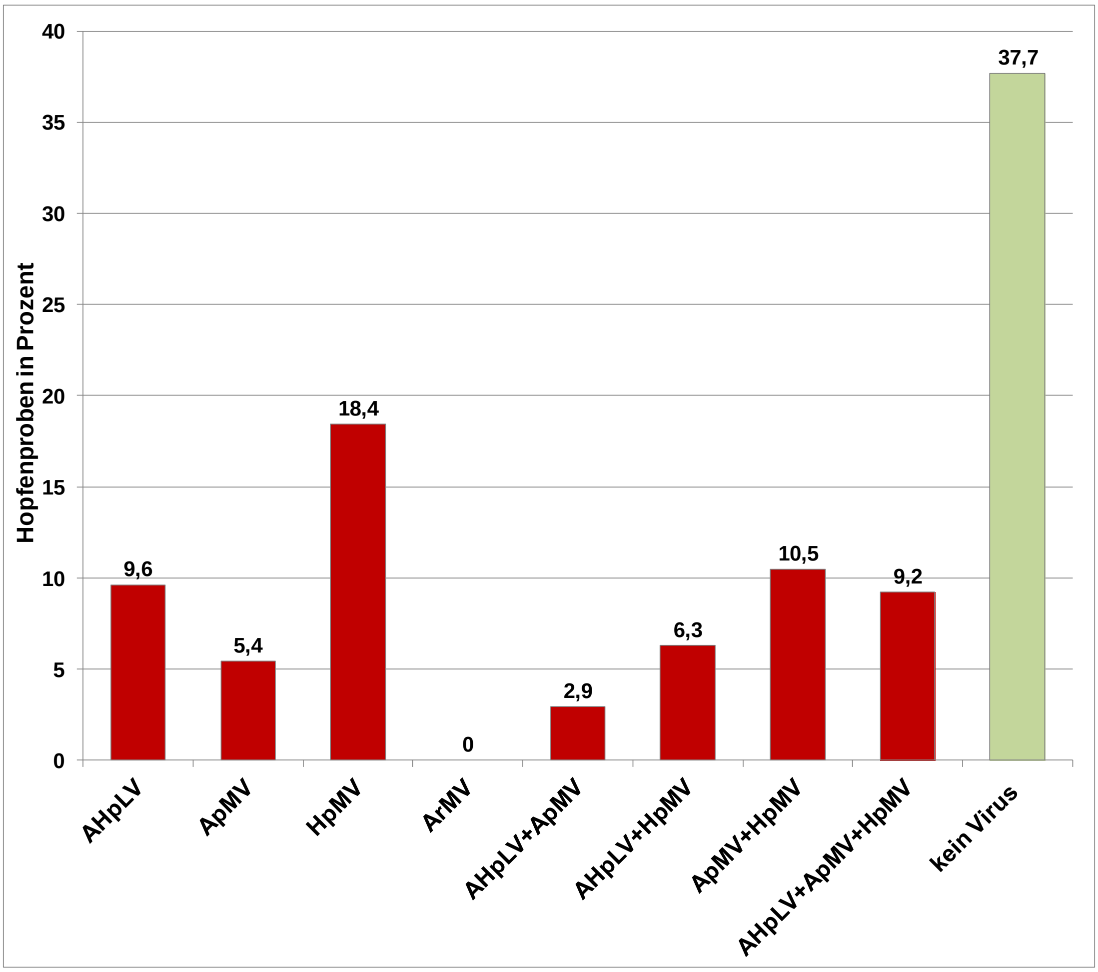


Fig. 1.2: Overview of virus and viroid infections detected in 2013; red = infections that impair crop and alpha-acid yields

No RT-PCR testing for HpLV was performed in 2013 on account of the project's limited budget. Since hop plants infected solely with this virus show no visible damage, it is simply tolerated. By contrast, serious effects on yields and hop components must be expected in the event of ApMV and HpMV infections, especially if they occur in combination. American hop latent carlavirus (AHpLV), previously assumed to occur exclusively in hop material from the USA, was recognized as a new problem. This virus is likely to cause pronounced damage, especially where it occurs in combination with ApMV and/or HMV. The dreaded ArMV, cause of nettlehead disease, was not detected at all in 2013. Since multiple infections, in particular, must be considered relevant to yields and quality, hop growers were advised to dig up plants with combined virus infections. In conclusion, it is important to emphasize once again that the Society of Hop Research's propagation contractor uses the findings of our monitoring activities to immediately eliminate all mother plants that have tested positive, thereby guaranteeing a supply of healthy, virus-free cuttings from this source.

Ito, T.; Ieki, H.; Ozaki, K.; Iwanami, T.; Nakahara, K.; Hataya, T.; Ito, T.; Isaka, M.; Kano, T. (2002): Multiple citrus viroids in Citrus from Japan and their ability to produce Exocortis-like symptoms in citron. Phytopathology **92(5)**. 542-547.

Radišek, S.; Oset, M.; Čerenak, A.; Jakše, J.; Knapič, V.; Matoušek, J.; Javornik, B. (2013): Research activities focused on hop viroid diseases in Slovenia. Proceedings of the Scientific Commission, International Hop Growers` Convention, Kiev, Ukraine, p. 58, ISSN 1814-2206, urn:nbn:de:101:1-201307295152,

Improvement of aroma characterisation for Hüll special-flavor hops

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Hopfenqualität und -analytik *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Quality/Hop Analytics)*
Financed by:	Erzeugergemeinschaft HVG e. G. *(HVG hop producer group)*
Project manager:	Dr. K. Kammhuber
Project staff:	E. Neuhof-Buckl, S. Weihrauch
Cooperation:	Dr. M. Dr. M. Coelhan and team, Munich Technical University, WZW *(Centre of Life and Food Sciences, Weihenstephan)*, Weihenstephan Research Center for Brewing and Food Quality
Duration:	01.10.2012 - 31.10.2013

Objective

The aim of this project is to refine and improve established Hüll methods of analysing aromas and thus to obtain a sound basis for the further breeding of flavor hops. The following project goals were defined:

- To clarify and identify the constituents of unknown substances by GC-MS
- To identify aroma-active substances by GC sniffing
- To perform informative tests for sulphur compounds with a flame-photometric detector (on combustion, sulphur atoms emit light with a wavelength of 394 nm, enabling highly sensitive and selective detection)

Results

Two new substances, alpha curcumene and zingiberene, were identified in Mandarina Bavaria. The GC sniffing tests showed myrcene and linalool to be the most aroma-active compounds and a number of esters were also easy to recognize. Many sensory impressions cannot be assigned to definite peaks in the gas chromatogram. Initial investigation of sulphur compounds has revealed distinct cultivar-specific differences.

1.2 Main research areas

1.2.1 Hop Breeding: main research areas

New hop breeding trend – hops with flowery, citrusy and fruity aromas

Project managers:	A. Lutz, Dr. E. Seigner
Project staff:	A. Lutz, J. Kneidl, E. Seigner, IPZ 5c team
Financed partially by:	Erzeugergemeinschaft Hopfen HVG e.G. *(HVG hop producer group)* (Oct. 2012 - Oct. 2013
Cooperation:	Dr. K. Kammhuber, IPZ 5d team
	Technical University of Munich/Weihenstephan, Chair of Brewing and Beverage Technology
	National and international brewing partners
	Hop trade
	Association of German Hop Growers and hop growers

Objective

Following the market launch of the first German special-flavor hop cultivars, work aimed at breeding novel hop varieties continues. Hops with complex, exotic flavors reminiscent of fruit, citrus and even vegetables permit countless aroma variations in beer.

Material and methods

Special crosses are performed in order to achieve this breeding goal. Work commenced by crossing mother plants of the US Cascade variety, favoured by Craft brewers, with male Hüll breeding lines in order to obtain new combinations of fruity aromas and disease resistance, good agronomic performance and also traditional aroma nuances. In the course of further breeding work, Hüll breeding lines obtained from crosses with Cascade and other US varieties and characterised by fruity, exotic aromas have been used as well. Lines stemming from earlier high-alpha breeding programmes are additionally introducing novel aromas into our breeding stock. Healthy, high-performance breeding lines exhibiting interesting aroma combinations are submitted for appraisal to experts in the hop and brewing industries.

Results

In 2013, aromas were weaker in all hop varieties due to the extreme weather conditions. The aromas of our special-flavor cultivars and breeding lines were typical but less intense than otherwise. The unfavourable growth conditions also prevented young hop plants from being harvested, which is why our findings concerning new breeds in particular are very limited. On the other hand, initial progress was made in refining laboratory methods of identifying the aroma substances contained in the new special-flavor hops (for details see Chap. 7.3); these methods will be used to back up organoleptic aroma assessments.

In 2013, we also teamed up with our colleagues from IPZ 5a and with hop growers to describe our findings concerning cultivation, tending and harvesting of the new special-flavor cultivars more clearly for advisory purposes in hop growing.

Brewers continue to show great interest in performing brewing trials with the new cultivars and breeding lines from this breeding programme.

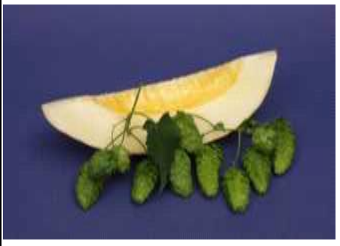
Mandarina Bavaria

Hopfen-Aroma: hopfig, fruchtig, frisch, Mandarinen- und Zitrusnote

Aroma im Bier: hopfig, Mandarinen- und Orangenaroma

Gesamtöle: 1,5 - 2,2 ml/100 g
Alphasäuren: 7,0 - 10,0 %
Polyphenole: 2,3 - 2,7 %

Huell Melon



Hopfen-Aroma: fruchtig, süß, Honigmelone, Aprikose und Erdbeere

Aroma im Bier: süßliche Aromen, Honigmelone, Aprikose

Gesamtöle: 0,8 - 2,1 ml/100 g
Alphasäuren: 7,0 - 8,0 %
Polyphenole: 3,0 %

Hallertau Blanc

Hopfen-Aroma: blumig-fruchtig, Mango, Maracuja, Grapefruit, Stachelbeere und Ananas

Aroma im Bier: grüne Früchte, Mango, Stachelbeere

Gesamtöle: 1,5 - 1,8 ml/100 g
Alphasäuren: 9,0 -11,0 %
Polyphenole: 3,1 %

Polaris

Hopfen-Aroma: würzig-fruchtig, Gletschereis-Bonbon-Note

Aroma im Bier: frisch, fruchtig, Minznote, leichte Zitrusnuance

Gesamtöle: 4,4 - 4,8 ml/100 g
Alphasäuren: 18,0 -23,0 %
Polyphenole: 2,6 - 2,7 %

Fig. 1.3: Chemical analyses and aroma descriptions of the new Hüll special-flavor hops; chemical analyses by IPZ 5d: alpha-acids in % (w/w); total oils in ml/100 g dried cones;

Reference

Lutz, A., Kammhuber, K. and Seigner, E., 2012: New Trend in Hop Breeding at the Hop Research Center Huell. BrewingScience 65, 24-32.

Breeding of dwarf hops for low trellis systems

Project managers: Dr. E. Seigner, A. Lutz

Project staff: A. Lutz, J. Kneidl (both from IPZ 5c)
Dr. K. Kammhuber, C. Petzina, B. Wyschkon, M. Hainzlmaier and S. Weihrauch (all from IPZ 5d)

Cooperation: M. Mauermeier hop farm
Dr. F. Weihrauch, IPZ 5b

Objective

Work on breeding hop varieties suitable for profitable and ecologically sustainable cultivation on low trellis systems, conducted during the period from 2007 to 2011 as part of a project financed by Germany's Federal Agency for Agriculture and Food (BLE), has been continued since 2012 on a self-funding basis.

Results

Selection of seedlings showing pronounced suitability for cultivation on low trellis systems was continued on the 3-metre trellis system in Starzhausen. A total of 64 lines are currently under test cultivation along with the eight reference cultivars (five Hüll high-trellis cultivars and three English dwarf varieties).

During the last two years, 10 plants each of 14 new low-stature breeding lines, preselected on the basis of their performance on high-trellis systems, were cultivated in the low-trellis trial yard. In 2013, the suitability of a promising low-stature breeding line planted in a hilled row was monitored as well. We expect to harvest these hop plants for the first time in 2014.

	BLE-financed trial years					**LfL**		**Total**
	2007	2008	2009	2010	2011	2012	2013	2007-2013
Crosses	29 aroma-type and 71 high-alpha crosses					3 A	4 A	107
No. of seedlings	-	32,000	34,700	25,000	18,000	1635	1420	112,755
Pre-selected seedlings (veget. hall)	-	678	1,280	1,023	592	180	250	4,003
High-trellis system: Planted out: - female seedlings - male seedlings	280* 46*	482 46	844 93	1,207 90	267 39	107 32	138 10	280*+3,045 46*+310
Low-trellis system: Propagated and planted out: - female seedlings	-	9*	10*	4*+12	2*+13	8	8	25*+41

*low-stature seedlings from other breeding programmes; A = aroma-type cross

Fifty-eight breeding lines stemming from the crosses performed specifically for the BLE-funded dwarf-hop project were harvested in 2013. Some of these breeding lines were of particular interest on account of their very fine and pleasant hop aroma, while others boasted crop volumes approaching those of our previously selected high-trellis aroma varieties. It is difficult to breed a low-growth bitter variety that comes anywhere near to matching the alpha-acid yields of 500-600 kg/ha obtained with Herkules under high-trellis cultivation.

In addition, work on the comparison between the “non-cultivation” method and the conventional cultivation method, involving pruning and tillage, continued in seven plots. In one plot, the effect of using netting instead of the customary training wires was investigated as well.

In joint work with Dr. Weihrauch from IPZ 5b, predatory mite species were employed again, as in 2011 and 2012, to combat the common spider mite. As in the preceding years, the hop plants were not treated with acaricide at all. The entire trial plot remained completely free of spider mites thanks to timely distribution of the predatory mites and to weather conditions in May and June that discouraged spider mite development.

To gain further insights into hop growing on 3-m trellis systems, and, in particular, to have the necessary controls, the three English dwarf varietes, low-growth breeding lines from other breeding programmes and five traditional Hüll high-trellis cultivars were again grown and harvested in Starzhausen, and the findings compared with those for the newly bred seedlings.

So far, it has not been possible to select a breeding line from those grown on low-trellis systems that has all the desired properties and would be worth the work and money involved in a brewing trial. However, work continues with the aim of selecting hop plants showing broad resistance, good yields, low-trellis suitability and high brewing quality from among the numerous seedlings grown between 2007 and 2011. The potential is by no means exhausted. In 2014, seedlings of the latest seedling generation, which stems from crosses performed in the final project year (2011), will be planted out for the first time under low-trellis conditions. The first reliable appraisals and crop evaluations for these hop plants will be available in 2016. Three further crosses were performed in 2012, and another four in 2013, with the intent of breeding hops that not only meet the known project goals but also boast pest resistance.

Meristem cultures to eliminate viruses – a basic requisite for virus-free planting stock

Project managers: Dr. E. Seigner, A. Lutz

Project staff: B. Haugg

Cooperation: Dr. L. Seigner, IPS 2c, and team

Objective

Virus-free hop planting stock has been an important part of our quality drive for years, great importance also being attached to virus elimination within the context of the commercial release of special-flavor hops.

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. Following heat treatment, these 0.2-0.3 mm cytogenous centres of the shoot tips are considered virus-free. The meristems are transferred to special culture media, where they grow into complete plants. 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 (see virus testing details in 4.1.5). 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) and hop stunt viroid (HpSVd) infections and in cases where only very little *in vitro* starting material was available for testing.

Results

The regenerated hop plants were not tested for hop stunt viroid and AHpLV as the virus-contaminated parent plants had tested free of these two pathogens.

Virus elimination was very reliable in the case of parent plants infected with HpMV (hop mosaic carlavirus). It was more difficult to eliminate ApMV and HpLV.

Fig. 1.4: A young shoot, grown from a meristem, on regeneration medium

The effectiveness of the method is always greatly influenced by seasonal fluctuations in growth vigour and vitality of the starting material and seasonal fluctuations in the *in vitro* regeneration capability of the excised meristem. It has also been shown that certain genotypes can be cured more effectively than others with this tissue-culture technique because the excised meristems regenerate better. In an attempt to promote *in vitro* growth of the meristems and young shoots (see) by increasing nutrient availability above that of the standard nutrient, casein hydrolysate, for example, was added as a source of amino acids, while various iron complexes (Reed and Aynalem, 2005) were supplied to improve iron uptake. Gelrite-agar and pH variants (cf. Reed and Hummer, 2012) were also tested. This work will be continued in 2014.

The findings from virus and viroid monitoring in Germany's hop-growing areas show how important meristem culture is for the provision of virus-free planting stock.

In the next few years, it is planned to investigate the extent to which meristem culture preceded by heat or cold therapy can also be used to eliminate the hop stunt viroid from infected hops (Momma and Takahashi, 1983; Adams et al., 1996). In principle, it should also be possible to produce V*erticillium*-free planting stock with this technique.

References

Momma, T., and Takahashi, T. (1983): Cytopathology of shoot apical meristem of hop plants infected with hop stunt viroid. Phytopath. Z., 106, 272-280.

Adams, A. N., D. J. Barbara, A. Morton, and P. Darby (1996): The experimental transmission of Hop latent viroid and its elimination by low temperature treatment and meristem culture. Annals of Applied Biology 128, 37-44.

Reed, B.M. and Aynalem, H. (2005): Iron formulation affects *in vitro* cold storage of hops. Acta Hort. 668, ISHS 2005, 257-262.

Wang, N. and Reed, B.M. (2003): Development, Detection, and Elimination of *Verticillium dahliae* in Mint Shoot Cultures. Hortscience (1), 67–70.

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

Project managers:	Dr. E. Seigner, A. Lutz
Project staff:	B. Forster, M. Jawad-Fleischer
Cooperation:	Prof. Dr. Th. Ebertseder, Weihenstephan-Triesdorf University of Applied Sciences

Objective

Broad disease resistance is one of the most important quality goals of breeding-stock and hop-cultivar development. Downy mildew, in particular, which is caused by the *Pseudoperonospora humuli* fungus, became a huge problem in hail-damaged hop stands in 2009 and 2010. To accelerate the breeding of downy-mildew-tolerant hops, work on improving the screening of seedlings for assessing hop tolerance was commenced in 2012. The intention is to supplement the findings concerning the reaction of hop plants to downy mildew by means of a detached-leaf assay.

Method

The hop seedlings under test were sprayed with a downy-mildew zoosporangia suspension and left covered with plastic bags overnight. Four days later, the plants were sprayed with water and again covered with plastic bags for 20 hours. The seedlings were examined for downy mildew 5-7 days post downy-mildew inoculation.

Results and outlook

Findings of major importance resulted from the seedling-screening work, which was carried out by a student (research thesis by Jawad-Fleischer, 2013) in cooperation with the LfL’s Work Group for Hop Breeding Reseach and Prof. Dr. Th. Ebertseder of Weihenstephan-Triesdorf University of Applied Sciences. The use of plastic bags, which prevents the seedlings from drying off prematurely following inoculation with the zoosporangia suspension and thus keeps the downy-mildew fungal infection process running, resulted in more comparable and hence more reliable assessment of the seedlings’ tolerance towards downy mildew.

The intention is to use this optimised, albeit more labour-intensive, screening method as of 2014 for the routine screening of new seedlings in the Hüll greenhouse.

In addition, work is being done on a detached-leaf assay. The various trial parameters used in downy-mildew screening studies conducted in the USA, UK, CZ and, in particular, in Hüll by Dr. Kremheller during the 1970s and 1980s, were reviewed. These studies will be continued in 2014.

Reference

Jawad-Fleischer, M. (2013): Optimierung eines Sämlingsprüfsystems im Gewächshaus zur Testung der Toleranz gegenüber Falschem Mehltau (*Pseudoperonospora humuli*) bei Hopfen. Hochschule Weihenstephan-Triesdorf, Fakultät Land- und Ernährungswirtschaft.

1.2.2 Hop Cultivation/Production Techniques: main research areas

Evaluation of the specific water requirements of various hop varieties irrigated on the basis of soil moisture tension

Project staff: T. Graf,

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

Material and methods

Equal volumes of water were supplied during the growing season to three adjacently planted hop cultivars (Herkules, Magnum and Perle) and soil-moisture tension, measured at specific depths, compared for the three varieties. Watermark sensors were used for this purpose and were installed in the same way as in 2012. The various soil-moisture tension curves provide information as to the specific water requirements of each variety.

Results

Fig. 1.5 shows increased soil moisture tensions for the Perle variety. As from August 10th, soil moisture tensions measured at a depth of 30 cm rise much more quickly for Perle (green line) than for Herkules (blue line) and Magnum (red line). All plants received the same volumes of supplemental water. Clear differences in soil moisture tension were recorded for the various cultivars in the non-irrigated plot as well.

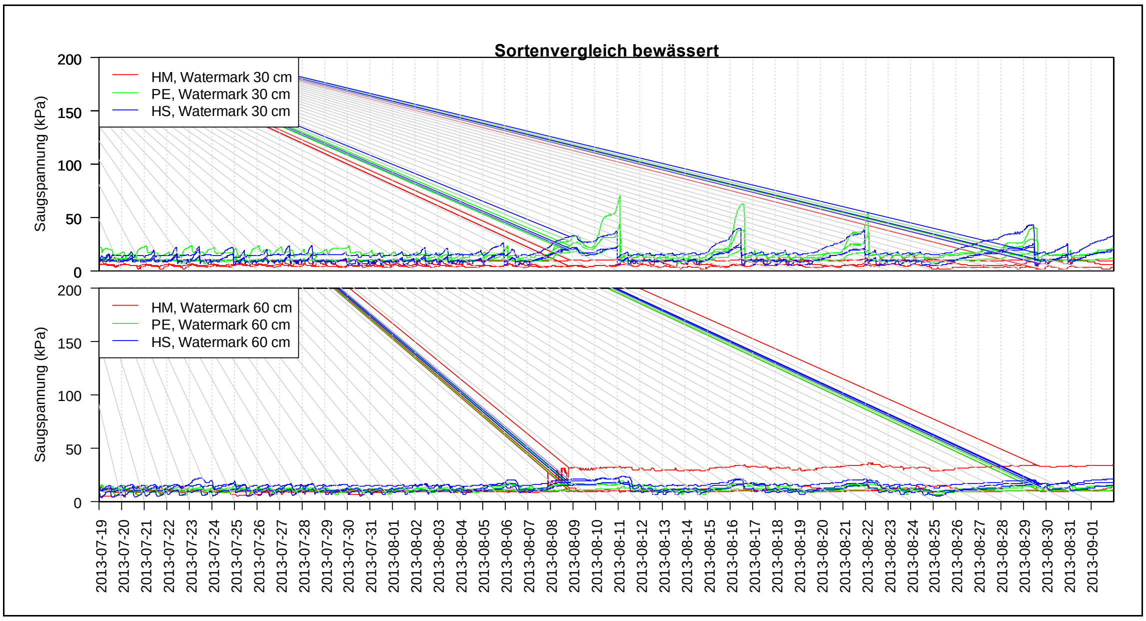


Fig. 1.5: Soil moisture curves (mean values, n=3) at depths of 30 cm (above) and 60 cm (below) from 19.07.- 02.09.12 for various hop cultivars irrigated simultaneously with equal volumes of water: soil moisture tensions measured at 30 cm were higher for Perle (green line) as from early August. Measurements taken at 60 cm were higher for Perle right from the start. Tensions for Magnum (red line) and Herkules (blue line) were relatively identical and below those of Perle at both depths.

Testing of an Adcon weather model for the downy mildew warning service

Project manager:	J. Portner
Project staff:	J. Schätzl
Duration:	2008-2013

To forecast the probability of a downy mildew outbreak with the Kremheller forecasting model, the number of zoosporangia is determined daily with spore traps at five locations in the Hallertau, one in Spalt and one in Hersbruck. If the economic threshold is exceeded and the weather conditions are favourable for the pest, a regional spray warning is issued, which varies according to variety.

In other hop-growing regions (Elbe-Saale, Czech Republic), the early-warning forecast is based purely on weather models. Infection potential is ignored. The 5-year trial was intended to determine the extent to which the time-consuming and labour-intensive counting of zoosporangia at the downy-mildew locations is necessary. To this end, the index calculated by the Adcon weather stations was compared with the warnings based on the Kremheller model in order to determine preliminary Adcon thresholds for susceptible and tolerant varieties. Scientific tests were then performed to determine whether the different methods of triggering spray warnings had influenced yield and quality.

The results of the comparison between the two models are described in detail in Section 5.

Optimisation of hop drying in a belt dryer

Project staff: J. Münsterer

The correct ratio between the drying parameters, i.e. cone depth, drying temperature and air speed, is crucial to preserving optimum quality and achieving maximum drying performance. Research work is accordingly being conducted with belt driers on commercial hop farms and in small-scale drying trials to ascertain which drying temperatures and air speeds produce the best drying results. A further intention is to test and develop control systems to facilitate belt drying and make it easier to regulate. Such systems have already been developed for floor kilns.

Influence of variations in drying temperatures on flavor-hop quality

Project staff: J. Münsterer, T. Presl, K. Kammhuber

Small-scale drying trials to investigate whether variations in drying temperatures influence the qualitative and quantitative quality of flavor hops are being conducted by a Bachelor student. Temperatures ranging from 60-70°C are being tested. To assess the influence of drying temperature, the hop storage index (HSI), α- and β-acid content, xanthohumol and total-oil content and the individual substances myrcene, linalool, beta- caryophyllene, humulene and geraniol are determined for all samples.

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 height 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 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 various 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.

For statistical reasons, a general recommendation that hop farmers reduce trellis height is not yet possible on the basis of the trial results because only one location was tested per cultivar.

This project is now being continued with the Hallertauer Tradition variety in a commercial hop yard that is highly suitable on account of its very homogeneous soil properties. The plan is to harvest the hops from this trial for the last time in 2014 and to evaluate the results obtained during the project years.

In addition, trial plots with 7m and 6m 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 will facilitate observation and comparison of the way in which the hop cultivars react to the various trellis heights. Unfortunately, the trial crop was badly damaged by a hail storm on July 20th, 2013, with approx. 80 % of the plants suffering head damage. The hops were not harvested as the crop would not have furnished conclusive results. However, the plants have recovered well and have not suffered lasting damage. As from 2014, the additional findings furnished by these trials will be used to draw up recommendation for hop farmers.

Variations 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 leaching after the harvest. In the past, cover crops have usually been sown in early summer after ploughing, the consequence being that heavy rainfall after sowing and before the cover crop has grown sufficiently has caused serious localized 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, soil mechanics measurements and qualitative soil erosion observations to compile information on optimising the process.

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 managers:	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. An 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.

Development of analytical methods for hop polyphenols

Project manager:	Dr. K. Kammhuber
Cooperation:	Working Group for Hop Analysis (AHA)
Project staff:	E. Neuhof-Buckl, Dr. K. Kammhuber
Duration:	2007 to (open-ended)

Polyphenols are attracting increasing attention within the context of alternative uses of hops, primarily on account of their health-promoting properties but also because they enhance the taste stability and drinkability of beer. It is therefore important to have suitable analytical methods available. To date, however, no officially standardised methods exist, and all laboratories that analyse polyphenols rely on their own methods. The AHA has been working on improving and standardising the analytical methods for total polyphenol and total flavonoid contents in hops since 2007. During the most recent ring tests with international involvement, however, the variation coefficients (cvr) for these techniques were so high that they have not yet been approved as official methods. The intention for the future is to place greater emphasis on more specific HPLC methods.

1.2.4 Plant Protection in Hop Growing: main research areas

Testing of two forecasting models for the control of powdery mildew in hops and implementation of one of the models for controlling the disease in the field

Project manager:	W. Sichelstiel
Project staff:	J. Schwarz, G. Meyr

Objective

Two forecasting models were tested for their practicality over a number of years in field trials. The initial forecasting model was formulated by B. Engelhard on the basis of empirical data, with spray recommendations deriving from weather parameters. A more sophisticated weather-based forecasting model drawing additionally on scientific data was formulated by Dr. S. Schlagenhaufer in a dissertation. At the time the models were being designed, however, the PM infection pressure at numerous locations was too low to permit conclusive statements on the reliability of the forecasts. Trials to clarify the reliability of both forecasting models were therefore set up to establish the basic requirement for their use in the field.

Results

The trials were performed at four locations and involved three test variants and three cultivars:

Hemhausen	-	HM, HT
Reitersberg	-	TU
Einthal	-	HM
Eichelberg	-	TU

Plots of each test cultivar were marked out at all four locations, treated in accordance with spray warnings by the preliminary and refined forecasting models and then compared with an untreated control plot. Each plots was approx. 500 m² in size.

As in the preceding years, PM pressure was low in 2013 and neither model triggered any spray warnings except for one each in June, on the 24th and the 26th. At harvesting time, infection levels in the untreated plots were again much too low to furnish conclusive results.

On conclusion of the assessment at the end of August, no relevant infection levels were detected in either the untreated control plot or the treated plots. Accordingly, cone assessment was not performed.

Evaluation of the two powdery mildew forecasting models, as a long-term task, will continue on the same scale during the coming years.

Tests performed on plant protectives in 2013 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

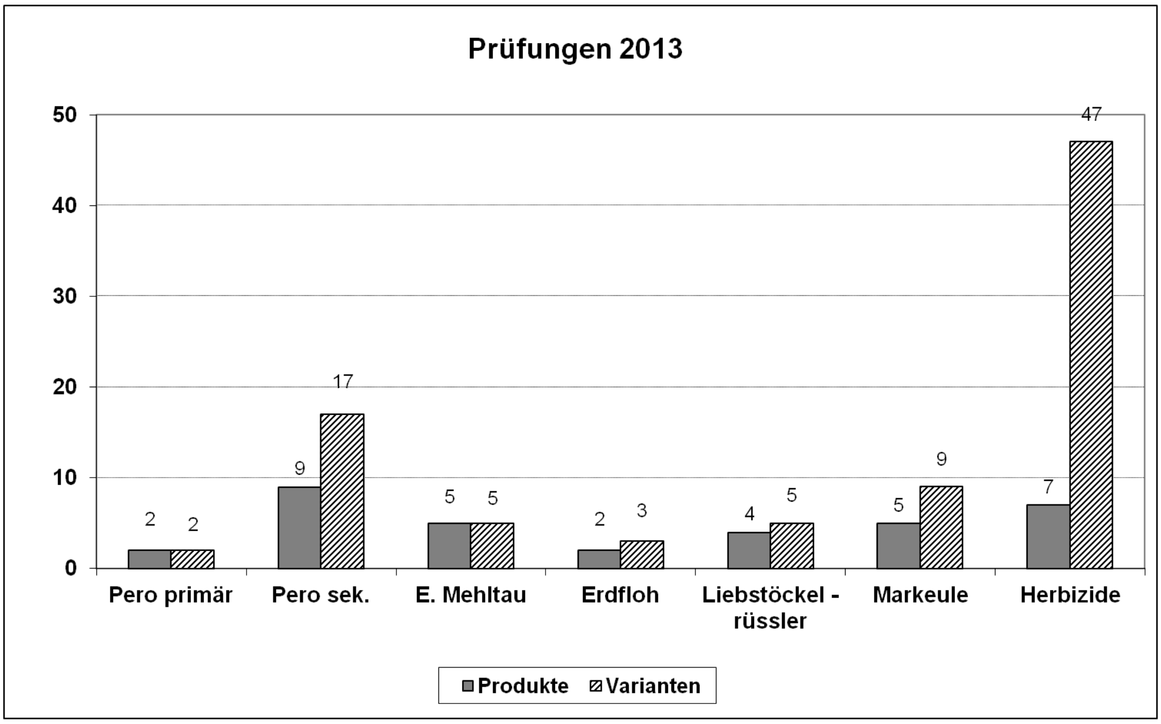


Fig. 1.6: PPP testing in 2013

2 Weather conditions and hop growth in 2013 – effects on production techniques in the Hallertau

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2013 will be remembered as a year of weather extremes. After a very late start to the growing season, there were only limited time frames for spring work. Stripping and training could not be performed until the first half of May. Cold weather and copious rain in May and June led to retarded growth, waterlogged soil and flooding in valley locations. An initial heat wave in June ended with widespread hail in the northern part of the Hallertau. Despite hot, dry weather in July and August, the stands were unable to make up the growth deficit. Harvesting took place in September under cool, damp conditions. Yields and alpha-acid contents were disappointing, especially for early and moderately early varieties. Later varieties produced average results at best.

Special weather conditions and their effects:

- Long winter and very lengthy dormancy

The winter of 2012/2013 was changeable, with very little sun. December and January were again too warm and too wet, with mean-temperature deviations at the Hüll location being +0.3 and +0.6°C, respectively, and rainfall amounts exceeding the 2003-2012 mean by 38 % and 10 %, respectively. Following a sub-zero period in January, February continued wintry, with long-lasting snow cover. However, the frost did not penetrate the soil sufficiently to result in mellowing. The late winter weather continued throughout March. The average temperature was 1.0°C and thus 2.9°C lower than the 10-year mean. Precipitation was slightly below average, and dormancy prevailed throughout the month.

- Late commencement of vegetation in April

The first 10 days of April continued wintry. Temperatures did not increase to springtime levels until the middle of the month and hop plants sprouted about two weeks late. The average temperature was 8.6°C, 1.2°C higher than the long-term mean but 1°C below the corresponding 10-year figure. It rained on 11 days of the month, and spring work had to be postponed until early to mid-April on account of the cold weather and wet soil. Neither crowning of the hop plants nor shallow cover-crop incorporation could commence before the end of April, with plant growth varying according to the relevant pruning time. Stripping and training activities could not begin until after 29th April, the soil having warmed up slightly by then. As from mid-April, wireworm damage in young hop plants and alfafa snout beetle infestation in slightly warmer locations were observed. Flea beetle infestation set in as from the end of April, whereas primary downy mildew infection and crown rot were limited to isolated cases.

- Cold, wet May ends with flooded hop yards

May was exceedingly wet, with 21 rainy days and precipitation totalling 145 mm. This is 169 % of the mean precipitation figure for May. Localised hail fell mid-month. Towards the end of the month, heavy, continuous rain saturated the ground. Hop yards were flooded in some areas, and in a few instances, massive damage was sustained. As the mean temperature of 11.7°C was below the long-term figure, hop growth was retarded. Cultivation measures were extremely difficult and had to be delayed.

Primary downy mildew infestation occurred in isolated cases, mainly in yards that had witnessed serious outbreaks in preceding years. Secondary infections did not develop. The forecasting models and warning service did not trigger any spray warnings for downy mildew or powdery mildew. No aphid migration was observed during May. The cold, wet weather also prevented common spider-mite migration. By contrast, Rosy Rustic moth larvae were identified very early on. Infestation was especially severe on acreages that had been affected in 2012, with caterpillars found tunnelling in the shoots as early as the first week in May.

- June characterised by wet weather, an initial heat wave and hail

The cold, wet weather continued unchanged for the first half of June. The year's first heat wave heralded a change for the better as from the middle of the month, but ended on 20th June with violent storms and hail. Approx. 5,000 ha under hop saw hail damage in the form of leaf loss, bine injury and head damage, with the northern Hallertau region being worst hit. For the rest of the month, the weather was again cool and wet. Overall, June was too cool (1.6°C below the 10-year mean) and too wet (60 % above the long-term average). The hop stands were unable to make up the two-week growth deficit in June and not all had reached trellis height by the end of the month. Not even early varieties had visible flower buds. Downy mildew spore counts rose steeply as temperatures increased towards the middle of the month, prompting two spray warnings for all varieties on 10th and 18th June. As of 24th June, the forecasting models for powdery mildew pointed to a high infection risk. Protective treatment was accordingly recommended for all varieties. Whereas aphid migration and infestation levels remained extremely low, some yards witnessed common spider-mite outbreaks that necessitated control measures.

- A hot July with hardly any rain

With only 10.7 mm rain at the Hüll location, 90 % less than the long-term figure, July 2013 went down in history. July is normally the wettest month of the year! 25 % more sunshine and an increase in average temperature of 3.1°C meant that growth conditions for the hops switched from one extreme to the other. Formation of laterals remained moderate to weak. Leaf yellowing and decreased numbers of leaves and flowers were observed on compacted soils and at non-irrigated sandy locations. Early varieties commenced flowering with up to a fortnight's delay, as from mid-July. Later varieties commenced flowering at the normal time or with a slight delay. Spore counts recorded by the downy mildew warning service decreased steadily as the month progressed. For this reason, and in view of the hot, dry weather, no spray warnings were necessary in July. The powdery mildew forecasting models did not trigger any spray warnings, either. Measures to combat aphid infestation proved unnecessary in many hop yards, as infestation levels remained extremely low. Common spider-mite infestation was observed in some yards.

- Little rain and plenty of sun for cone formation

Initially, August remained true to the dry, warm character of the second half of 2013. The water shortage was exacerbated on non-irrigated hop acreages and led to poor cone and component formation. 58 mm rain were recorded at Hüll, only half the average for the last ten years. The start of harvesting was delayed until the end of August or early September. Whereas early aroma varieties, in particular, were characterised by below-average yields and alpha-acid contents, later-maturing high-alpha cultivars profited from the rain in the second half of August. This was reflected in better yields and higher alpha-acid contents. External quality was comparatively high thanks to the very low disease and pest pressure.

2.1 Hüll weather data (monthly means and monthly totals) for 2013 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	2013	-0.2	-3.1	2.0	89.8	66.0	19.0	24.0
∅	10-y	-0.8	-4.3	2.9	88.3	59.9	13.0	67.6
	50-y	-2.4	-5.1	1.0	85.7	51.7	13.7	44.5
February	2013	-1.9	-5.4	0.9	88.9	82.3	19.0	17.0
∅	10-y	-0.8	-5.2	4.3	85.1	37.6	11.6	95.9
	50-y	-1.2	-5.1	2.9	82.8	48.4	12.8	68.7
March	2013	1.0	-2.8	5.7	80.8	47.9	16.0	129.0
∅	10-y	3.9	-1.4	10.1	80.0	55.9	11.7	151.9
	50-y	2.7	-2.3	8.2	78.8	43.5	11.3	134.4
April	2012	8.6	3.8	13.9	78.4	45.8	11.0	131.0
∅	10-y	9.6	2.9	16.4	72.1	60.6	10.5	213.3
	50-y	7.4	1.8	13.3	75.9	55.9	12.4	165.0
May	2013	11.7	7.0	16.5	81.8	145.2	21.0	130.0
∅	10-y	13.7	7.3	20.2	73.4	97.3	14.6	222.5
	50-y	11.9	5.7	17.8	75.1	86.1	14.0	207.4
June	2013	15.7	10.5	21.2	79.3	171.4	15.0	193.0
∅	10-y	17.3	10.9	23.9	74.6	97.4	14.9	229.2
	50-y	15.3	8.9	21.2	75.6	106.1	14.2	220.0
July	2013	20.0	11.9	27.6	66.9	10.7	5.0	301.0
∅	10-y	18.3	12.1	25.3	75.8	115.5	15.3	242.1
	50-y	16.9	10.6	23.1	76.3	108.4	13.9	240.3
August	2013	17.9	11.1	25.3	75.5	58.1	8.0	244.0
∅	10-y	17.6	11.5	24.7	79.4	115.1	13.7	219.9
	50-y	16.0	10.2	22.5	79.4	94.9	13.3	218.4
September	2013	13.1	8.3	18.4	83.9	116.9	14.0	126.0
∅	10-y	13.6	7.9	20.5	82.9	55.1	10.4	179.1
	50-y	12.8	7.4	19.4	81.5	65.9	11.4	174.5
October	2013	9.5	5.0	14.6	86.7	57.8	10.0	98.0
∅	10-y	8.5	3.8	14.4	87.2	52.4	10.1	122.4
	50-y	7.5	2.8	13.0	84.8	60.0	10.4	112.9
November	2013	3.9	1.1	6.5	90.0	61.6	16.0	36.0
∅	10-y	3.8	0.4	7.8	91.4	52.5	11.3	65.6
	50-y	3.2	-0.2	6.4	87.5	58.8	12.6	42.8
December	2013	1.3	-1.4	4.9	91.1	9.6	8.0	52.0
∅	10-y	0.1	-3.0	3.3	90.8	63.9	14.6	53.9
	50-y	-0.9	-4.4	1.6	88.1	49.1	13.3	34.3
∅ 2013		8.4	3.8	13.1	82.8	873.3	162.0	1481.0
10 – year mean		8.7	3.6	14.5	81.7	863.1	151.7	1863.3
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 2003 through 2012.

3 Statistical data on hop production

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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
1974	8,120	2.48	1994	3,282	6.69
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

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 - 2013 vs 2012				Increase + / Decrease - 2013 vs 2012			
	2012	2013	ha	%	2012	2013	Farms	%	2012	2013
Hallertau	14,258	14,086	- 172	- 1.2	1,046	989	- 57	- 5.4	13.63	14.24
Spalt	351	350	- 1	- 0.4	65	62	- 3	- 4.6	5.41	5.65
Tettnang	1,215	1,208	- 7	- 0.6	153	149	- 4	- 2.6	7.94	8.11
Baden, Bitburg and Rheinl-Pal.	20	20	± 0	± 0	2	2	± 0	± 0	10.00	10.00
Elbe-Saale	1,284	1,186	- 98	- 7.7	29	29	± 0	± 0	44.28	40.89
Germany	**17,128**	**16,849**	**- 279**	**- 6.1**	**1,295**	**1,231**	**- 64**	**- 4.9**	**13.23**	**13.69**

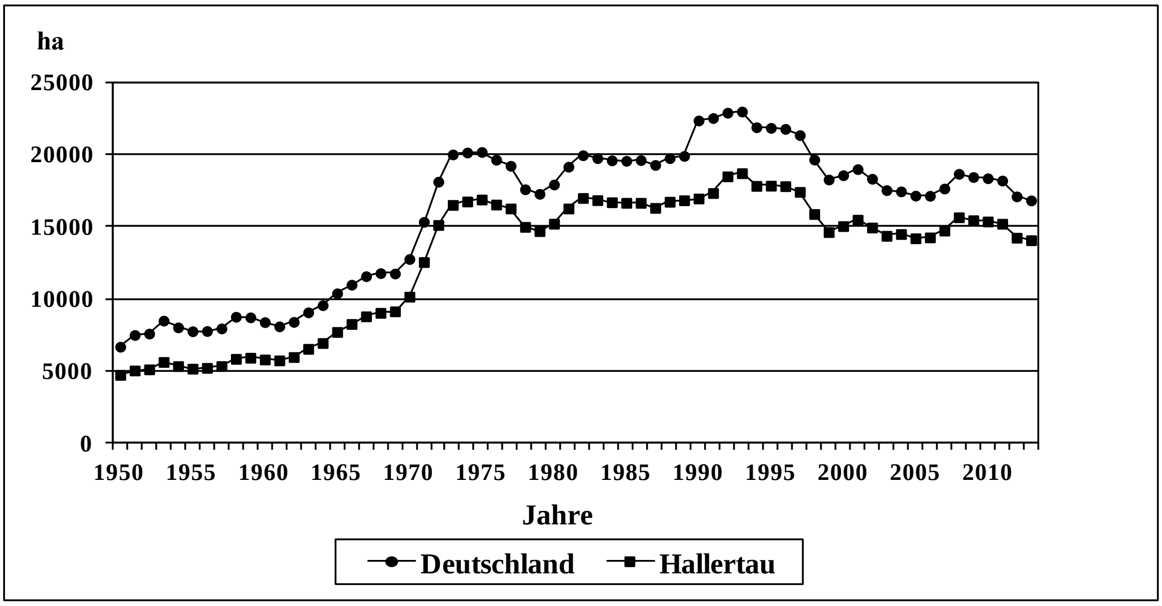

Fig. 3.1: Hop acreages in Germany and in the Hallertau

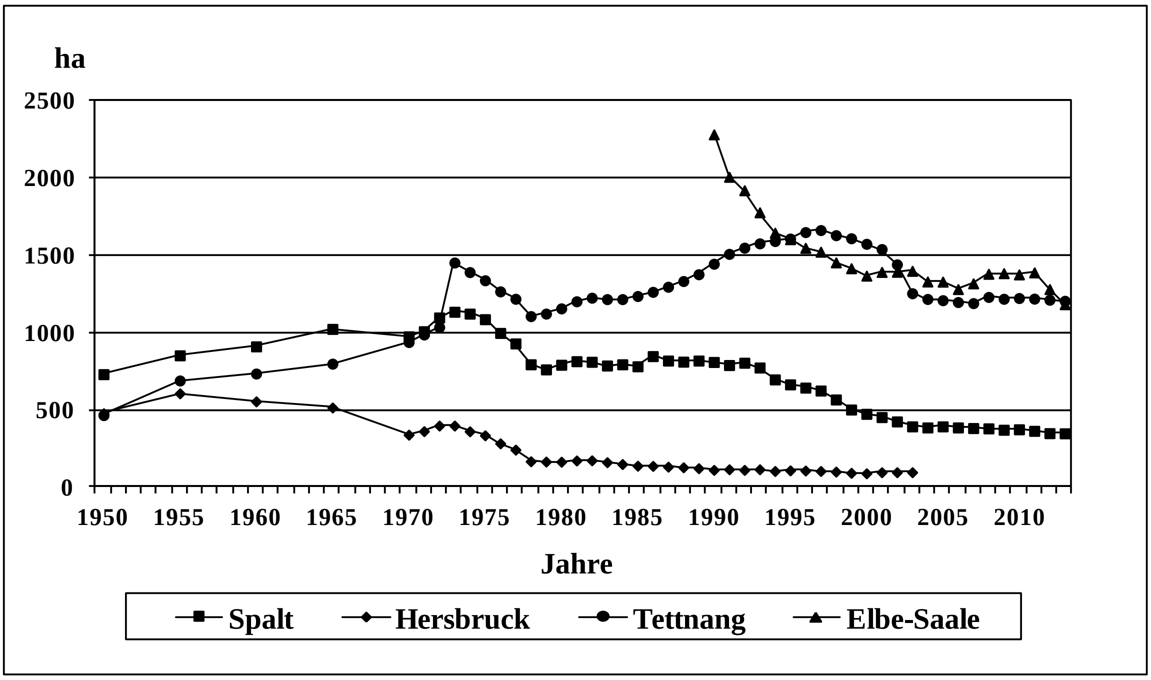

Fig. 3.2: Hop acreages in the Spalt, Hersbruck, Tettnang and Elbe-Saale regions

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

Hop varieties

The pronounced hop acreage reduction of more than 1,000 ha seen in 2012 has slowed down, with the area under hop decreasing by only 279 ha in 2013 and total hop acreage in Germany therefore amounting to 16,849 ha. Of the aroma varieties, the principal cultivars, Perle and Hallertauer Tradition, saw complete clearance of a noteworthy area previously under cultivation, namely 248 ha. By contrast, Spalter Select and Hersbrücker Spät were more in demand, with acreages under cultivation increasing by 72 ha and 62 ha respectively. With the exception of Herkules, all the bitter and high-alpha varieties saw some of their acreage cleared, in all 144 ha. Over 400 ha previously planted with Hallertauer Magnum were replanted with Herkules.

The recent trend towards increased cultivation of special-flavor or dual-purpose hops has intensified, and their respective acreages are therefore shown in a separate table as of 2013. According to the statistics, 114 ha, or 0.7 % of the total area under hop production in 2013, were planted with the new Hüll cultivars Hallertau Blanc, Huell Melon, Mandarina Bavaria and Polaris or the earlier US Cascade variety. As further acreages were planted with special-flavor hops in summer, the acreage under cultivation is probably approx. 150 ha. Production of these special varieties, which boast very distinctive fruity and floral aromas, is expected to increase in 2014, especially as the trend towards craft brewing is intensifying and hops with novel flavors and special aromas are attracting increasing attention.

An exact breakdown of varieties according to growing regions is given in Tables Tab. 3.3 to Tab. 3.5.

Tab. 3.3: Hop varieties in the German hop-growing regions in ha in 2013

Aroma varieties

Region	Total acreage	HA	SP	TE	HE	PE	SE	HT	SR	OL	SD	Other	Aroma varieties	
													ha	%
Hallertau	14,086	687			843	2,813	408	2,537	308	25	27	5	7,653	54.3
Spalt	350	48	112		4	24	82	31	6	1	1		309	88.4
Tettnang	1,208	189		787		67	4	53	11	1	13		1,125	93.2
Baden, Bitburg and Rhinel.-Pal.	20	1				8	2	5					16	80.4
Elbe-Saale	1,186					136		34				8	178	15.0
Germany	**16,849**	**925**	**112**	**787**	**847**	**3,048**	**496**	**2,661**	**324**	**28**	**41**	**13**	**9,281**	**55.1**
% acreage by variety		5.5	0.7	4.7	5.0	18.1	2.9	15.8	1.9	0.2	0.2	0.1		

Variety changes in Germany

2012 (in ha)	17,128	1,012	106	790	785	3,203	538	2.748	253	33	43	20	9,530	54.3
2013 (in ha)	16,849	925	112	787	847	3,048	496	2.661	324	28	41	13	9,281	55.1
Change (in ha)	-279	-87	7	-3	62	-155	-42	-87	72	-5	-3	-7	-248	0.8

Tab. 3.4: Hop varieties in the German hop-growing regions in ha in 2013

Bitter and high-alpha varieties

Region	NB	BG	NU	TA	HM	TU	MR	HS	CM	Other	Bitter varieties	
											ha	%
Hallertau	184	19	156	1	2,360	682	31	2,869	3	29	6,335	45.0
Spalt					2		4	32		1	39	11.2
Tettnang						5		69		0	74	6.2
Baden, Bitburg and Rhinel.-Pal.					3			1			4	19.6
Elbe-Saale	96		28		737	22	2	115		2	1.002	84.5
Germany	**281**	**19**	**184**	**1**	**3,102**	**709**	**38**	**3,086**	**3**	**31**	**7,454**	**44.2**
% acreage by variety	1.7	0.1	1.1	0.0	18.4	4.2	0.2	18.3	0.0	0.2		

Variety changes in Germany

2012 (in ha)	296	22	207	2	3.509	821	49	2.642	0	49	7.598	45,7
2013 (in ha)	281	19	184	1	3.102	709	38	3.086	3	31	7.454	44,2
Change (in ha)	-16	-3	-23	-1	-407	-112	-12	444	3	-18	-144	-1,5

Tab. 3.5: Hop varieties in the German hop-growing regions in ha in 2013

Special-flavor and dual-purpose varieties

Region	CA	HC	HN	MB	PA	Flavor varieties	
						ha	%
Hallertau	10	11	14	28	35	98	0.7
Spalt	1	1				1	0.4
Tettnang				4	4	8	0.7
Baden, Bitburg and Rhinel.-Pal.						0	0.0
Elbe-Saale				2	4	6	0.5
Germany	**10**	**12**	**14**	**35**	**43**	**114**	**0.7**
% acreage by variety	0.1	0.1	0.1	0.2	0.3		

Variety changes in Germany

2012 (in ha)	0	0	0	0	0	0	0.0
2013 (in ha)	10	12	14	35	43	114	0.7
Change (in ha)	10	12	14	35	43	114	0.7

3.2 Yields in 2013

Approximately 27.554.140 kg (= 551.083 cwt.) hops were harvested in Germany in 2013, as compared with 34,475,210 kg (= 689,504 cwt.) in 2012. The crop thus weighed 6,921,070 kg (= 138,421 cwt.) less than in the previous year, a decrease of 20.1 %. Among other things, the poor crop was due to widespread hail in the northern Hallertau region on 20th June, 2013, which resulted in estimated crop losses of 2,250,000 kg.

At 1,635 kg, the mean per-hectare yield was below average. Alpha content was also below average in 2013. Early-maturing aroma varieties, in particular, had suffered considerably from the adverse weather conditions.

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

	2008	2009	2010	2011	2012	2013
Yield kg/ha and (cwt./ha)	2,122 kg (42.4 cwt.)	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)
Acreage in ha	18,695	18,473	18,386	18,228	17,124	16,849
Total yield in kg and cwt.	39,676,470 kg = 793,529 cwt.	31,343,670 kg = 626,873 cwt.	34,233,810 kg = 684,676 cwt.	38,110,620 kg = 762,212 cwt.	34,475,210 kg = 689,504 cwt.	27,554,140 kg = 551,083 cwt.

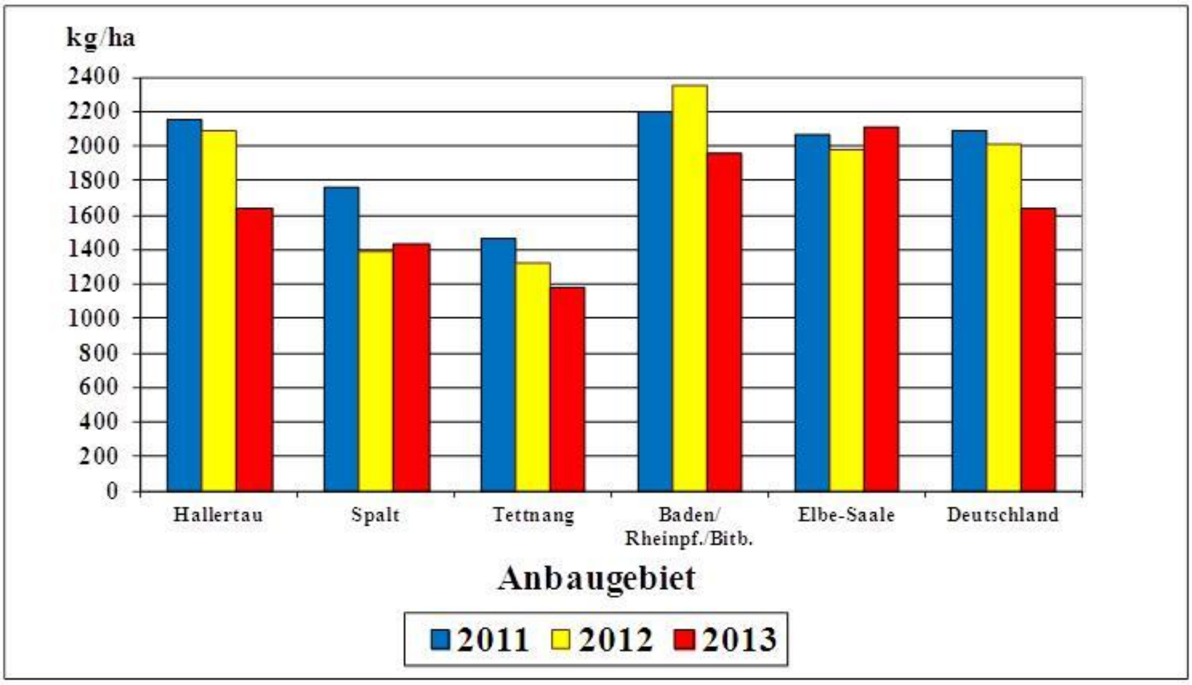

Fig. 3.3: Average yields by hop-growing region in kg/ha

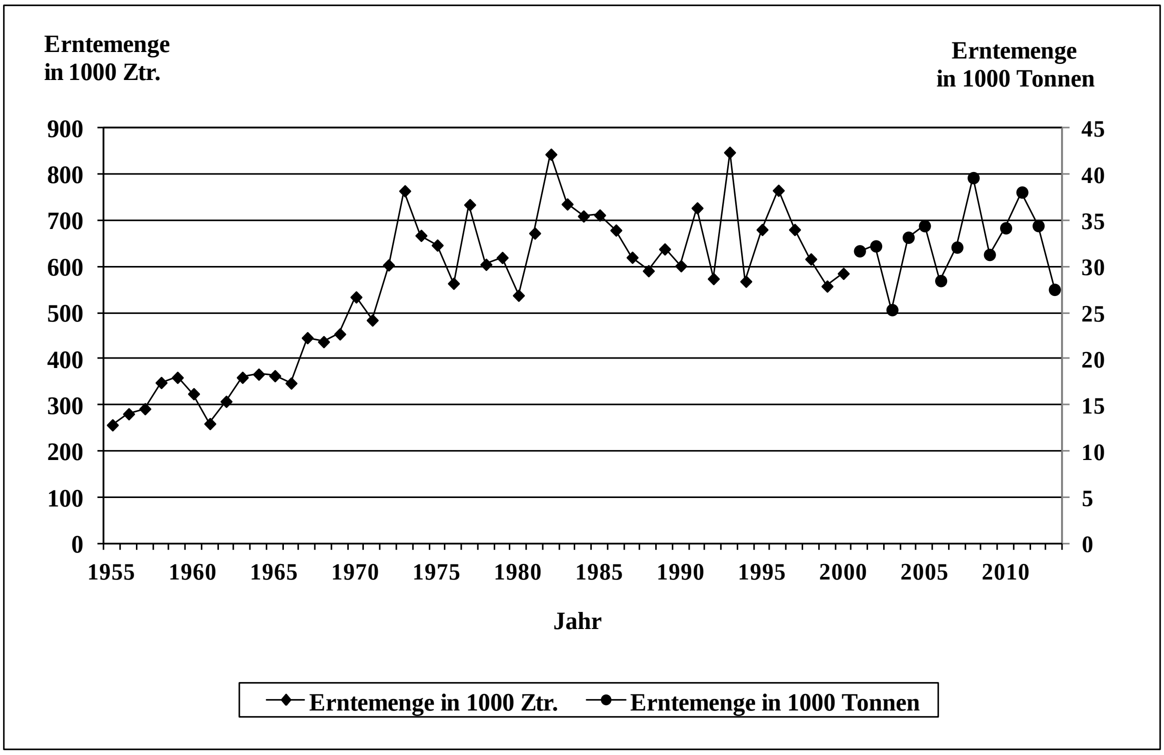

Fig. 3.4: Crop volumes in Germany

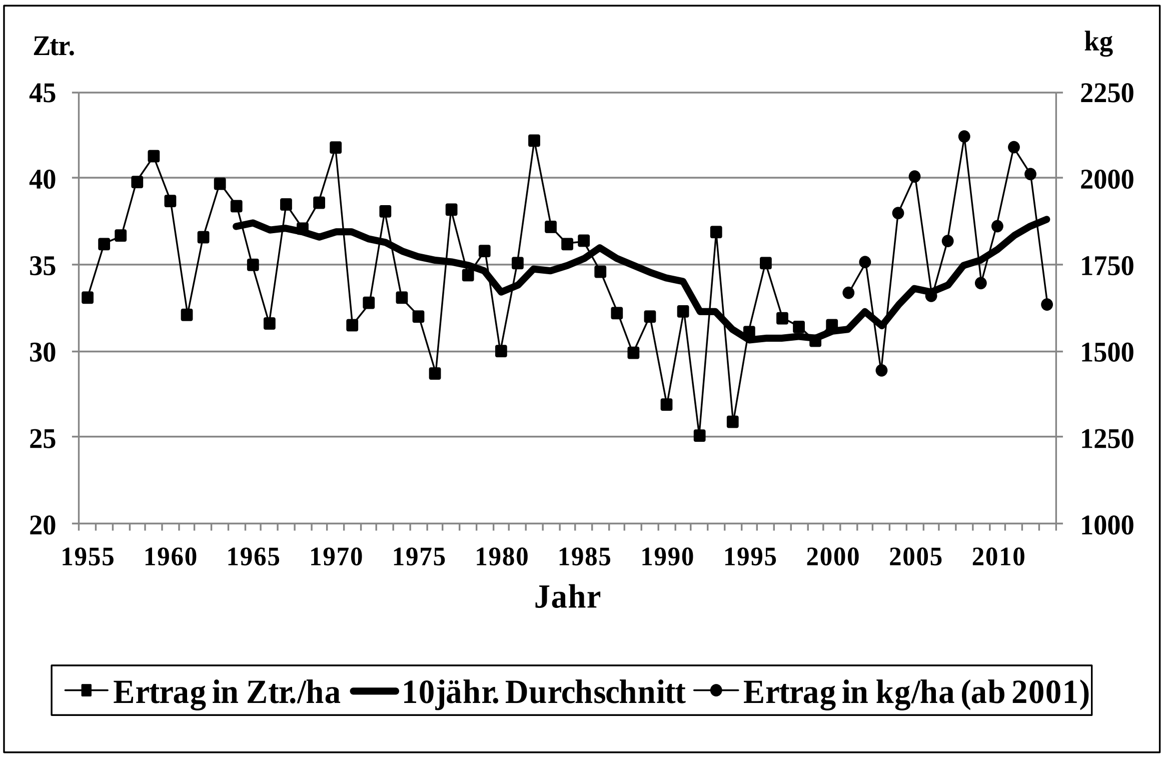

Fig. 3.5: Average yields (cwt. and kg/ha) in Germany

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

Region	Yields in kg/ha total acreage								
	2005	2006	2007	2008	2009	2010	2011	2012	2013
Hallertau	2,084	1,701	1,844	2,190	1,706	1,893	2,151	2,090	1,638
Spalt	1,518	1,300	1,532	1,680	1,691	1,625	1,759	1,383	1,428
Tettnang	1,405	1,187	1,353	1,489	1,320	1,315	1,460	1,323	1,184
Baden, Rhine-land-Palat. and Bitburg	1,881	1,818	2,029	1,988	1,937	1,839	2,202	2,353	1,953
Elbe-Saale	1,867	1,754	2,043	2,046	1,920	1,931	2,071	1,983	21,16
∅ Yield / ha **Germany**	**2,006 kg**	**1,660 kg**	**1,819 kg**	**2,122 kg**	**1,697 kg**	**1,862 kg**	**2,091 kg**	**2,013 kg**	**1,635 kg**
Total crop Germany (t and cwt.)	34,467 t 689,335	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
Acreage Germany	17,179	17,170	17,671	18,695	18,473	18,386	18,228	17,124	16,849

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

Region/Variety	2004	2005	2006	2007	2008	2009	2010	2011	2012	**2013**	∅ 5 years	∅ 10 years
Hallertau Hallertauer	4.3	4.4	2.4	3.9	4.4	4.2	3.8	5.0	4.6	**3.3**	**4.2**	**4.0**
Hallertau Hersbrucker	3.0	3.5	2.2	2.6	2.9	3.4	3.5	4.5	3.0	**1.9**	**3.3**	**3.1**
Hallertau Hall. Saphir	3.4	4.1	3.2	4.6	5.1	4.5	4.5	5.3	4.4	**2.6**	**4.3**	**4.2**
Hallertau Perle	6.4	7.8	6.2	7.9	8.5	9.2	7.5	9.6	8.1	**5.4**	**8.0**	**7.7**
Hallertau Spalter Select	4.9	5.2	4.3	4.7	5.4	5.7	5.7	6.4	5.1	**3.3**	**5.2**	**5.1**
Hallertau Hall. Tradition	6.3	6.3	4.8	6.0	7.5	6.8	6.5	7.1	6.7	**5.0**	**6.4**	**6.3**
Hallertau North. Brewer	9.8	9.8	6.4	9.1	10.5	10.4	9.7	10.9	9.9	**6.6**	**9.5**	**9.3**
Hallertau Hall. Magnum	14.8	13.8	12.8	12.6	15.7	14.6	13.3	14.9	14.3	**12.6**	**13.9**	**13.9**
Hallertau Nugget	10.6	11.3	10.2	10.7	12.0	12.8	11.5	13.0	12.2	**9.3**	**11.8**	**11.4**
Hallertau Hall. Taurus	16.5	16.2	15.1	16.1	17.9	17.1	16.3	17.4	17.0	**15.9**	**16.7**	**16.6**
Hallertau Herkules				16.1	17.3	17.3	16.1	17.2	17.1	**16.5**	**16.8**	
Tettnang Tettnanger	4.7	4.5	2.2	4.0	4.2	4.2	4.0	5.1	4.3	**2.6**	**4.0**	**4.0**
Tettnang Hallertauer	5.0	4.8	2.6	4.3	4.7	4.5	4.2	5.1	4.7	**3.3**	**4.4**	**4.3**
Spalt Spalter	4.4	4.3	2.8	4.6	4.1	4.4	3.7	4.8	4.1	**2.8**	**4.0**	**4.0**
Elbe-S. Hall. Magnum	14.0	14.4	12.4	13.3	12.2	13.7	13.1	13.7	14.1	**12.6**	**13.4**	**13.4**

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 most delicate 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 hereditary material of hop plants and in the identification of hop pathogens.

4.1 Traditional breeding

4.1.1 Crosses in 2013

A total of 99 crosses were carried out during 2013. Tab. 4.1 shows the number of crosses performed for each breeding goal.

Tab. 4.1: Cross-breeding goals in 2013

<table>
<tr><th>Breeding programme combined with resistance/ tolerance towards various hop diseases</th><th>Further requirements</th><th>Number of crosses</th></tr>
<tr><td rowspan="6">Aroma type</td><td>Traditional aromas</td><td>37</td></tr>
<tr><td>Special aromas</td><td>19</td></tr>
<tr><td>High beta-acid content</td><td>2</td></tr>
<tr><td>Verticillium tolerance</td><td>1</td></tr>
<tr><td>Pest resistance</td><td>1</td></tr>
<tr><td>Pest resistance + low-trellis suitability</td><td>3</td></tr>
<tr><td rowspan="5">High-alpha-acid type</td><td>Special aromas</td><td>9</td></tr>
<tr><td>High beta-acid content</td><td>4</td></tr>
<tr><td>Improved powdery-mildew (PM) resistance</td><td>21</td></tr>
<tr><td>Verticillium tolerance</td><td>1</td></tr>
<tr><td>Pest resistance</td><td>1</td></tr>
</table>

4.1.2 New hop breeding trend – Hüll special-flavor hops with floral, citrusy and fruity aroma nuances

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. US craft brewers, who prompted this expansion of traditional breeding programmes, remain the growth engine behind the USA's brewing industry. The number of breweries (over 2,720 at the end of 2013) is on the rise, as is the demand for hops that can be used to produce rich, hoppy and hence distinctive beers. So far, US hop farmers have been the main beneficiaries of this new trend and they have already adapted their hop production to the craft brewers' steadily increasing demand for special-aroma hops (Fig. 4.1).

This enthusiasm for special beers with exceptional aromas and flavors has now spread from the USA, via Canada, to Europe, where it has also caught on in Germany. German hop growers, too, will thus be able to tap into this booming market by growing the newly bred Hüll special-flavor cultivars.

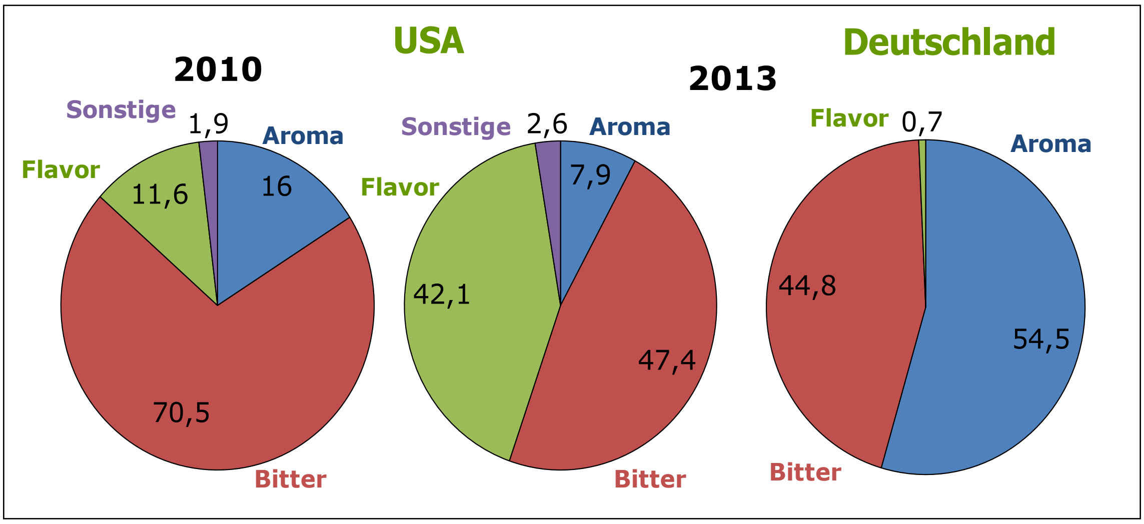

Fig. 4.1: Acreage shift away from aroma and bitter hops towards flavor hops in the USA between 2010 and 2013 and acreages under hop production in Germany in 2013. The variety range is much greater in the USA. Whereas five varieties account for 80 % of the acreage under hop production in Germany, 26 varieties are grown on the same share of the USA's total hop acreage.

Material and methods

Crosses performed specifically to achieve this breeding goal were initially based on the US Cascade variety in order to introduce fruity aroma notes into Hüll breeding material. In the course of further breeding work, Hüll breeding lines obtained from crosses with Cascade and other US material and characterised by fruity, exotic aroma nuances are now being used as well, the aim being to obtain new combinations of fruity, exotic and distinctive aroma nuances and disease resistance, good agronomic properties and traditional aroma notes.

Healthy, high-performance breeding lines which also show interesting aroma combinations were submitted for appraisal to experts in the hop and brewing industries, who tested them in numerous brewing trials.

The organoleptic aroma descriptions of the breeding lines and cultivars were rounded off by chemical analyses (performed by the IPZ 5d Work Group) of bitter content, essential-oil components and polyphenol content.

Results

This breeding programme has produced numerous new breeding lines. Although we do not currently expect to launch a further Hüll special-flavor variety, breeding activities continue. The GfH's newly appointed hop advisory committee, comprising 15 aroma experts representing hop trading enterprises, hop growers, brewers and related associations, and headed by our breeder, Anton Lutz, has submitted its aroma assessments of 13 new breeds with multifaceted fruity, citrusy, unusual and also traditional aroma notes. Although the hop samples harvested in 2013 were no longer fresh when submitted to the committee at the end of January and their aromas were suboptimal on account of adverse weather conditions in 2013, the committee members succeeded in arriving at conclusive appraisals for all 13 breeding lines. The panel of experts ranked the submitted breeds according to aroma, content (alpha- and beta-acid content, cohumulone and xanthohumol), disease resistance and agronomic performance, and communicated the results to the GfH's board members for decision-making purposes. On the basis of this specialist information and taking economic and strategic aspects into consideration, the GfH will decide which lines to propagate and test on larger acreages. Sufficient hop quantities for brewing trials will then be available to all interested parties at the same time. Two breeds ranked at the very top of the list thanks to their distinctive aromas and pronounced fruitiness.

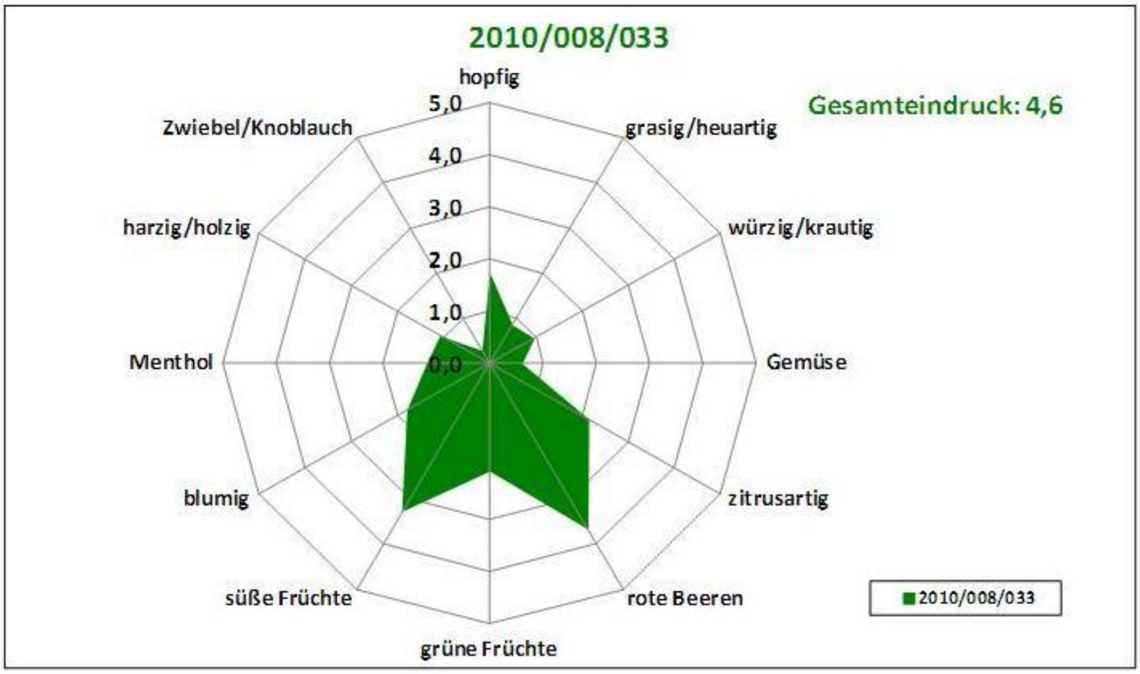

Fig. 4.2: Aroma profile of breeding line 2010/008/033, as assessed by the newly appointed advisory committee. The aroma of each breeding line was assessed on a scale from 0-5, which ranged from imperceptible through to very intensive. This new breed, which received the highest overall impression score (= averaged overall impression of all the aroma experts) of 4.6 on a scale from 0 to 5, was the most convincing.

4.1.3 Optimisation of greenhouse screening of seedlings for assessing hop tolerance towards downy mildew (*Pseudoperonospora humuli*)

Objective

Downy mildew, caused by the *Pseudoperonospora humuli* fungus, poses a huge, recurring challenge for hop growers. Although downy mildew infections were rare in 2013, 2009 and 2010 will be remembered for the severe primary and secondary infections that occurred in hail-damaged hop stands. Breeding to significantly improve hop tolerance towards downy mildew plays a major role in solving this problem. To permit timely selection of a large number of downy-mildew resistant seedlings, thousands of seedlings in trays are sprayed with a suspension of fungal spores in the greenhouse each year and subsequently screened for the disease. One of the shortcomings of screening in the greenhouse becomes evident when the exact level of tolerance or susceptibility needs to be assessed in individual plants. A further disadvantage of these mass screening conditions is the impossibility of ensuring that the same infection conditions prevail for all the seedlings (equal concentrations of spores, adequate wetting, no drying off in the tray-edge vicinity with concomitant termination of the downy mildew infection, etc.). For these reasons, work to optimise this greenhouse method of screening seedlings was commenced in 2013 as part of a student research project. The findings of Coley-Smith (1965), Hellwig, Kremheller and Agerer (1991), Beranek and Rigr (1997), Darby (2005), Parker et al. (2007), Mitchell (2010) and of Lutz and Ehrmaier (personal communication) were re-assessed and included.

Method

The eight-to-twelve-week old seedlings, which derived from four crosses with different genetic backgrounds, were growing in trays containing 35 individual pots. Most of the seedlings had five or more leaf nodes at commencement of the trial. The leaves were sprayed with a downy-mildew zoosporangia suspension until completely wetted with the fungal suspension. Once sprayed, the seedlings were immediately covered with transparent plastic bags. After 20 hours of exposure to very high humidity, the seedlings were uncovered. Four days later, the plants were sprayed with water and again covered with plastic bags. The seedlings were assessed and examined for downy mildew 5-7 days after initial inoculation.

Results

The findings obtained with this optimised seedling screening method were compiled in a Bachelor thesis (Jawad-Fleischer, 2013) in cooperation with Prof. Dr. Th. Ebertseder of Weihenstephan-Triesdorf University of Applied Sciences. The use of plastic film, in particular, which prevents the seedlings from drying prematurely following inoculation with the zoosporangia suspension and thus supports the downy-mildew fungal infection process, resulted in more comparable and hence more reliable assessment of the seedlings' tolerance towards downy mildew. Covering the seedlings meant that the same selection conditions prevailed both for hop plants at the tray edges, where the seedlings otherwise dry off more quickly, and for those in the middle of the trays. The intention is to use this optimised, albeit more labour-intensive, screening method as of 2014 for the routine screening of new seedlings in the Hüll plastic-film greenhouse. This new method is also intended to permit substantiated conclusions as to the downy-mildew tolerance of individual seedlings:

Within just five days of inoculation, susceptible seedlings showed dark lesions on the upper leaf surfaces. On the leaf undersides, a greyish-black coating of spores was visible, which developed a few days later into the chocolate-brown patches (necroses) typical of downy mildew. Depending on a seedling's degree of tolerance or susceptibility, 10 % to well over 50 % of the leaf surface was affected. There were even variations in the number of affected leaf nodes and the speed at which lesions formed within the offspring of a single cross.

Fig. 4.3: Greenhouse screening of seedlings for downy-mildew tolerance

4.1.4 Establishment of a detached-leaf laboratory assay

Objective

A further goal was to establish a largely standardised detached-leaf assay that would allow reliable and more accurate assessment of downy-mildew tolerance/susceptibility in the laboratory.

Results

Work on the development and optimisation of a detached-leaf assay commenced in 2012. The various trial parameters used in studies conducted in the USA, UK, CZ and, in particular, in Hüll by Dr. Kremheller during the 1970s and 1980s, were reviewed. Detailed information on the findings from these studies is currently being compiled in a Bachelor thesis (Jawad-Fleischer) and has already been published in a poster (Forster et al., 2013).

We plan to review various parameters again during 2014 and then to clarify the comparability of downy-mildew tolerance as estimated in laboratory assays with field data from hop farms. The new LemnaTec moving-field scanalyser installed at IPZ will be used in special instances, but not routinely, to obtain a more precise assessment of hop resistance/susceptibility towards downy mildew.

Our thanks go to Dr. Wouter Vahl from IPZ 2a for his assistance with this software.

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4.1.5 Monitoring for dangerous viroid and viral hop infections in Germany

Objective

The broad-based project aimed at monitoring for dangerous viroid and viral diseases in German hop-growing regions was continued in 2013, the main intention being to detect primary infection centres and clarify the way in which these pathogens are spread. Viruses and viroids, first and foremost the dreaded hop stunt viroid (HpSVd), are spread easily and rapidly by mechanical means, both within hop stands and from stand to stand. As infected hop plants frequently show no visible symptoms, these diseases often go unnoticed for many years, their potential to cause economic damage in the form of yield and alpha-acid losses only being revealed under stress-inducing weather conditions. As neither plant protectives for controlling viruses and viroids nor resistant hop cultivars are available, precautionary measures are the only effective way of curbing or preventing economic losses. Our virus and viroid monitoring activities are among such precautionary measures.

Methods

Work groups IPZ 5c and 5a were responsible for choosing the monitoring locations, organising the project and taking samples. The hop samples came from hop farms in the various hop-growing regions of Germany, from one of the Society of Hop Research's propagation facilities and from its breeding yards, and from the Hüll Hop Research Centre's international hop collection. Samples were preferably taken from plants with a suspicious appearance, which means that monitoring was selective and not random. Foreign hops intended for European Community DUS testing on Hop Research Centre land were also tested. These plants had been growing in a quarantine greenhouse in Freising until they were confirmed HpSVd-free by this test.

The samples were tested for HpMV, ApMV and ArMV via the DAS-ELISA method, using commercially available polyclonal antisera. The RT-PCR method was used to test for hop stunt viroid, using primer information from Eastwell und Nelson (2007). The RT-PCR method was also used to test for AHpLV because there are no commercially available antisera for this purpose. The primer sequences for HpSVd detection were kindly provided by Dr. Ken Eastwell (communicated personally to Dr. L. Seigner, IPS 2c, 2009). CVd IV was detected using the primer from Ito et al. (2002). To verify individual results, PCR bands were also sequenced. All the tests were conducted in the LfL's pathogen diagnostics lab (IPS 2c) in Freising.

Tab. 4.2: Table of the monitored viroids and viruses, arranged alphabetically, and the detection methods used

Viroid/Virus German name	Viroid/Virus English name	Abbreviati on	Detection method
Latentes Amerikanisches Hopfen-Carlavirus	American hop latent carlavirus	AHpLV	RT-PCR
Apfelmosaik-Ilarvirus	Apple mosaic ilarvirus	ApMV	DAS-ELISA
Arabis Mosaik-Nepovirus	Arabismosaic nepovirus	ArMV	DAS-ELISA
Hopfenmosaik-Carlavirus	Hop mosaic carlavirus	HpMV	DAS-ELISA
Hopfenstauche-Viroid	Hop stunt viroid	HpSVd	RT-PCR
Zitrusviroid IV	Citrus viroid IV	CVd IV	RT-PCR

Results

In 2013, 275 hop samples from the various origins (see Tab. 4.3) were tested within the framework of this virus and viroid monitoring project. Once again, hop stunt viroid was not detected. Even among hop plants growing in the vicinity of the infection centre discovered in 2010, where nine HpSVd-infected plants from the Hop Research Centre's international hop collection were immediately destroyed with glyphosate, not a single infection with this dreaded pathogen has since been detected. All samples were tested for HpSVd. Individual samples taken from hop farms fertilised for many years with compost were tested additionally for citrus viroid CVd IV, since in Slovenia, composted citrus fruit had been identified as having transmitted this viroid to hops. Where it occurred in combination with hop stunt viroid, citrus viroid, which was completely new to hops, led to massive yield and quality losses in Slovenia (Radisek et al., 2013). However, neither HpSVd nor citrus viroid was detected in these samples.

A very different picture emerges for the various virus infections, where incidence levels are massive. However, the situation appears worse than it actually is, because most of the samples from hop farms were taken from plants with a suspicious appearance.

No testing for HpLV was performed in 2013 on account of the project's limited budget. For one thing, this virus causes no apparent damage. For another, as testing in 2011 and 2012 showed, the virus is already very widespread in Germany, making its eradication appear impossible. For this reason, HpLV infections are simply tolerated.

Tab. 4.3: Overview of virus and viroid tests in 2013

Origin and nature of the 2013 sample material	Number of samples	RT-PCR			DAS-ELISA		
		HpSVd positive	CVd* positive	AHpLV positive	HpMV positive	ApMV positive	ArMV positive
Hüll breeding yard: mother plants	19	0	nt	6 (32%)	8 + (1) (47%)	8 (42%)	0
Hüll breeding yard: Stammesprüfung	7	0	nt	2 (29%)	0	0	0
Hüll breeding yard: cultivar yard	76	0	nt	43 (57%)	46 + (2) (63%)	33 (43%)	0
Hüll breeding yard: EU-registered varieties	29	0	nt	10 (34%)	16 (55%)	4 (14%)	0
GfH Hallertau propagation facility: mother plants	44	0	nt	5 (11%)	3 (7%)	2 +(1) (7%)	0
Elbe-Saale field crops: cultivars	4 + 10*	0	0 of 10*	0	2 (50%)	1 (25%)	0
Hallertau field crops: cultivars	34 + 2*	0	0 of 2*	1 (3%)	15 (44%)	8 (24%)	0
Tettnang experimental station and field crops: cultivars	10	0	nt	0	5 (50%)	4 (40%)	0
Foreign cultivars	40	0	nt	nt	nt	nt	nt
Total	**275**	**0**	**0 of 12**	**67 (29 %)**	**95 +(3) (42 %)**	**60 +(1) (26 %)**	**0**

*Samples taken from farms that use compost as a fertiliser; nt = not tested; (number) = weak infection signal

By contrast, HpMV and ApMV infections are not tolerated. They are regarded as being relevant both to quality and yield, especially if two or more viruses occur in combination. In light of the fact that no tests were performed for hop latent carlavirus in 2013 and, as already mentioned, this virus is widespread, the number of multiple infections is likely to be much higher. Hop growers were advised to dig up plants with ApMV and HpMV. A different approach is adopted in our Hüll yard despite very high levels of infection with ApMV, HpMV and AHpLV. For scientific reasons, namely to prevent any reduction in hop genetic diversity, we do not dig up hop cultivars and lines even if they have multiple virus infections. A similarly high level of infection was found in the hop collection of the Žatec Hop Research Institute.

However, when passing on mother plants to our propagation contractor and when setting up "Stammesprüfungen", "Hauptprüfungen" and field trials, we take the utmost care that only virus-free material is propagated and used. The dreaded ArMV, cause of nettlehead disease, was not detected at all in 2013.

In conclusion, it is important to emphasize once again that the Society of Hop Research's propagation contractor uses the findings of our monitoring activities to immediately eradicate all mother plants that have tested virus-positive, thereby guaranteeing a supply of healthy, virus- and viroid-free cuttings from this source. Testing by Dr. Seefelder furthermore guarantees these cuttings to be *Verticillium*-free.

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Appreciation

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

4.1.6 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. With new, more aggressive *Verticillium* races having been clearly identified in isolated regions of the Hallertau (Seefelder et al. 2009), a further aim of the research work on *Verticillium* in hop was to develop a molecular test that would obviate the need for protracted fungus cultivation. *V. albo-atrum* and *V. dahliae* are listed as harmful organisms (Council Directive 2000/29/29) and are regarded worldwide as high-risk pathogens. At the Hüll Hop Research Centre, testing for *Verticillium* before plant material is further propagated will have top priority in future. Since there are no plant protection methods anywhere in the world for combating *Verticillium* wilt, neither in hop nor in any other crops, a further focus of our research work was to test the suitability of various bioantagonists for preventing *Verticillium* infection in hop cuttings. Microorganisms, as biological adversaries of soil fungi, have already been well described (Berg et al. 2013).

Methods

Molecular detection of *Verticillium*

Prior to further propagation steps, hop bines from 325 mother plants (23 cultivars) grown in a propagation facility and 58 breeding lines from the Hüll Hop Research Centre were tested for latent *Verticillium* infection using the recently established molecular in-planta test (Maurer et al. 2013a). The multiplex real-time PCR assay developed as part of the research project permits 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).

Testing of bioantagonists

Four bacterial strains (*Burkholderia terricola* ZR2-12, *Pseudomonas poae* RE*1-1-14, *Serratia plymuthica* 3Re4-18 and *Stenotrophomonas rhizophila* DSM14405^{T}) from Graz Technical University's pool of antagonistic microorganisms were selected on the basis of their property descriptions and tested for their fungal defence effect in hops. To this end, the roots of Hallertauer Tradition hop plants were immersed in a bacterial suspension. After four weeks, colonisation was monitored by way of plating/re-isolation and CLSM (confocal laser scanning microscopy).

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 Centre breeding-line plants, one was found to have a latent *Verticillium* infection. 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.

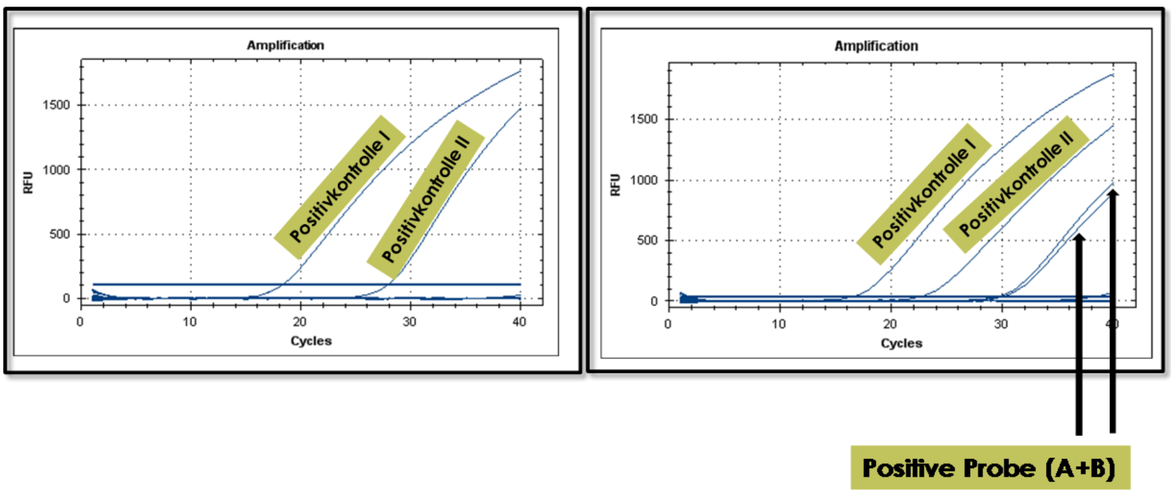

Fig. 4.4: Real-time PCR of a sample testing negative (left) and of one testing positive (right): of 385 samples, 384 tested negative and one positive (sub-samples A and B).

The bacterial colonisation studies (Fig. 4.5) were concluded and published (Maurer et al. 2013b) during the course of the research project. Successful bacterial colonisation is a prerequisite to using bacteria as biological control agents for combating *Verticillium* infections in the field. Initial trials are currently being conducted on 450 plants each of the Hallertauer Tradition und Hersbrucker Pure varieties.

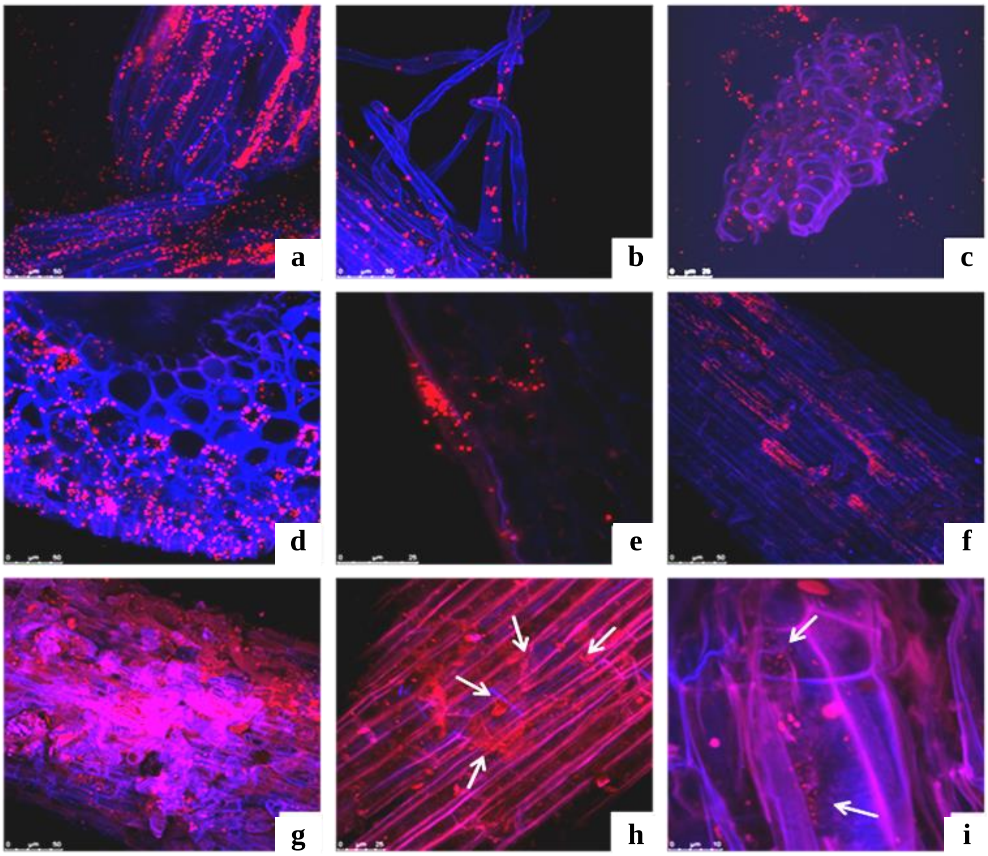

Fig. 4.5: Colonisation of hop roots 6-7 days post inoculation with various DsRed-labeled bacterial strains (red-fluorescent). ***(a)*** *B. terricola ZR2-12 shows high colonisation density on the root surface,* ***(b)*** *on root hairs and* ***(c)*** *on root tips.* ***(d)*** *B. terricola ZR2-12 also colonises the endorhiza and* ***(e)*** *forms a large number of colonies on the surface of the shoot axis.* ***(f)*** *P. poae RE*1-1-14 colonises root cells and* ***(g)*** *shows low-density colonisation of the root-hair surface.* ***(h-i)*** *S. plymuthica 3Re4-18 also formed small colonies in the root cells (see arrows), from Maurer et al. 2013b.*

Outlook

Even though very few hop stands showed wilt symptoms in 2013 on account of the extremely hot weather, the history of *Verticillium* wilt in the hop-growing countries England and Slovenia, as well as in Germany (1952 – approx. 1985), should be borne in mind. We must therefore advise against a premature all-clear for this dangerous disease in hop farming. 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.

It would therefore be advisable to revert to a selection system of the kind used by the Hüll Hop Research Centre until 1985, where breeding lines growing in pots are artificially infected with *Verticillium* isolates of known virulence, incubated for several weeks in shaded, fenced-off areas and then assessed for their *Verticillium* tolerance. This method has been used successfully for years in other European countries.

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5 Hop Cultivation/Production Techniques

LD Johann Portner, Dipl.-Ing. agr.

5.1 N_{min} test in 2013

The N_{min} nitrogen fertiliser recommendation system has become an integral part of fertiliser planning on hop farms. In 2013, 527 hop farms (50 %) in the Hallertau and Spalt growing areas of Bavaria participated in the N_{min} test, with 2,853 hop yards being tested for their N_{min} levels and the recommended amount of fertiliser calculated.

The table below tracks the numbers of samples tested annually for N_{min} since 1983. At an average 52 kg N/ha (2012: 74 kg), N_{min} levels in Bavarian hop yards in 2013 were at their lowest since commencement of N_{min} testing 30 years ago. The average recommended amount of fertiliser, which is calculated from the N_{min} level, was 167 kg N/ha and thus 10 kg N higher than in 2012.

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

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

Year	Number of samples	N_{min} kg N/ha	Fertiliser recommendtion kg N/ha
1983	66	131	
1984	86	151	
1985	281	275	
1986	602	152	
1987	620	93	
1988	1,031	95	
1989	2,523	119	
1990	3,000	102	
1991	2,633	121	
1992	3,166	141	130
1993	3,149	124	146
1994	4,532	88	171
1995	4,403	148	127
1996	4,682	139	123
1997	4,624	104	147
1998	4,728	148	119
1999	4,056	62	167
2000	3,954	73	158
2001	4,082	59	163
2002	3,993	70	169
2003	3,809	52	171
2004	4,029	127	122
2005	3,904	100	139
2006	3,619	84	151
2007	3,668	94	140
2008	3,507	76	153
2009	3,338	85	148
2010	3,610	86	148

Year	Number of samples	N_{min} kg N/ha	Fertiliser recommendtion kg N/ha
2011	3,396	76	154
2012	3,023	74	157
2013	2,853	52	167

The following 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 2013. It can be seen from the list that N_{min} levels are highest in the Spalt hop-growing area, in the area around Kinding and in the former hop-growing region in the Jura mountains. N_{min} levels in the Hallertau region south of the Danube were all around 50 kg N/ha.

Tab. 5.2: Number, average N_{min} levels and fertiliser recommendations for hop yards by administrative district and region in Bavaria in 2013

District/Region	Number of samples	N_{min} kg N/ha	Fertiliser recommendation kg N/ha
Eichstätt (plus Kinding)	203	76	158
*SD Spalt (minus Kinding)	76	75	137
*SD Hersbruck	50	67	151
Kelheim	1,080	50	169
Landshut	141	50	166
Pfaffenhofen	1,014	49	169
Freising	289	48	170
Bavaria	**2,853**	**52**	**167**

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

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

Tab. 5.3: Number, average N_{min} levels and fertiliser recommendation in 2013 for various hop varieties in Bavaria

Variety	Number of samples	N_{min} kg N/ha	Fertiliser recommendation kg N/ha
Herkules	503	50	183
Nugget	28	46	171
Hall. Magnum	436	48	169
Hall. Taurus	178	49	168
Hall. Tradition	529	53	165
Perle	535	53	164
Saphir	49	53	164
Spalter Select	106	60	162
Hersbrucker Spät	169	61	161
Hallertauer Mfr.	208	50	153
Northern Brewer	45	63	153
Spalter	39	66	139
Other	28	66	156
Bavaria	**2,853**	**52**	**167**

5.2 Morphological and anatomical examination of Humulus lupulus, Herkules cultivar

Objective

Within the framework of the DBU project "Optimisation of irrigation management in hop growing", water metabolism in hop plants is being closely investigated. As it is extremely difficult to make a generally valid statement within a period of only three years and field trials are exposed to uncontrollable weather conditions, additional strategies were pursued with the aim of investigating water uptake, which is closely linked to nutrient uptake. Water availability in individual plants can be estimated more accurately on the basis of morphological root studies. Such insights underscore the findings established in field trials. They are also of major importance when it comes to implementing an objective control system like the one planned with what is known as the "Geisenheimer model".

Anatomical studies provide additional information on transport paths, the proportion of vascular tissue in the overall plant and the distribution of photosynthetically active tissue. Vascular tissue is also the means by which active agents are distributed. Such information, combined with gas-exchange measurements, makes it easier to comprehend assimilation and transpiration rates.

Material and methods

The morphologcal investigation of the Herkules root system was performed at a sandy-soil location near Neustadt on the Danube. This soil has the following composition at a depth of 0.3-0.6 m :

Clay (< 0.002 mm):	3.22 %	(± 1.38 %)
Silt (0.002 - 0.063 mm):	4.23 %	(± 1.6 %)
Sand (0.063 – 2.0 mm):	92.55 %	(± 2.72 %)

The topsoil or A horizon, which extends to a depth of approx. 40 cm, has a high proportion of humus.

The roots were exposed on July 23rd, 2013, at the commencement of generative growth (BBCH Code 65). To this end, a mini skid loader was used to dig a 3.2 x 3.2 - m ditch, 1.6 m deep, around an average, irrigated hop plant. The roots were exposed carefully, starting from the north side, and documented with photographs. A morphological drawing was then prepared on the basis of photos and on-site measurements, and these were used to calculate the soil volume taken up by the roots. This necessitated taking the zone jointly rooted by neighbouring plants into account and adjusting the results accordingly.

For the anatomical investigation, various parts of a non-irrigated plant were collected on August 2nd, 2013, prepared with a razor blade and processed via customary methods (fixation in formaldehyde, dehydration, embedding in historesin, block insertion and cutting of 8-µm microtome sections) for examination under the microscope. The sections were stained with ACN, toluidine blue or Lugol's iodine, depending on the specific substances or structures to be made visible.

Results

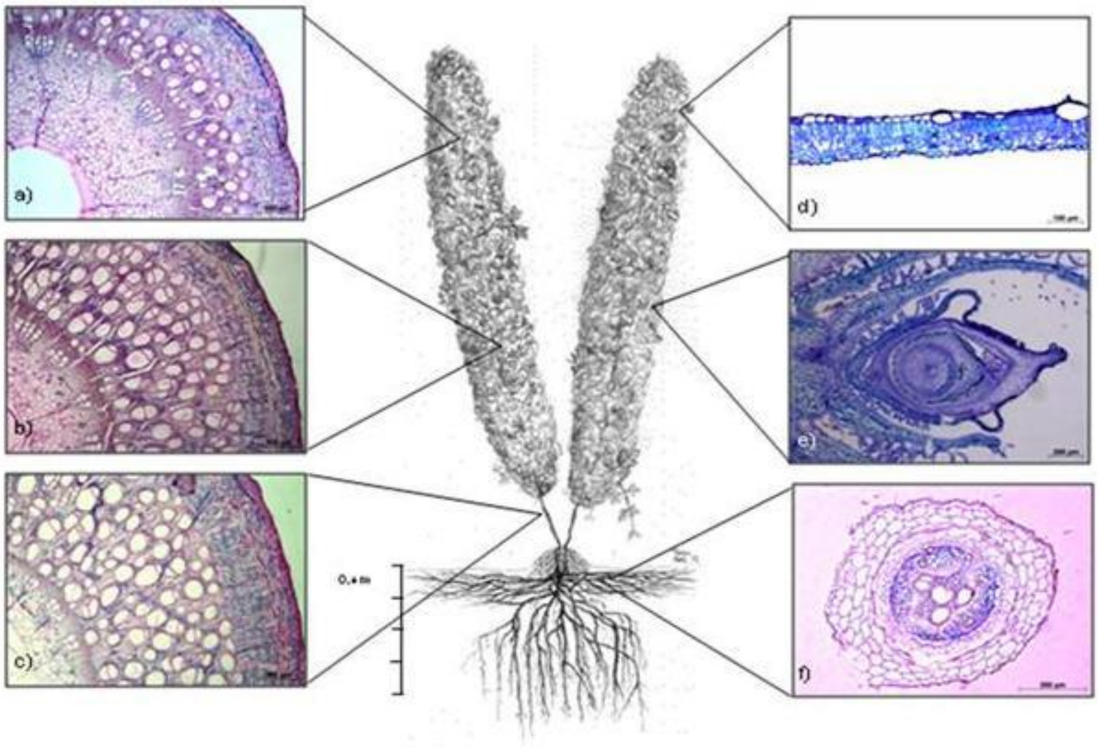


Fig. 5.1: Humulus lupus (Herkules cultivar) in the 6th year after planting; scaled lateral view of an irrigated plant growing on sandy soil and representative, 8-µm histological sections showing the following structures in cross-section: a) shoot, plant top b) shoot, plant middle c) shoot, plant bottom d) leaf, plant top e) ovary with cut lupulin glands (trichomes) f) fine root. (Staining techniques:toluidine blue: d) and e), otherwise ACN).

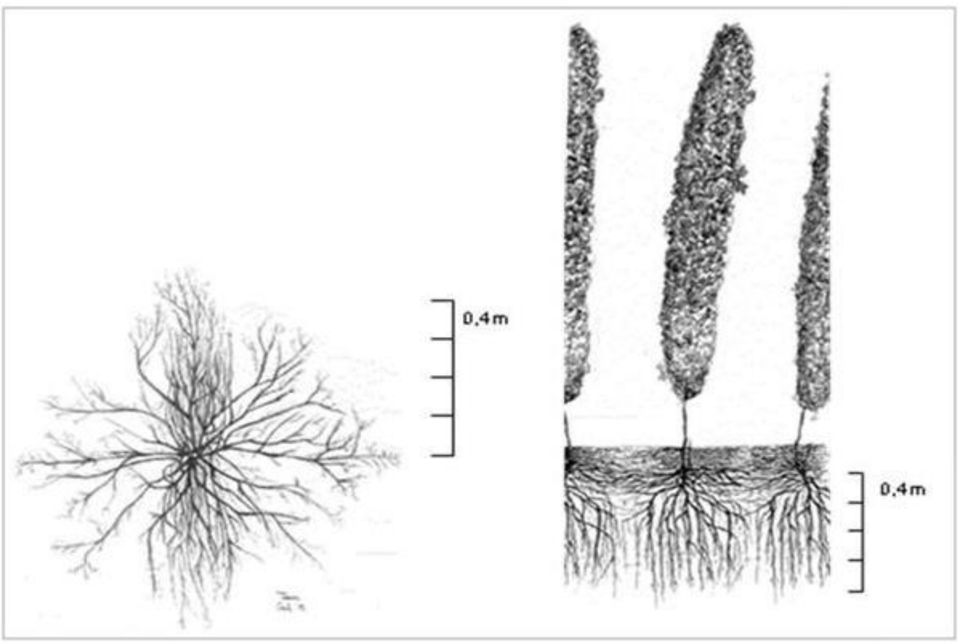


Fig. 5.2: Humulus lupulus (Herkules cultivar) in the 6th year after planting; top view and row view of the root system, with scale.

The root system is divided into three parts: hilled-row roots, roots occupying a plate-like area around the rootstock and a downwards-oriented root block. The latter two areas contain both first-year and older roots, while the hilled row has only first-year roots connected directly to the shoot axis. At the site of the investigation, the roots penetrated a soil volume of 4.59 m^3. The histological sections show large numbers of xylem vessels, with diameters of up to 300 µm. The leaves feature very dense intercellular spacing, a property common to all the plant leaves irrespective of how high up they are on the plant.

Implications and outlook

The plant’s potential to take up water from the soil and distribute it throughout the plant is very high. It is our intention to directly compare specific structures, particularly intercellular spaces in the leaves, in irrigated and non-irrigated hop plants in order to detect plant adaptations to water stress. In addition, we plan to expand the description of the rooting system to include other types of soil and other hop varieties, and thus to obtain more detailed insights into water and nutrient uptake.

5.3 Preserving optimum quality by optimising air speed in belt driers

Initial situation and objective

It has been shown in trials aimed at optimising hop drying that in belt driers, as in floor kilns, selecting the correct air speed relative to cone depth and drying temperature has the greatest influence on drying performance in kg dry hops/m^2 drying surface/h drying time.

If, on a harvesting day, hop samples are taken at defined intervals on termination of belt drying, the external quality of the freshly dried hop cones is often found to vary greatly, although the air speed selected is ideal in terms of drying performance. The reason for this is that the drying properties of green hops change continually as a function of weather conditions, ripening time, growing conditions and moisture content on the top drying belt. Quality deficits can occur within a very short time and are visible on termination of drying in the form of a lack of gloss and a change in typical cone colour. The cones may even turn brownish. In the hop industry, the terms “tainted cones” or “discolourations” are used. They indicate that the water extracted during drying was not sufficiently removed from the surface of the cones.

The plan is, therefore, to perform small-scale drying trials aimed at determining the drying temperatures and air speeds at which external quality is best preserved.

Fig. 5.3: Small-scale drying-trial setup (left) and weighing device (right) for measuring water extraction during drying

Method

A special small-scale drier was kindly provided by Hans Binder, Maschinenbau GmbH for the drying trials. Green hops were dried in a container with a perforated metal bottom through which drying air flowed. Temperatures could be adjusted steplessly between 50-85 °C, and air speeds between 0.1-1.1 m/s, depending on the specific parameter under investigation. This enabled selection of any ratio between the drying parameters, i.e. cone depth, drying temperature and air speed, found in practice on the top drying belt of a commercial belt drier.

During drying, the temperature, in °C, the relative humidity, in %, and the absolute humidity, in g/kg, of the incoming drying air and the waste drying air were measured and charted in real time.

Absolute humidity is the water (vapour) content of the air. The amount of water extracted from the hop cones in the drier was weighed and the optimal water content determined.

The drying variants differed, for the same initial cone weight, in terms of the drying temperatures and air speeds used during the first 40 minutes of drying. The trial samples were then dried under uniform conditions to a uniform end weight in further small-scale driers, at a drying temperature of 65 °C and an air speed of 0.35 m/s.

Results

Water extraction from the cones was measured very reliably via the absolute humidity of the waste drying air in g/kg. Most of the water was extracted during the first 10-15 minutes of drying. Under the drying conditions of this trial, deterioration in quality was already evident as from an absolute humidity of 18 g/kg waste drying air. The more water vapour the waste air contained, i.e. the longer this high content prevailed, at the time of maximum water extraction, the poorer was the external cone quality. As the water-uptake capacity of the air increases with rising temperatures, the drying temperature cannot be increased arbitrarily. Increasing the air speed during this drying stage resulted in distinct quality improvements at all temperatures and also improved drying performance.

It was shown in the different trial variants that colour loss and "tainting" of the cones occurred predominantly during the first 10-15 minutes of drying, the reason being that the air speed was too low for the drying temperature at the time of maximum water extraction from the cones. The highest quality was obtained by selecting drying temperatures of 62-65 °C and increasing the air speed sufficiently to prevent the water-vapour content of the waste drying air, i.e. its absolute humidity, from exceeding 18 g/kg. In the trial, this required air speeds of 0.5-0.8 m/s.

Air-speed control via the absolute humidity, in g/kg, of the waste drying air is a new control option. The plan is to confirm this finding during the 2014 harvest in further trials conducted in small-scale driers and to implement it during belt-drier optimisation on commercial hop farms.

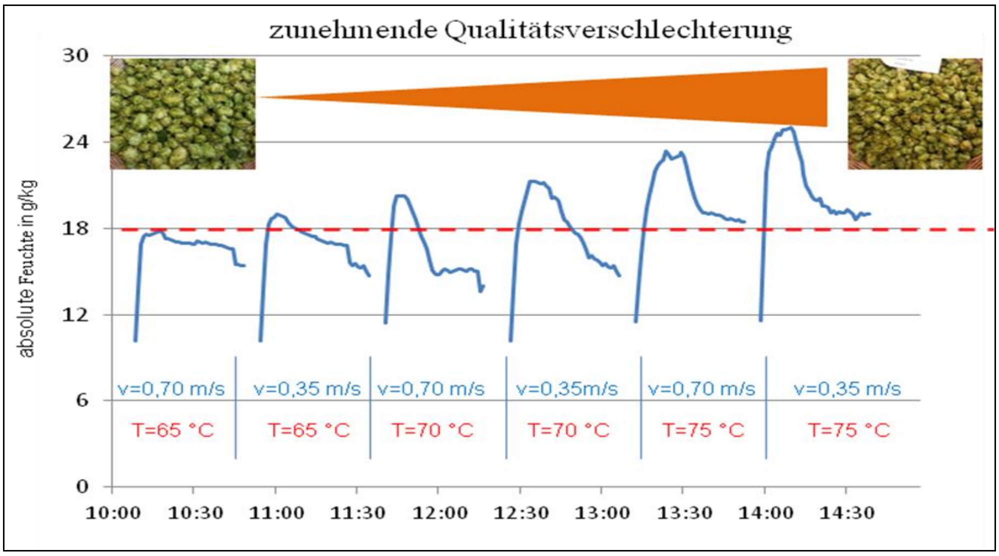


Fig. 5.4: Absolute humidity, in g/kg, of waste drying air during the first 40 minutes of drying at different drying temperatures and air speeds

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 launched a programme to collect, record and evaluate representative yield and quality data for selected agricultural crops from 2009 to 2013. This task was 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 aims of the hop projects are described briefly below and the results summarized and evaluated.

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

"Alpha-Express"

During each harvest, approx. 600 freshly harvested hop samples were analysed for alpha-acid content on the day of harvesting. The daily measurements provided valuable information on alpha-acid levels in each crop year and on harvest maturities of the hops, and the information was used to issue recommendations.

The plan for a follow-up project is to replace the random analyses performed hitherto by a selective monitoring program involving regular alpha-acid analyses. The weekly dry-matter and alpha-acid measurements will then provide insight into harvest maturities of the major hop cultivars, allowing recommendations to be made concerning ideal harvesting times. The inclusion of location- and production-related data will enable regional differences to be explained more easily.

Neutral Quality Assessment Procedure (NQF) results

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.

In future it is planned to supplement the neutral quality assessments of 150 lots of major cultivars with the corresponding 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.

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

Representative, real-time and accurate assessments of and investigations into disease and pest infestations are necessary in order to provide advice and develop control strategies. The relevant results are provided by the Hop Producers' Ring, which monitors aphid, spider-mite and virus infestation.

Aphid and spider-mite monitoring has proved very useful for assessing infestation levels and epidemiological pest development, and it is imperative that it be continued. In this context, two additional infestation assessment dates are planned in order to provide more accurate information concerning infestation commencement and termination.

Virus infestation:

For three years, the Institute for Plant Protection (IPS 2c) and the Hops Department of the Institute for Crop Science and Plant Breeding (IPZ) have been conducting a joint viroid- and virus-monitoring project. Here too, suspicious-looking commercial hop stands are examined for virus infestation and these results can thus also be used to assess infestation levels in hop yards. Continuation of virus monitoring in collaboration with the Hop Producers' Ring was therefore considered no longer necessary.

5.4.3 Maintenance of Adcon weather stations for forecasting downy mildew in hop crops

The downy-mildew warning service for hop growers is essential for economic and ecological reasons. Meteorological and biological data from various locations are required for reliable diagnosis of infestation probability. The formula known as the "Kremheller model", which is based on biological data (zoosporangia counts) as well as weather parameters (leaf wetting), has been used to forecast infestation probability for 30 years now. Other models, based exclusively on the weather, have also been used for many years. These include the Adcon model, which calculates an infestation probability index. The aim of this project was to compare the two models at selected forecasting locations and to establish, for the Adcon model, suitable threshold values for generating spray warnings for susceptible and tolerant varieties.

Within this project, it was the task of the Hop Producers' Ring to set up, service and operate Adcon weather stations at the seven downy-mildew forecasting locations in the hop-growing regions (five in the Hallertau region, one in Spalt and one in Hersbruck). Weather-related data had to be evaluated daily and a probability index for downy-mildew outbreak calculated. This index was needed at the LfL's three scientific-test sites for comparing secondary downy-mildew control according to the Kremheller early-warning model with control according to the Adcon weather model.

The results and implications of the model comparison are described in detail in the following report.

5.5 Testing of an Adcon weather model for the downy mildew warning service

Initial situation and objective

To forecast the probability of a downy mildew outbreak by means of the LfL's Kremheller model, the number of zoosporangia is determined daily from May through August with spore traps at five locations in the Hallertau, one in Spalt and one in Hersbruck. If a given threshold is exceeded and the weather conditions are favourable for the pest, a regional spray warning is issued, which varies according to variety. In other hop-growing areas such as the Elbe-Saale region and the Czech Republic, the early-warning forecast is based purely on weather models. Infection potential is ignored.

The 6-year trial was intended to determine the extent to which the time-consuming and labour-intensive counting of zoosporangia at the spore-trap locations is necessary. To this end, the index calculated by the Adcon weather stations was compared with the warnings based on the Kremheller model in order to establish suitable thresholds for the weather-based Adcon model in the Hallertau region. A further plan was to perform scientific tests in which susceptible and tolerant hop varieties were treated according to the spray warnings triggered by each of the two models and the harvested cones then examined for infestation.

Method

The forecasting model devised by Dr. Kremheller in 1979 is based on the four-day total of the zoosporangia counts. A spray warning is triggered if given threshold values for tolerant and susceptible varieties are exceeded and it has rained for at least four hours each day. Dr. Kraus (Hüll, 1983) refined this model by taking the effective lifespan of zoosporangia, as a function of relative humidity, air temperature and effective leaf wetting, into account (eZs). Formulating the forecasting data is lengthy in each case, requiring approx. three hours' work per station and day. By contrast, models based purely on the weather can be largely automated and are less labour-intensive. The Adcon model tested over the six trial years is based exclusively on weather parameters and calculates a daily index by taking daytime leaf wetting and temperature into account. The Adcon weather stations were operated during the project by the Hop Producers' Ring, who provided daily weather data and index values for the various downy-mildew stations. At the start of the trial (2008-2009), preliminary index-based thresholds of 0.20 and 0.16 were set for tolerant and susceptible culitvars, respectively, for generating spray warnings. During May, zoosporangia counts and primary downy-mildew infestation pressures were also taken into account. A follow-up spray warning was issued at the earliest on the 7th or 8th day after the preceding treatment. In 2010, building on the experience gained with the Adcon model during the first two trial years, the preliminary index-based thresholds for a downy-mildew spray warning were adjusted in order to make a distinction between "prior to flowering" and "as of flowering". The threshold is now exceeded if the following index values are reached: prior to flowering, 0.20 for susceptible and 0.25 for tolerant cultivars; as from commencement of flowering, 0.18 for susceptible and 0.22 for tolerant cultivars. The thresholds, being a function of vegetation, are usually lowered from the "prior to flowering" values to the "as of flowering" values during the first half of July.

<u>Index formula for the Adcon model</u>

$I = -0.275 + 0.044\ RWD + 0.012\ T$

Key to index :

I	Index
RWD	Rain Wetness Duration (= leaf wetness caused by precipitation) between 4 a.m. and 5 p.m.
T	Time in hours during which the temperature is between 15 and 22 °C.

The following additional parameters apply to index calculation:

- The index is calculated every day anew
- The calculation period is always from 5 p.m. to 5 p.m. the next day
- The average air temperature during the calculation period (24 h) must not be lower than 8 °C and not higher than 29 °C.
- Once the RWD (leaf wetness due to precipitation) has been interrupted, subsequent leaf wetness (not due to preciptation) is no longer taken into account.

The limiting index value, as defined by the algorithm, is 0.2.

It assumes values between -0.2 and 1, with negative values indicating no infection risk and 1 a very high risk.

Trial design

Trial plots for scientific monitoring were marked out at three forecasting stations on hop farms and treated separately according to the spray warnings triggered by each of the two models. Each trial plot had a breadth of six hilled rows. The trial plots were sited in the immediate vicinity of the spore trap at each forecasting station, which meant that the LfL plots could be treated precisely in accordance with spray warnings.

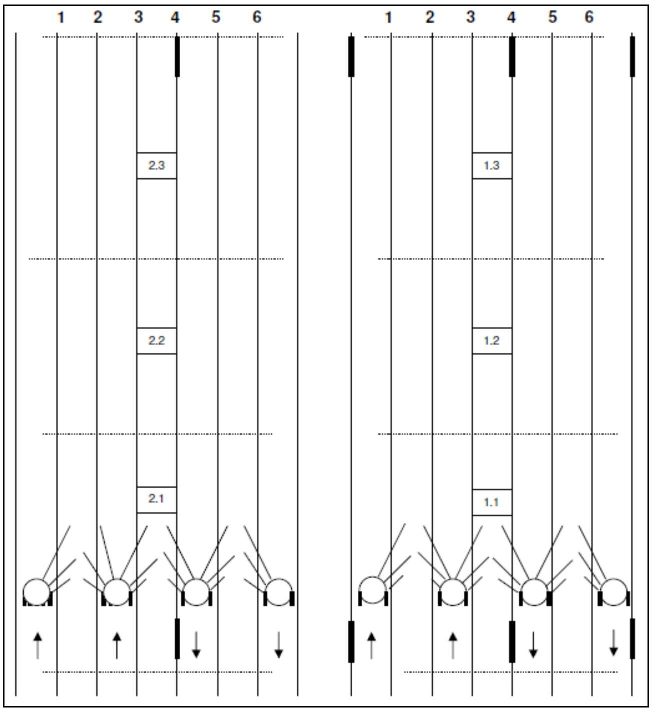


Fig. 5.5: Diagram of the trial design, showing the Adcon trial blocks (2.1-2.3) and the LfL blocks (1.1-1.3). The arrows indicate the direction of travel for downy-mildew control spraying.

<u>Trial locations and cultivars</u>

Eschenhart 2009 – 2012:	Hallertauer Magnum (HM)
Aiglsbach 2008 – 2013:	Hallertauer Tradition (HT), Hersbrucker Spät (HE)
Speikern (Hersbruck) 2008 – 2013:	Spalter Select (SE);
2008 – 2009:	Brewers Gold (BG);
2010 – 2013:	Hersbrucker Spät (HE)

Flowers were usually assessed for infestation levels in early August and cones towards the end of August, shortly before harvesting, the exact times depending on weather patterns and development stages. Thrice-replicated blocks of hop plants growing up the five innermost training wires in each plot were assessed. This meant that each trial plot was assessed according to the requirements of the official pesticide efficacy test, with two people assessing the upper, and two the middle, portion of the plant. Cone samples were collected during harvesting from these 30 hop plants from the thrice-replicated blocks assessed in the field, dried and examined for infestation. In this assessment, approx. 500 cones from each sample are viewed and diseased cones classified as slightly, moderately or severely infested with downy mildew. The weighted average is then calculated according to a key specified by the official pesticide efficacy test.

Results

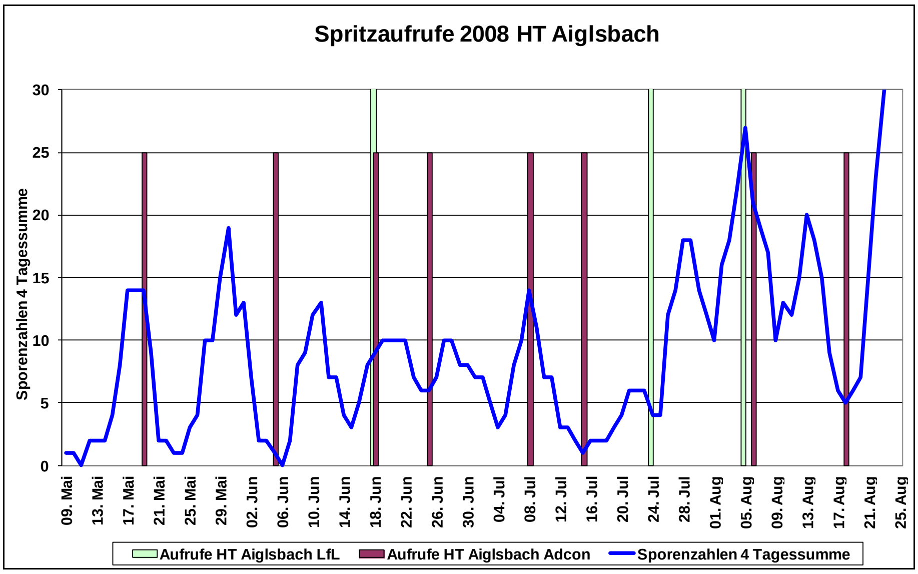


Fig. 5.6: Downy-mildew spray warnings for Hallertauer Tradition at Aiglsbach in 2008

Despite the LfL plot having received only three spray treatments in 2008, compared to eight in the Adcon plot, no infestation was detected during the field assessment or in the harvested cones. With a total of eight treatments in 2009, the Adcon plot again received three more than the LfL plot with five. Once again, there were no visible differences in the results. At the other two locations, in Eschenhart and Speikern, the Adcon model also generated considerably more spray warnings than the LfL's warning service, both for tolerant and susceptible varieties.

In light of the experience gained with the Adcon forecasting model in 2008 and 2009, the preliminary index-based threshold for a spray warning was raised as from trial year 2010 to "prior to flowering" values of 0.20 and 0.25 for susceptible cultivars and tolerant cultivars, respectively, and to "as of flowering" values of 0.18 and 0.22 for susceptible and tolerant cultivars, respectively.

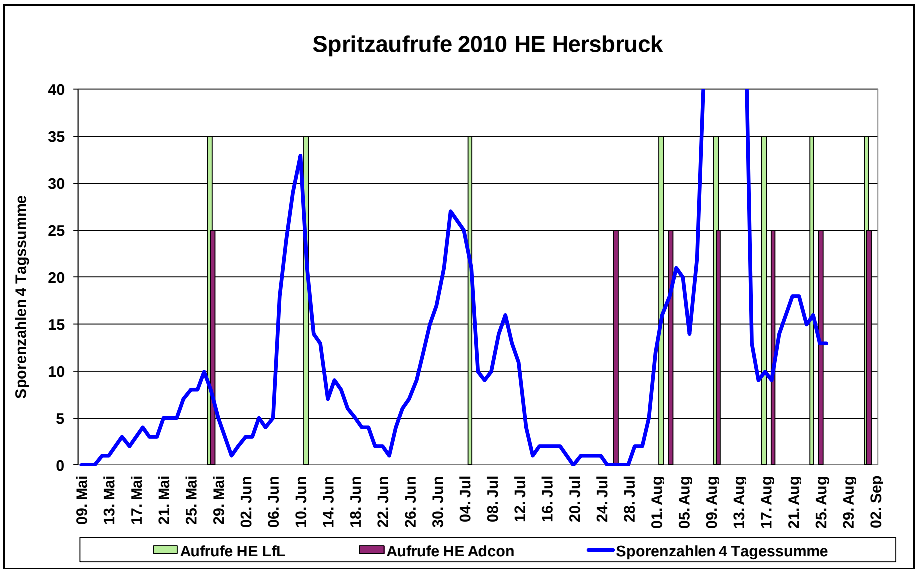


Fig. 5.7: Downy-mildew spray warnings for Hersbrücker Spät at Speikern (Hersbruck) in 2010

Despite rain on two days in the period from 6th – 10th June 2010 and several hours' leaf wetting daily, the Adcon model did not trigger a spray warning at the Speikern location. Around July 4th 2010, leaf wetting of several hours was recorded but the threshold value was not reached on account of insufficient rain. The control threshold as per zoosporangia count was exceeded by far in both cases (Fig. 5.7). By contrast, the Adcon model generated a spray warning on July 24th (index value 0.19), although spore dispersal at this point was almost zero.

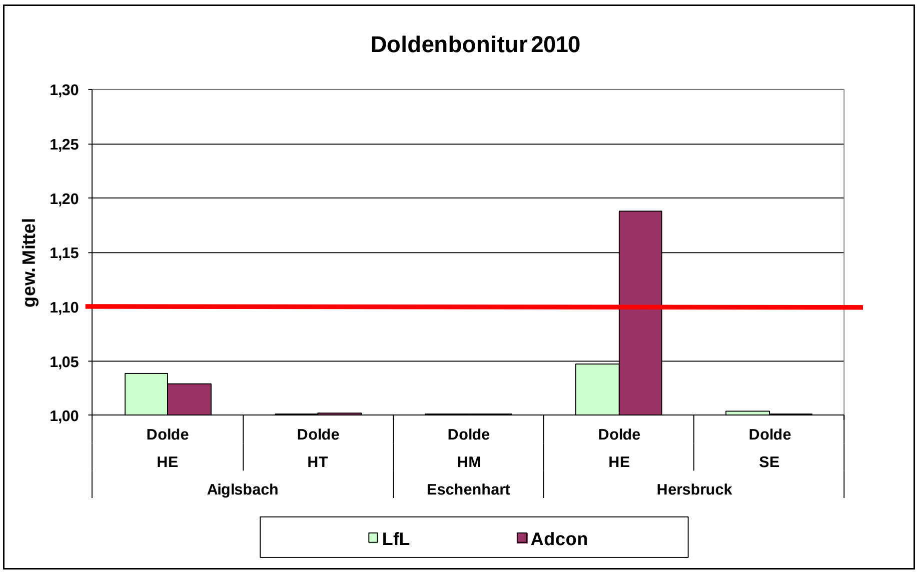


Fig. 5.8: Results of cone assessment at the trial locations in 2010

The results of the Adcon-plot cone assessment in 2010 clearly demonstrates the potential danger that arises when no spray warning is triggered although the zoosporangia count exceeds the threshold and leaf wetness is also correspondingly high. NFQ price reductions are probable as from an index of 1.1 (as per weighted average).

In 2010, a catastrophic downy-mildew year following the widespread hail of 2009 in the Hallertau, the Adcon model responded with a delay of 11 days at Hirnkirchen and not at all at Haushausen.

At Hirnkirchen, the Adcon control index was not exceeded until Friday, 4th June, although the zoosporangia count had exceeded the control threshold as from 24th May and heavy rain on eight consecutive days as from 26th May had wetted the hop leaves for several hours each day. The Aiglbach location witnessed 13 days of precipitation, with several hours of leaf wetting each day, between 15th May, the last time the Adcon model had rersponded, and 3rd June. The Adcon model did not respond again during this period. Here too, the spore dispersal threshold for susceptible cultivars had already been exceeded on 26th May. The situation was similar at Eschelbach.

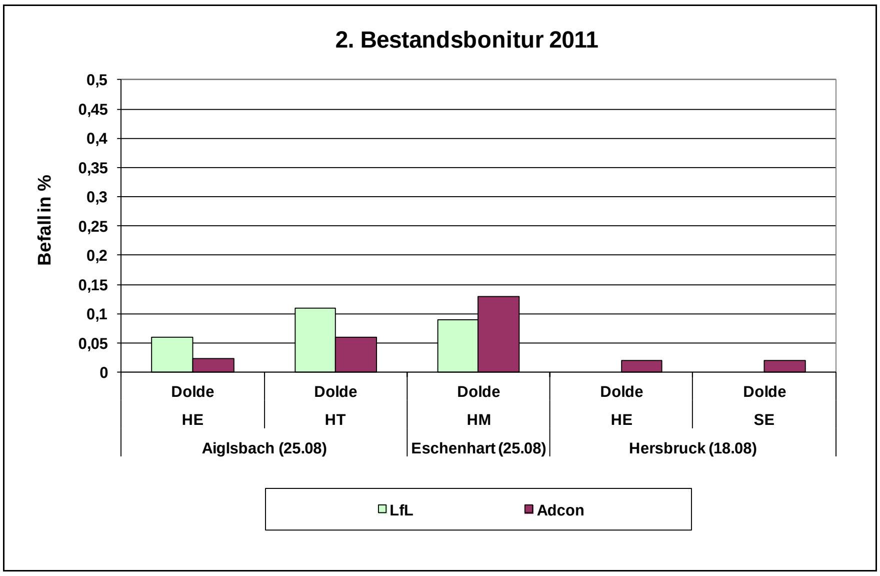


Fig. 5.9: Results of hop-stand assessment at the trial locations in 2011

The hops stands were usually assessed twice – as a precaution at the time of flowering in early August and then again shortly before harvesting. No significant differences between the two models were apparent from these hop-stand assessments.

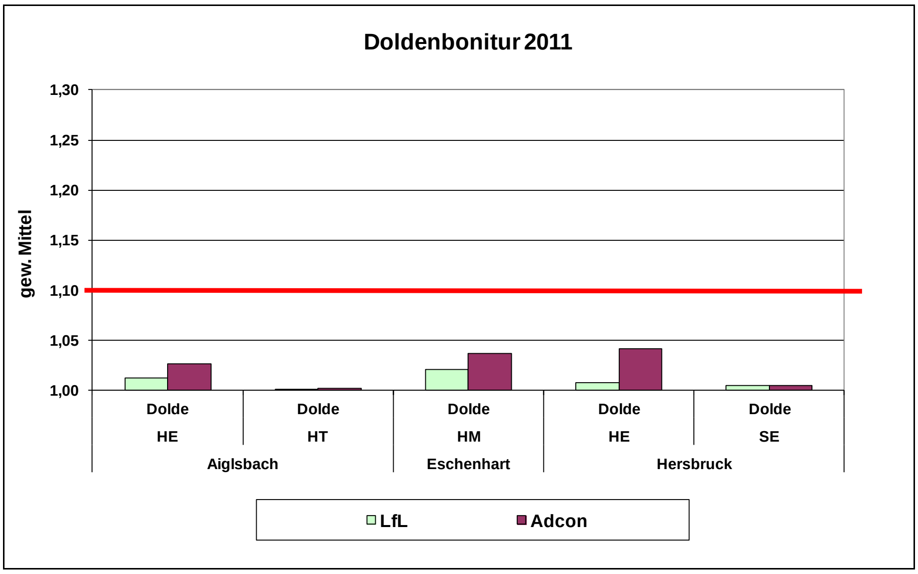


Fig. 5.10: Results of cone assessment at the trial locations in 2011

No differences were apparent from the cone assessments, either, except in 2010 (see above). All the results were below the weighted average of 1.1 and there was no quality impairment.

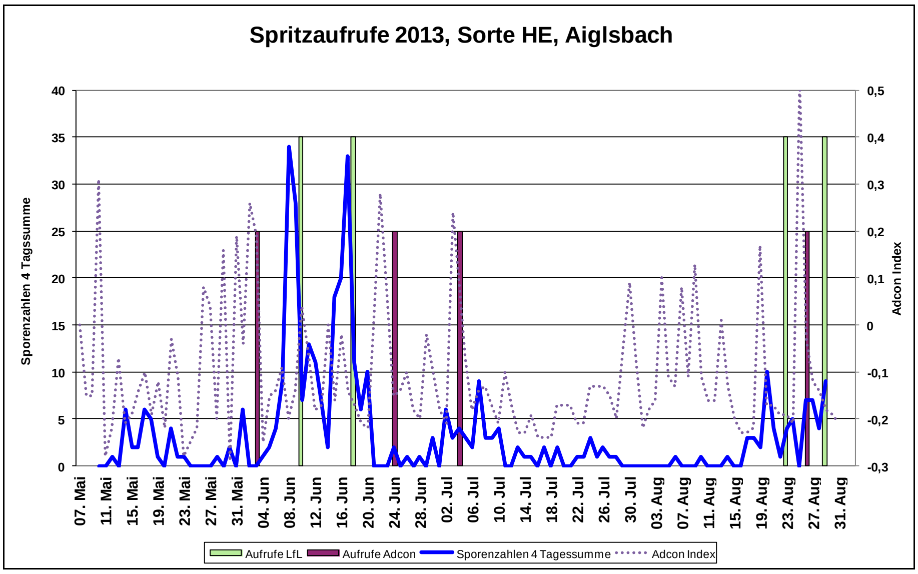


Fig. 5.11: Downy-mildew spray warnings for Hersbrucker Spät at Aiglsbach in 2013

The Adcon warnings on 24th June and 4th July 2013 were generated at Aiglsbach at times when spore dispersal was low, thus precluding any risk of downy-mildew infection. At the end of the season, the LfL's warning service generated spray warnings on 23rd and 29th August. (I've added LfL for clarity's sake) The Adcon model generated only one warning, on 28th August. The above chart shows clearly that the LfL warnings were triggered when the spore-dispersal control threshold was exceeded.

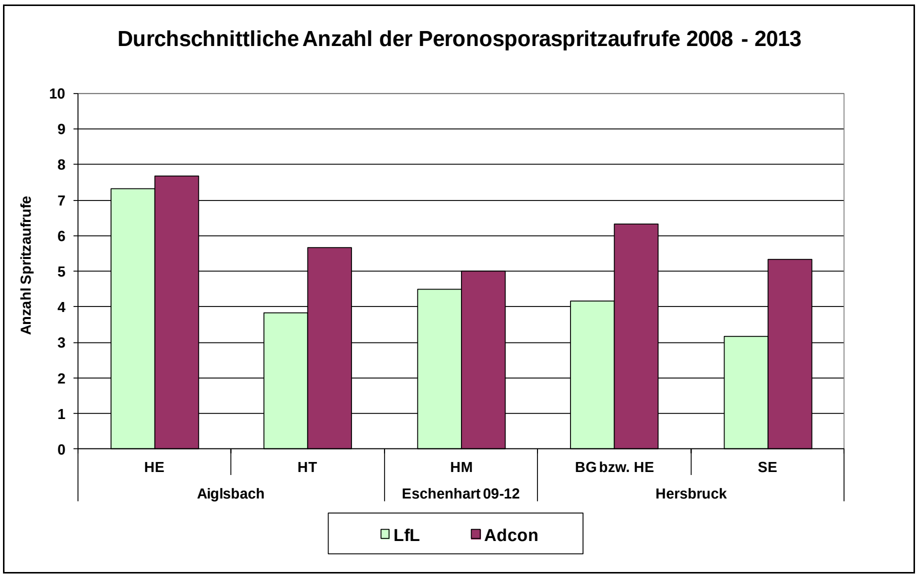


Fig. 5.12: Average number of downy-mildew spray warnings generated 2008 – 2013 by the Kremheller (LfL) and Adcon models, by cultivar and location

The chart shows that the Adcon model generated a higher number of spray warnings, averaged over all six years, for both tolerant and susceptible varieties at all the trial locations, necessitating up to two additional treatments for some varieties.

Since the Adcon model is, moreover, based purely on the weather and does not measure spore dispersal, the infection risk is greater at locations with high initial infestation and therefore a relatively high infection potential.

The Adcon model is also problematic during prolonged rainy periods as the warning index may exceed the control threshold throughout the wet weather; a long rainy period, however, does not automatically mean a high zoosporangia count and hence a high infection probability.

The number of spray warnings generated by the Adcon model decreased at almost all the trial locations after the index value had been adjusted but, in most cases, still called for 1-3 additional sprayings compared to the Kremheller model.

Discussion

Whereas an increase in the risk of downy mildew, as indicated by rising zoosporangia counts, is usually foreseeable with the Kremheller model, the index is exceeded very spontaneously with the Adcon model and is strongly dependent on longish periods of rain. Preventive warnings (e.g. before the weekend or before longish periods of rain) are therefore not possible with the Adcon model. The difficulties of monitoring, inspecting and servicing the weather stations proved an additional disadvantage, as the information is transmitted by radio and the stations are not visited daily as with the Kremheller model. As a result, erroneous data transmissions, particularly those relating to the important leaf-wetting sensor, frequently went unnoticed for a while during the trial period and greater susceptibility to failure was experienced.

The fact that the Adcon model forecasts infection probability independently of pest infestation pressure (zoosporangia count) partially explains the higher number of spray warnings. The Kremheller model, by contrast, only triggers a warning if the zoosporangia count is sufficiently high, even if the weather is favourable for the pest. The Kremheller model is thus more successful than the Adcon model when it comes to achieving the goals of integrated plant protection and the national campaign for a lasting reduction in the use of plant protection products. In the opinion of the government hop consulting team from the LfL, it is therefore imperative that biological monitoring (counting of zoosporangia) be continued as part of the downy-mildew warning service.

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 2010 are summarized below:

Written information

- The 2013 “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. 2,490 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.
- 29 of the 61 faxes sent in 2013 (53 for the Hallertau region + 5 for Spalt + 3 for Hersbruck) by the Hop Producers’ Ring to 1,047 hop growers contained up-to-the minute information from the work group on hop cultivation and spray warnings.
- 2,853 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 6 monthly issues of the Hopfen Rundschau.
- 190 field records on the 2013 hop harvest were evaluated by two working groups 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 Hop Cultivation/Production Techniques work group (Wolnzach) and the Plant Protection in Hop Growing work group (Hüll) and updated 76 times during the period from 10.05 to 30.08.2013, was available via the answerphone (Tel. 08442/9257-60 and 61) or via the internet.
- Consultants from the Hop Cultivation/Production Techniques work group answered around 2,300 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)
- 51 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 examination topics and assessment of 5 work projects for the Master’s examination
- 11 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, 2 sessions
- 1 information event for pupils at Pfaffenhofen vocational school
- One “BiLa” seminar (educational programme for farming) on hop growing, in 4 evening sessions
- 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

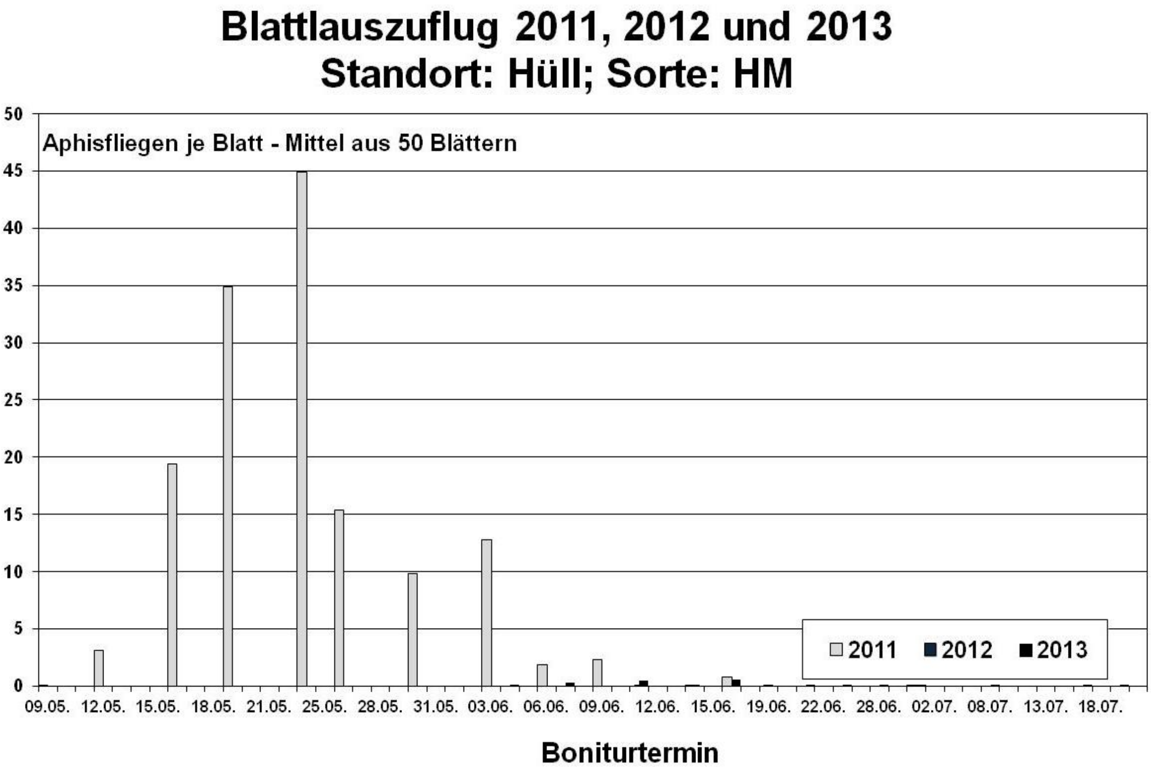


Fig. 6.1: Aphid migration

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

Date	Aphids per leaf			Spider mites per leaf		
	Ø	min.	max.	Ø	min.	max.
10.06.	0.99	0.00	17.62	0.03	0.00	0.33
17.06.	0.53	0.00	4.86	0.12	0.00	1.77
24.06.	0.49	0.00	7.14	0.23	0.00	2.17
01.07.	0.92	0.00	12.40	0.55	0.00	7.17
08.07.	1.94	0.00	32.00	0.71	0.00	5.00
15.07.	0.24	0.00	1.12	0.26	0.00	1.50
22.07.	0.07	0.00	0.34	0.56	0.00	9.30
29.07.	0.02	0.00	0.08	0.32	0.00	5.40
	Main spraying dates 09. - 25.07. 22 locations untreated			Main spraying dates 09.07 - 25.07. 13 locations untreated		

As in 2012, hop aphids caused very little damage in 2013. Migrations were observed only in isolated cases and were extremely weak. In many cases, no control measures were needed at all as three quarters of the hop yards observed within the scope of pest monitoring were completely free of aphids. Low to moderate levels of infestation justifying at least one precautionary treatment were observed in a quarter of the hop yards.

The common spider mite, on the other hand, was initially unable to establish itself in the 30 hop stands under observation due to the cold, wet spring weather. Not until July, when the weather changed, was spider-mite infestation observed in some hop yards. In almost all cases, one treatment sufficed to keep it under control. In 13 hop yards, infestatation levels were so low as to make treatment unnecessary, and in two yards, no spider mites were found at any time.

6.1.2 Downy mildew

Tab. 6.2: Downy and powdery mildew warning service

Fax No.	Date	Primary downy mildew	Spray warnings			Powdery mildew
			Suscep. cultivars	All cultivars	Late cultivars	
14	22.04	xxx				
17	14.05	xx				
18	22.05	xx				
20	05.06.	xx				
21	10.06.			x		Susceptible
23	18.06.			x		
24	21.06.		Spray warning for hail-damaged yards			
25	24.06.		Spray warning for hail-damaged yards			x
36	23.08.				x	
38	29.08.				x	
No. of spray warnings				2	+2	1

6.2 EU Working Group on Minor Uses: Hops

EU-level cooperation on issues concerning minor uses of plant protection products (PPP)

Solving minor-uses issues in the field of plant protection is a challenge for the profession, the chemical industry, the authorities and the legislature, and tackling problems relating to the lack of authorised PPPs is an ongoing task. New framework conditions for EU authorisation of PPP were created when EC Regulation No. 1107/2009 concerning the placing of plant protection products on the market took effect. The Regulation prompted innovations in international cooperation on issues concerning minor uses and provides the basis for these innovations. It permits Europe-wide cooperation in addressing plant protection problems on a work- and cost-sharing basis.

The most important organisational units created in the context of EU minor-uses work are the Commodity Expert Groups Minor Uses (CEG). Their job is to solve specific plant protection problems in minor crops. The CEGs organise projects relating to new PPP and to unsolved problems with the aim of speeding up zonal authorisations for minor crops. To date, CEGs exist for processing vegetables, fresh vegetables, small and stone fruits, ornamental plants and hops.

CEG Hops

The Commodity Expert Group Hops was founded in Hüll in 2012. Its members include representatives from hop research institutes in Germany, Slovenia, the Czech Republic and Poland, experts from hop-grower associations in France, Belgium, Great Britain, Austria and Germany, and representatives from the Julius-Kühn Institute, the German Hop Industry Association and the US hop industry. The CEG Hops is headed by the Work Group for Plant Protection in Hop Growing at the Hüll Hop Research Centre.

The aim of the group is to solve plant protection problems in hops on a cost- and work-sharing basis and, in particular for new products and active agents, to compile the basics for zonal applications as per Article 51 of EC Regulation No. 1107/2009. The CEG's centralised organisation has several advantages:

- Specialised plant protection expertise from the European Union's major hop-growing areas is bundled here. US hop-industry participation provides a platform for exchanging information concerning the authorisation situation in the world's largest hop-growing regions.
- Problems relating to a lack of authorised PPP for use on hops, as well as new plant protection problems, are rapidly identified and addressed according to urgency.
- The national experts are familiar with the process of setting up efficacy and residue trials.
- Work-sharing agreements pertaining to trials permit faster and more cost effective processing of necessary data for joint use, meaning that new products are available sooner to hop growers.

The working groups convene twice yearly. Plant protection problems faced by European hop growers and available solutions are systematically discussed and recorded, and joint efficacy trials agreed. The CEGs' work requires close cooperation with PPP manufacturers, with whom they agree projects concerning new PPPs well in advance. This also means that the PPP industry now has contact persons for EU authorisation projects in minor crops. Mid-term, mutual recognition with regard to minor uses/crops will probably result in enhanced harmonisation on plant protection issues in Europe.

European Minor Uses Database (EUMUDA)

The data collected by all the CEGs is compiled in EUMUDA, the joint European minor-uses database. In addition to general information on plant protection and links to national databases, EUMUDA contains the following information:

- List of minor uses/crops
- List of national crop acreages
- CEG project and work lists
- Members of the EU working groups and the OECD working group
- EU contact persons for PPP manufacturers

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

Background

The Rosy Rustic is deemed a minor pest in hop-growing, its occurrence over the past ten years having been localised and of very short duration. The last noteworthy occurrence of the species in the Hallertau district was in 1969 and 1970. In 2012, and to an even greater extent in 2013, 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. Two hop farms were infected to such an extent in 2013 as to necessitate large-area control (exceptional permission as per Section 22.2 PflSchG). To find out more about the moth's biology, occurrence and flight habits in hop yards, its flight was monitored in late summer and autumn 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 were infected. The trap was emptied daily and all the adult moths identified and counted.

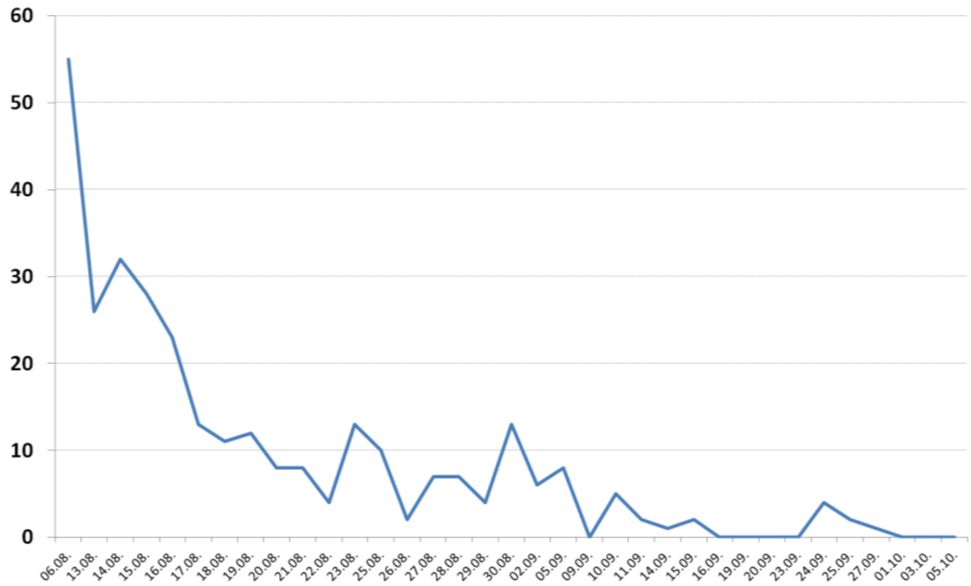


Fig. 6.2: Flight curve of the Rosy Rustic moth (Hydraecia micacea) near Steinbach in late summer and autumn 2013, based on the number of adult moths caught in the light trap

Result

Moth-catching did not commence until early August, following a snap decision. As the curve in Fig. 6.2 shows, the flight period 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. Although the number of trapped moths decreased steadily during August and September, moths were still being caught in early October, suggesting that egg-laying probably continues until this time. The work will be continued in 2014, when the trap will be set up much earlier.

6.4 Trials to minimise the use of copper-containing plant protectives in organic hop farming

Introduction

Combating downy mildew (*Pseudoperonospora humuli*) is one of the major plant protection measures taken in all hop yards every year. This applies to both conventional and organic hop farms. In the latter case, as with all other organically farmed crops regularly infected with downy mildew or similar diseases, there is currently no alternative to the use of copper-containing formulations as these diseases cannot be controlled effectively with other available agents licensed for organic farming.

However, since copper is a heavy metal and is assessed as being ecotoxic, there is public demand for dispensing with copper-containing plant protectives entirely or restricting their use to a minimum. In an earlier research project, copper hydroxide formulations were tested for their efficacy in controlling downy mildew in the highly susceptible Hallertauer Mittelfrüher cultivar. Although good results were obtained, trials involving further reductions were not carried out. Phosphonate-containing Frutogard tonic, which is copper-free, also worked well against downy mildew; however, since Frutogard will be listed as a plant protective in future, its use in organic hop farming is currently not under discussion.

In the strategy paper concerning copper application in agriculture and, specifically, in organic farming, which was published in 2009 by ecological organisations, further procedures for a stepwise solution to the copper dilemma in organic farming were finally outlined. The following "short-term goal" was formulated: "The intention is to reduce the currently permitted average copper dose rate for all crops of 3 [hops: 4] kg/ha to 2.5 [hops: 3] kg/ha within the next five years". An initiative funded by the "Bundesprogramme Ökologischer Landbau und andere Formen nachhaltiger Landwirtschaft" (BÖLN) and aimed at replacing or reducing copper-containing plant protectives in various crops was launched accordingly and included this project. The plan was to develop strategies by which the use of copper in plant protectives for organically grown hops can be minimised as far as possible through use of "modern" copper hydroxides and synergists.

Material and methods

The trials were conducted on a Naturland farm in Haushausen, near Wolnzach. The trial hop yard (approx. 1.5 ha, Perle variety) was located at the edge of the Wolnzach river valley and was bounded to the north and south by conventionally farmed hop yards. Rows of poplars between the yards provided protection against drift from these yards.

The project focused on testing new formulations of copper-containing products and reducing dose rates by adding plant tonics as synergists. The latter often resemble each other in their compositions and the way they work. Three tonics differing from each other in respect of their biologically active components were originally selected from the wide range available:

(1) "Herbagreen" (Mikro-Mineral GmbH, AT); total annual dose rate 27.25 kg/ha in five sprayings (2010-2013); (2) "Biplantol H forte NT" (Bioplant Naturverfahren GmbH); total annual dose rate 10.0 l/ha in five sprayings (2010-2013); and (3) "Frutogard" (sold by Spiess-Urania); total annual dose rate 10.0 l/ha in three sprayings up until flowering (2010-2012).

In 2013, the fourth trial year, Frutogard was replaced by “Myco-Sin” (Biofa GmbH, Münsingen); planned annual dose rate 0.6 kg/ha in five sprayings.

In addition, tentative one-year trials with spray variants containing little or no copper were conducted as from the third year; each of these trials, for which the knotweed extract “Sakalia” (Syngenta, 2012), “Polyversum” (*Pythium oligandrum*, Biopreparaty, CZ; 2012) and “Flavonin Agro Protect” (Citrox Natural Solutions, AT; 2013) were used, was performed in one plot only.

Twenty-six plots planned as 13 different trial blocks were marked out in the trial yard. Each trial block measured approx. 0.1 ha (912 to 1,046 m²). In the first trial year, 2010, the trials were conducted with two new copper hydroxides (SC formulation and WP formulation) from Spiess-Urania, which were sprayed at dose rates of 2.0 and 3.0 kg/ha copper (no additives) or at the same dose rates but in combination with the three plant tonics. A conventional organic product containing, among other things, Diabas lava meal, brown algae extract and sometimes wettable sulphur was added to each spray.

In spring 2011, the two copper hydroxides used in 2010 had already been, or were about to be, officially authorised for use against downy mildew in hops (“Cuprozin progress” was authorised in February 2011, “Funguran progress” was authorised in May 2011). However, shortly before commencement of the first treatments, an unexpected complication cropped up: it was discovered during an inspection of the trial farm in May 2011 that two formulation auxiliaries of “Funguran progress” and “Cuprozin progress” did not conform to the US guidelines of the National Organic Program (NOP). The farm would have lost its US certification if the two hydroxides had been used, necessitating a further three-year changeover phase. As the NOP rejected an immediate application for a temporary exemption, the NOP-compliant copper oxychloride “Funguran” was used instead of the two problematic formulations in 2011, at the planned copper dose rates of 2 or 3 kg/ha. In 2012 and 2013, this legal problem having been resolved, the two originally planned copper hydroxides were used again; use was also made of the copper sulphate formulation “Cuproxat” and of microencapsulated copper sulphate (“CuCaps”). “Funguran” (copper oxychloride), the standard spray used in the past, was selected as reference spray in 2010-2012 (dose rate: 4.0 kg/ha); in 2013, “Funguran progress” (dose rate: 4.0 kg/ha) was used instead, as Funguran’s authorisation had expired.

A solar-powered Burkhard spore trap was set up in the centre of the trial yard in order to obtain the first-ever information about downy-mildew infestation pressure in an organically managed hop yard. After the first two trial years, the spore trap was moved about 200 m away from the centre of the trial yard to a neighbouring, organically farmed plot planted with the same hop variety, where it remained in 2012 and 2013. The trap was moved due to the risk, recognised in 2011, of the actual infestation pressure being overrated on account of the untreated plot in the direct vicinity of the trap’s original site. Each year, from the beginning of June until harvesting, the zoosporangia samples were removed from the trap on weekdays and analysed (Fig. 6.3).

Results

The zoosporangia counts for the four trial years showed that, in years with normal infestation levels, infestation pressure in this organic hop yard was much higher than in conventional managed hop stands. The zoosporangia counts in 2010 and 2012 peaked according to the same time pattern as those determined for the downy-mildew warning service but at much higher levels (Fig. 6.3).

In trial year 2011, the extremely high infestation levels measured as from the beginning of August (four-day total continuously above 150 and sometimes up to 450) pointed to an exceptional "home-made" infestation pressure caused by the untreated control plot. The extreme weather conditions in 2013 – cold, wet spring, hot and extremely dry mid-summer – meant that infection pressure was virtually zero as from early July and no evaluable results were obtained. Even in the untreated control plot, infestation was still 0.0 % shortly before the harvest, and did not exceed 0.1 % in any of the trial blocks.

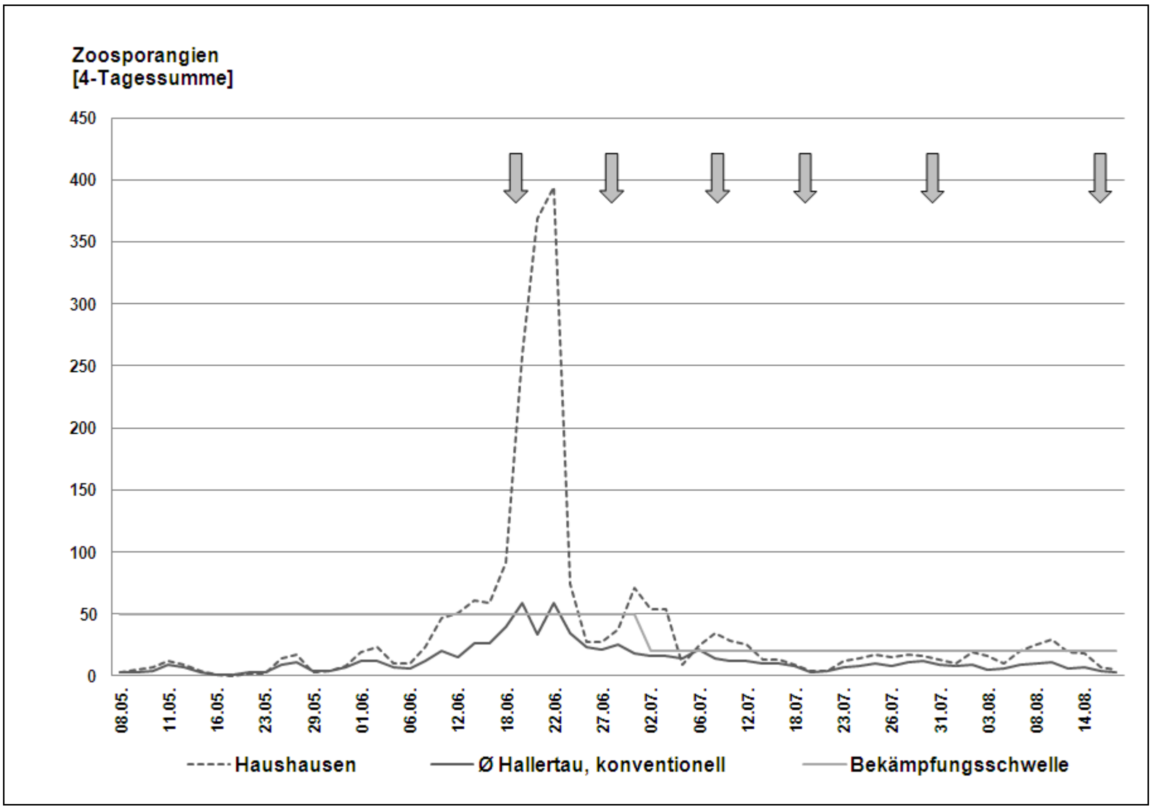


Fig. 6.3: Comparison of downy-mildew infection pressure, expressed as zoosporangia counts, at Haushausen in 2012 with the averaged figure from the warning-service stations in the Hallertau. The arrows indicate the six spraying dates for downy mildew.

Hop-yard assessment of the efficacy of the individual spray mixtures was generally not possible prior to commencement of cone formation towards the end of July, when the percentages of visibly diseased cones in the individual plots are used as a measure. On the untreated plots, near-total crop losses were witnessed by harvesting time in three of the four trial years, 2013 being the exception (2010: 86.1 %; 2011: 97.2 %; 2012: 92.8 % diseased cones). By contrast, all copper variants provided significant protection against downy mildew in all the years with evaluable results, the 3 kg/ha variants proving considerably more effective than the 2 kg/ha variants in almost all cases.

The copper hydroxides used in 2010 and 2012 appeared to be considerably more potent than the copper oxychloride sprays applied in 2011 at identical dose rates. The "CuCaps" formulation, which was tested in the field for the first time in 2012 and contains microencapsulated copper sulphate as the active agent, also produced promising results. Despite a few teething problems concerning application of the capsules, this formulation kept cone infection incidence consistently at the same level as did the best of the other variants.

All three combinations with plant tonics increased spray efficacy, the variants containing Frutogard always producing the best results. Even at a dose rate of 2 kg/ha, cone infection levels were lower than with the 4 kg/ha copper oxychloride variant, for years the standard spray used to control downy mildew in organic hop farming (Fig. 6.4 and Fig. 6.5).

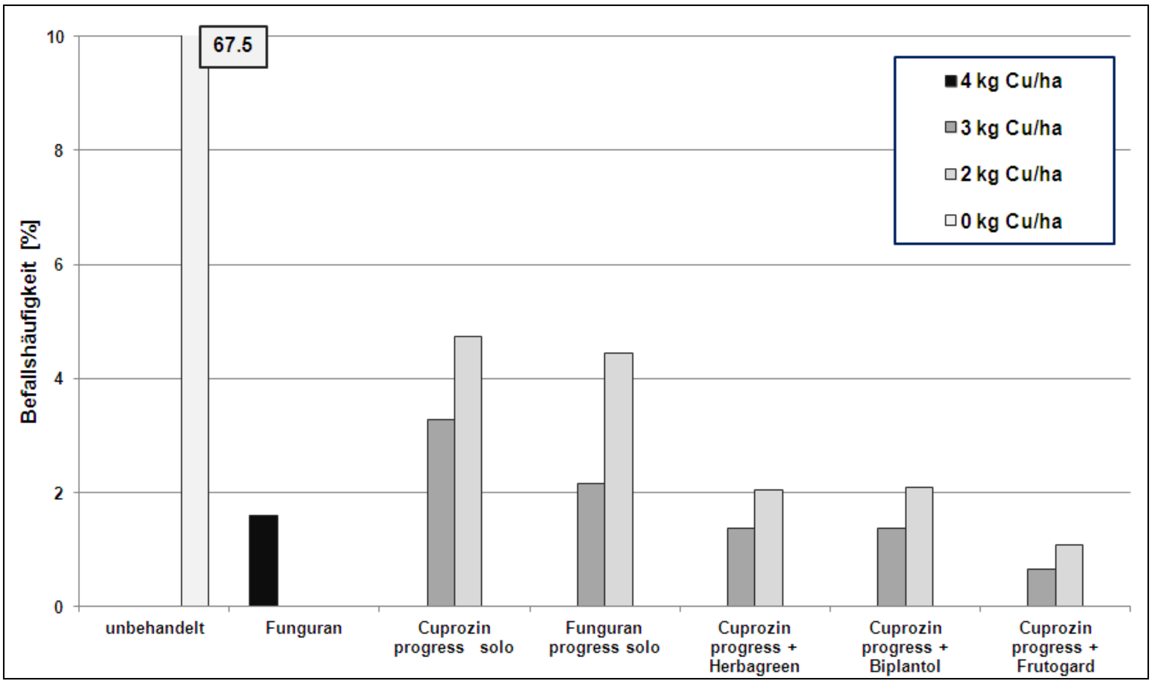


Fig. 6.4: Cone infection with downy mildew in the Haushausen trial yard on 18.08.2010.

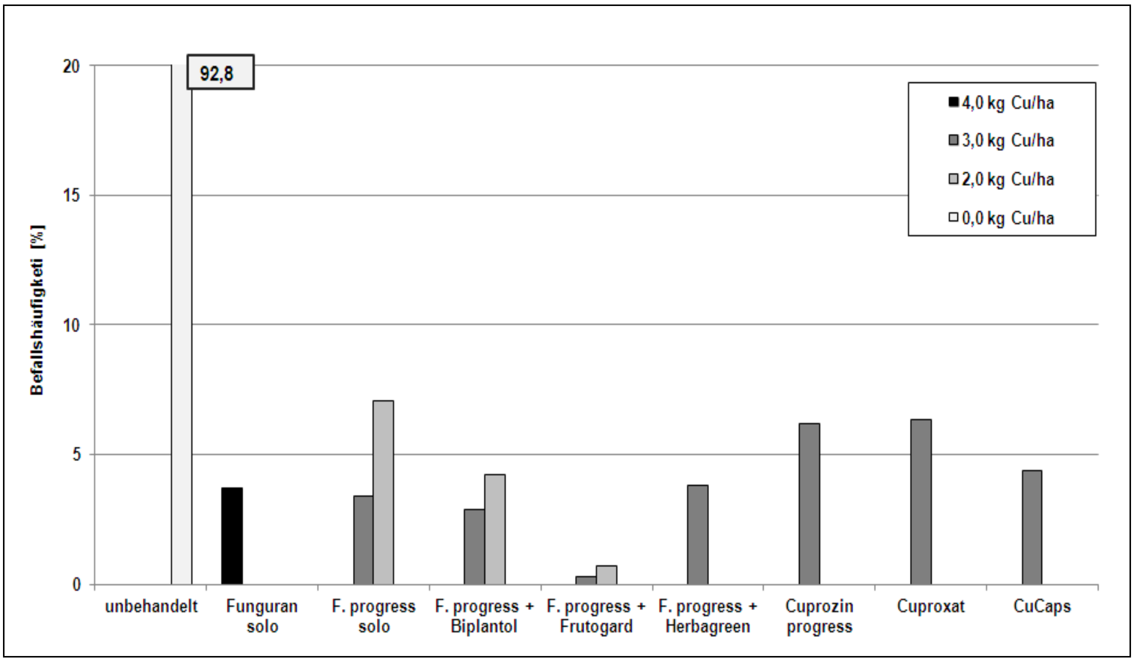


Fig. 6.5: Cone infection with downy mildew in the Haushausen trial yard at harvesting time on 3.09.2012, based on assessment of the dried cones.

Phosphonate residue analysis

During each of the three 2010 – 2012 harvests, mixed cone samples were taken from plots 1 (untreated), 11 (Frutogard + 2 kg/ha copper) and 12 (Frutogard + 3 kg/ha copper) and stored under vacuum at 2°C. A few days/weeks after the harvests, a mixed root sample (more than 500 g of thick, oldish roots per plant, no "summer roots") was dug up from each of four hop plants growing on each of the same three plots. All the root samples were then sent to the Office of Agricultural Chemistry, Laimburg Research Centre for Agriculture and Forestry (Pfatten, Auer/Ora, South Tyrol, Italy) for phosphonate analysis

The analyses showed HPO_3 levels in all the tested root samples from all three years to be under the detection limit of 0.5 mg/kg DM. These results refer explicitly to samples taken from plants treated with Frutogard over three vegetation periods. Use of the tonic apparently causes no notable phosphonate accumulation in the roots. HPO_3 levels in the cone samples from the first two trial years were also below the detection limit of 0.5 mg/kg FM. By contrast, HPO_3 levels in the cone samples harvested in 2012, the third trial year, were 15.7 and 12.1 mg/kg FM (plots 11 and 12, respectively), which we found relatively surprising. Levels for the untreated plot were again below the detection limit in 2012. The 2012 Frutogard treatment had therefore led to residual phosphonate in the cones harvested on 3rd September, although the last treatment had been on 9th July, prior to flowering.

Implications and outlook

Unfortunately, the entire project suffered from the familiar problem of field trials, with only two of the four project years furnishing conclusive results. Even so, these two years provide enough information to suggest that the short-term goal of the strategy paper published in 2009 for reducing copper dose rates might well be attainable: this is illustrated by the fact that, although every additional kilogramme of copper has a recognizable effect in the battle to combat downy mildew, adequate control of the fungus with "modern" copper hydroxides applied at a reduced dose rate of 3 kg/ha nevertheless appears possible. This is especially true when the spray mixtures also contain the tested plant tonics, as these clearly reinforce the effect of the copper. The most potent mixture is most definitely the one containing Frutogard, although its use in the field is currently not under discussion. With regard to further minimisation of copper application in organic hop farming, we are therefore pinning our greatest hopes on the CuCaps microencapsulation technique, which involves the slow, steady release of only as many Cu^{2+} ions as are actually needed to combat the fungus. Following very encouraging initial results in 2012 (and a lost year 2013), our plan for 2014 – and beyond if our funding application is successful – is to test microencapsulated copper sulphate also at lower dose rates than the currently achieved one of 3 kg/ha.

Funding information

This research project was funded by the Bundesanstalt für Landwirtschaft und Ernährung (BLE) via the Bundesprogramm Ökologischer Landbau und andere Formen nachhaltiger Landwirtschaft (BÖLN) (project funding reference number: 2809OE058).

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. Hops are, after all, grown for their components, with 95 % of hop output being used by the brewing industry and only 5 % for other purposes. 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.

A change is under way, however, because the craft brewer scene in the USA is growing and the new trend is spreading to Germany and Europe, with all the 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. Polyphenols and nitrate are also transferred to the beer. Hops used for dry hopping must meet very special requirements with respect to plant hygiene.

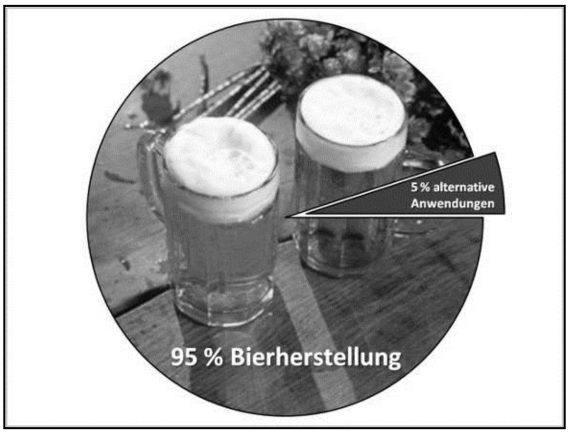
Craft brewers are looking for hops with special aromas, some of them not typical of hops. Such hops are referred to collectively as “Special Flavor Hops”.

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 things 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



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. 7.1).

Fig. 7.1: Use of hops

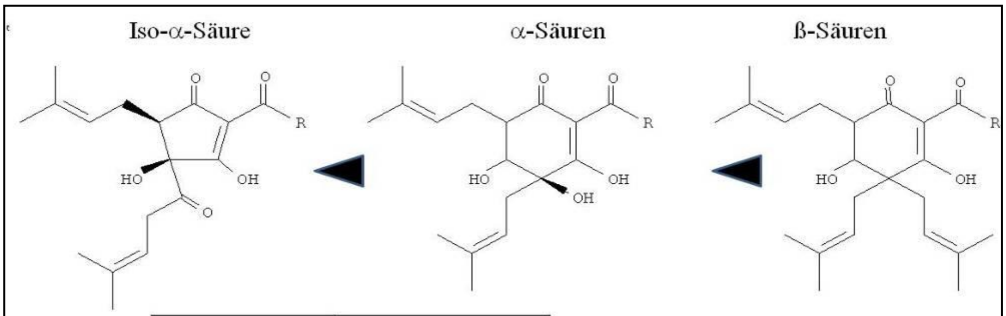
As far as hopping is concerned, breweries follow two extremely different philosophies. The aim of the first approach is to obtain alpha-acids as cheaply as possible, with variety and growing region being irrelevant. The aim of the second is to cultivate beer diversity through a variety of hop additions 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 analytics, which provide 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 aromas. Craft brewers are also interested in purchasing hops with exotic aromas such as mandarin, 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. 7.2).



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

Fig. 7.2: Sequence of antimicrobial activity of iso-α-acids, α-acids and β-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, it is already established practice to replace formalin with 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. The oligomeric proanthocyanidins (up to 1.3 %), glycosidically bound quercetin (up to 0.2 %) and kaempferol (up to 0.2 %) are substances with very strong anti-oxidative potential. 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. 7.3 shows their chemical structures.

Multifidol glucoside itself has structure A. Hops mainly contain the B compound, but also A and C in smaller concentrations.

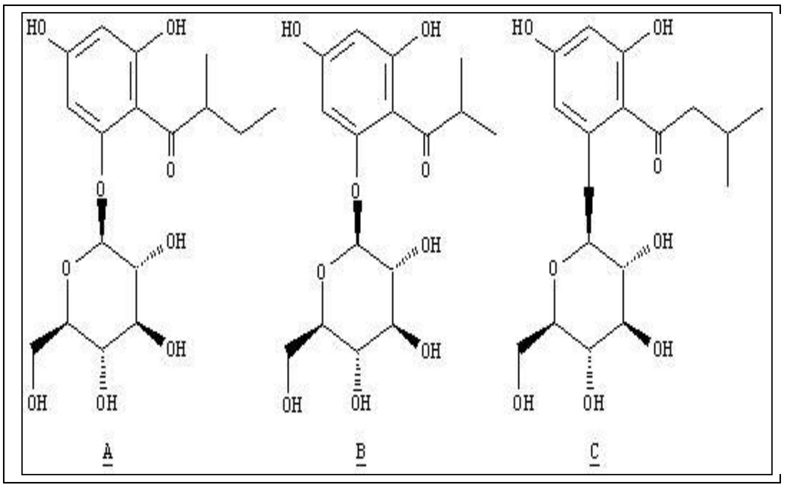


Fig. 7.3: Chemical structures of the multifidols

These substances might also become of interest for the pharmaceutical industry due to 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.

7.2.3 World hop range (2012 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 2012 harvest. The findings can be helpful in classifying unknown hop varieties.

Tab. 7.1: World hop range 2012

Variety	Myr-cene	2-m.-iso-butyrate	Sub. 14 b	Sub. 15	Lina-lool	Aroma-den-drene	Unde-canone	Humu-lene	Farne-sene	γ-muu-rolene	ß-seli-nene	α-seli-nene	Cadi-nene	Selina-diene	Gera-niol	α-acids	ß-acids	ß/α	Cohu-mulone	Colu-pulone
Admiral	2372	669	10	39	35	0	7	235	6	7	4	2	15	0	4	15.3	6.2	0.41	43.5	66.1
Agnus	1295	55	1	6	10	1	3	104	0	6	5	3	12	0	2	14.8	6.3	0.42	31.9	55.6
Ahil	3900	599	47	10	35	6	13	201	34	9	10	8	17	0	11	8.6	4.2	0.49	29.1	52.9
Alliance	1217	153	3	7	25	0	6	281	0	8	4	3	17	0	2	5.5	3.0	0.54	27.5	49.5
Alpharoma	1814	54	16	8	19	0	12	306	18	10	6	4	20	0	5	8.1	4.6	0.57	36.8	62.9
Apollo	2756	61	14	29	4	4	3	178	0	5	2	1	13	0	3	16.9	7.6	0.45	28.3	50.3
Apolon	5640	111	51	16	40	4	3	225	66	8	8	6	16	0	8	8.4	4.0	0.48	24.2	50.7
Aramis	1774	49	4	10	18	17	21	218	0	11	29	27	17	43	1	9.4	3.9	0.41	18.8	40.3
Aromat	1789	13	2	8	37	0	23	312	21	11	9	6	22	0	7	4.4	4.2	0.94	24.3	45.7
Atlas	3972	690	24	13	33	4	2	198	41	8	11	9	16	0	16	7.2	4.0	0.56	36.6	56.8
Aurora	2639	171	4	66	58	2	28	293	30	6	6	2	14	0	3	9.0	4.4	0.50	21.1	46.9
Backa	1494	332	4	11	28	0	8	284	3	10	6	3	19	0	3	8.6	5.5	0.64	42.2	58.2
Belgisch Spalter	2021	139	3	13	24	11	11	156	0	9	27	29	14	42	2	6.0	3.4	0.56	17.4	43.5
Blisk	3490	360	24	10	41	0	3	271	45	8	9	7	17	0	10	7.2	3.6	0.50	27.7	52.4
Boadicea	1823	81	1	9	5	2	2	117	11	5	6	6	12	0	1	6.1	4.8	0.79	21.8	42.8
Bobek	9892	329	12	137	74	0	20	215	29	6	5	4	13	0	7	5.8	5.0	0.87	25.4	46.6
Bor	2941	127	4	50	12	2	9	283	0	7	5	3	15	0	5	10.1	4.9	0.48	23.8	47.5
Bramling	1905	189	15	16	52	0	13	273	0	9	8	4	18	0	8	4.1	3.4	0.82	35.0	50.3
Braustern	1610	57	2	29	10	0	6	256	0	7	4	2	16	0	2	6.5	4.2	0.65	24.7	47.6
Bravo	6256	129	30	19	11	2	2	139	0	13	9	7	28	11	6	14.7	4.2	0.28	36.1	56.1
Brewers Gold	1465	272	18	12	20	2	2	177	0	10	9	8	20	0	8	6.9	4.5	0.65	36.7	61.5
Brewers Stand	10431	668	28	80	68	24	18	51	0	56	78	71	101	102	14	8.8	4.2	0.48	25.5	46.8
Buket	2825	218	3	87	36	0	16	252	21	8	5	2	17	0	3	10.1	5.1	0.50	21.1	46.8
Bullion	7299	183	18	26	74	0	15	254	0	8	73	75	16	0	6	8.8	5.2	0.60	41.0	62.7

Variety	Myr-cene	2-m.-iso-butyrate	Sub. 14 b	Sub. 15	Lina-lool	Aroma-den-drene	Unde-canone	Humu-lene	Farne-sene	γ-muu-rolene	ß-seli-nene	α-seli-nene	Cadi-nene	Selina-diene	Gera-niol	α-acids	ß-acids	ß/α	Cohu-mulone	Colu-pulone
Cascade	3718	360	24	17	34	1	7	237	20	14	19	16	27	7	6	6.4	6.2	0.97	33.1	49.8
Chang bei 1	1940	17	3	3	52	0	18	236	10	10	27	24	18	29	4	3.5	3.5	1.02	17.5	41.4
Chang bei 2	2040	3	3	3	60	0	21	239	8	9	23	21	17	26	4	3.3	3.7	1.11	13.5	38.1
College Cluster	1124	148	16	14	10	0	4	144	0	5	8	7	10	0	3	8.0	2.3	0.28	24.4	40.5
Columbus	4788	118	12	14	10	1	1	139	0	16	13	9	32	13	1	15.1	5.0	0.33	35.1	56.9
Comet	1787	48	6	43	12	0	2	8	2	2	36	37	3	13	1	8.4	3.2	0.38	37.8	61.6
Crystal	949	38	6	14	52	38	14	201	0	14	52	48	17	61	3	2.5	6.2	2.52	6.9	38.0
Density	1370	105	10	8	38	0	14	283	0	9	11	8	17	0	5	4.4	3.8	0.86	35.2	51.7
Diva	3799	328	8	26	62	0	31	273	8	11	139	146	21	0	5	6.6	5.9	0.88	24.4	46.0
Early Choice	1650	83	2	13	10	0	7	248	0	8	58	59	15	0	3	2.5	1.3	0.51	24.1	46.6
Eastwell Golding	1551	120	3	13	24	0	7	269	0	7	4	4	16	1	3	5.4	2.7	0.50	21.7	45.5
Emerald	738	63	7	7	12	0	9	311	0	8	5	4	17	0	4	6.1	4.5	0.74	28.0	47.7
Eroica	2813	314	32	160	5	13	4	155	1	5	10	9	12	0	2	12.1	9.4	0.78	39.1	61.0
Estera	2524	168	3	8	30	0	8	288	17	8	11	9	16	0	3	4.7	2.9	0.63	25.3	49.6
First Gold	3733	571	3	25	42	3	12	279	19	9	104	109	18	0	3	6.6	3.4	0.51	30.1	53.9
Fuggle	1054	87	1	4	20	0	6	260	10	8	4	2	16	0	2	5.6	3.2	0.57	27.5	46.4
Ging Dao Do Hua	178	8	2	0	4	0	8	281	0	14	93	87	25	0	3	5.9	3.8	0.65	24.2	55.0
Glacier	2056	145	13	8	13	0	1	154	0	21	12	10	40	14	2	15.3	4.9	0.32	28.1	56.1
Golden Star	2416	665	2	6	30	2	8	251	0	26	63	57	47	0	8	5.3	3.8	0.72	45.7	62.2
Granit	1823	108	5	13	10	5	21	208	0	6	11	8	13	0	5	8.4	5.2	0.62	21.4	46.4
Green Bullet	3613	293	34	19	49	3	12	290	0	8	4	3	16	0	3	7.7	4.3	0.56	33.3	59.4
Hallertau Blanc	46589	1840	388	71	209	0	25	47	0	20	1137	1245	36	0	21	9.9	5.2	0.53	20.9	36.9
Hall. Gold	2383	169	33	8	51	0	10	291	0	10	7	5	20	0	4	7.2	5.8	0.81	17.3	41.7
Hallertauer Magnum	3656	123	30	24	12	3	5	276	0	6	4	3	13	0	2	15.5	7.0	0.45	25.7	49.3
Hallertauer Merkur	2669	194	17	11	25	3	5	277	0	7	4	3	16	0	2	15.8	6.2	0.39	18.8	43.2
Hallertauer Mfr.	536	47	2	2	28	0	11	320	0	12	6	3	23	0	2	4.0	3.5	0.88	18.1	39.0

Variety	Myr-cene	2-m.-iso-butyrate	Sub. 14 b	Sub. 15	Lina-lool	Aroma-den-drene	Unde-canone	Humu-lene	Farne-sene	γ-muu-rolene	ß-seli-nene	α-seli-nene	Cadi-nene	Selina-diene	Gera-niol	α-acids	ß-acids	ß/α	Cohu-mulone	Colu-pulone
Hallertauer Taurus	5402	124	14	27	56	2	10	247	0	8	64	67	16	0	3	15.5	5.1	0.33	18.6	40.6
Hallertauer Tradition	989	101	13	5	41	0	10	316	0	10	8	6	19	0	3	7.1	4.5	0.63	26.7	46.8
Harmony	5399	50	4	14	33	3	12	249	0	8	71	76	16	0	2	8.5	6.9	0.80	19.1	38.0
Herald	3741	506	6	91	17	5	24	199	0	7	26	23	14	0	4	11.7	4.7	0.40	31.4	59.7
Herkules	4633	457	69	72	12	1	8	284	0	6	4	3	15	0	4	14.6	4.9	0.33	33.7	60.5
Hersbrucker 328	2022	58	11	11	42	34	13	194	0	11	39	38	15	53	3	3.5	6.1	1.71	14.9	32.2
Hersbrucker Pure	3777	192	6	19	49	24	24	203	0	11	37	35	16	56	4	4.7	2.4	0.52	21.5	42.2
Hersbrucker Spät	606	52	6	6	60	55	11	187	0	17	66	62	18	74	5	1.6	4.7	3.02	8.4	34.0
Huell Melon	9053	1599	18	107	46	14	24	79	0	22	346	351	41	109	16	6.7	7.5	1.12	27.7	46.2
Hüll Anfang	410	62	6	1	17	0	7	310	0	12	4	3	21	0	1	4.5	3.3	0.74	18.7	46.4
Hüll Aroma	615	50	4	3	26	0	9	308	0	11	5	3	20	0	2	5.1	4.0	0.78	25.6	47.9
Hüll Bitterer	2954	212	35	8	44	16	11	159	0	42	58	51	70	68	5	6.6	5.4	0.81	20.8	44.2
Hüll Fortschritt	563	30	9	3	30	0	12	310	0	11	7	4	20	0	3	4.0	4.2	1.06	24.6	42.3
Hüll Start	340	31	1	2	11	0	11	332	0	13	5	3	23	0	2	2.6	3.4	1.32	17.9	41.1
Jap. C 730	1314	3	14	26	16	6	16	148	31	7	11	8	13	0	7	4.6	2.6	0.56	27.9	51.7
Jap. C 845	537	21	4	3	4	0	10	297	9	11	4	3	20	1	2	8.4	3.5	0.42	21.4	44.3
Kazbek	1170	22	7	26	6	0	3	289	0	8	3	2	16	0	2	10.0	4.0	0.41	21.1	44.9
Kirin 1	1620	455	8	7	21	0	6	213	0	17	54	52	31	0	4	5.9	3.5	0.59	41.2	62.0
Kirin 2	2199	655	2	6	28	2	8	242	0	25	63	57	46	0	7	5.7	4.0	0.71	45.1	62.1
Kumir	2446	94	3	23	25	0	9	286	6	7	4	2	16	0	3	12.8	5.3	0.42	20.1	43.2
Late Cluster	19984	710	45	90	66	32	21	47	0	52	82	74	94	98	9	9.3	4.8	0.52	25.6	47.4
Lubelski	2578	4	3	6	28	0	15	322	4	8	6	3	16	0	4	6.4	5.1	0.80	22.9	45.4
Marynka	3560	263	4	51	15	6	7	174	123	5	6	5	12	0	6	11.5	4.5	0.39	19.2	44.3
Mt. Hood	493	130	20	6	29	1	8	243	0	17	8	5	29	0	3	3.9	5.7	1.48	19.9	40.9
Neoplanta	1566	84	3	23	10	0	8	241	15	8	4	3	16	0	2	8.1	4.1	0.50	30.2	54.5
Neptun	984	92	31	6	18	1	2	190	0	7	3	2	16	0	1	16.0	5.2	0.32	20.6	40.1

Variety	Myr-cene	2-m.-iso-butyrate	Sub. 14 b	Sub. 15	Lina-lool	Aroma-den-drene	Unde-canone	Humu-lene	Farne-sene	γ-muu-rolene	ß-seli-nene	α-seli-nene	Cadi-nene	Selina-diene	Gera-niol	α-acids	ß-acids	ß/α	Cohu-mulone	Colu-pulone
Northern Brewer	1820	88	3	30	9	0	5	229	0	7	4	2	15	0	2	8.9	4.4	0.50	26.8	51.7
Nugget	1985	96	3	20	20	4	4	180	0	5	8	7	10	0	2	12.7	4.8	0.38	25.0	51.1
Olympic	2031	100	3	24	19	4	5	175	1	5	8	7	11	0	2	13.1	4.7	0.36	24.9	50.6
Opal	1775	69	12	23	33	3	8	204	0	7	5	32	15	16	3	7.9	5.8	0.73	13.7	30.4
Orion	1226	140	8	6	24	0	8	197	0	9	4	2	17	0	2	9.2	5.5	0.59	27.2	49.9
Outeniqua	665	12	3	4	5	5	11	240	0	10	58	57	19	1	4	10.7	4.9	0.46	26.3	51.7
PCU 280	1825	85	2	12	6	0	5	262	0	6	4	3	13	0	2	11.0	4.4	0.40	27.4	52.0
Perle	1637	98	3	19	9	0	4	261	0	8	4	3	16	0	2	8.2	4.6	0.56	29.8	53.7
Phoenix	2027	192	2	12	9	0	6	268	0	7	60	70	16	0	2	14.5	4.4	0.30	23.7	53.0
Pilgrim	4691	720	6	152	20	5	22	270	0	8	75	80	17	0	6	8.2	4.3	0.52	36.9	59.5
Pilot	9172	854	14	113	109	20	47	55	0	12	426	474	25	0	13	7.3	3.7	0.51	37.4	59.8
Pioneer	6114	611	3	277	15	5	28	213	0	7	29	29	15	0	4	13.1	4.2	0.32	28.1	55.3
Premiant	1259	80	3	21	27	2	8	282	5	7	5	3	15	0	2	11.7	5.0	0.42	18.8	41.5
Pride of Kent	1767	57	5	5	35	0	9	303	0	8	5	3	17	0	3	6.3	3.2	0.50	25.1	48.6
Pride of Ringwood	2609	160	15	9	14	0	1	135	0	19	15	12	36	16	2	14.9	4.7	0.31	32.2	63.4
Progress	10798	684	49	70	66	33	21	41	0	60	91	81	108	114	10	9.8	4.9	0.49	24.9	46.3
Rubin	1709	156	29	16	14	0	4	229	0	9	64	70	17	0	4	13.6	4.7	0.34	30.5	48.9
Saazer	1109	18	8	4	23	0	14	310	18	10	6	3	20	0	4	2.9	3.7	1.27	23.3	39.8
Saphir	1816	66	1	31	40	8	28	194	0	8	21	21	14	23	2	3.5	6.4	1.81	11.4	41.5
Serebrianker	527	62	3	5	32	0	8	192	0	17	57	49	27	0	5	2.2	4.2	1.95	15.6	40.3
Sladek	2566	98	3	30	25	0	8	281	8	7	4	3	15	0	2	11.6	5.2	0.44	19.6	44.2
Smaragd	2331	33	15	14	51	2	9	272	0	9	8	38	19	29	5	5.9	5.2	0.87	13.1	29.1
Southern Promise	274	28	6	7	1	0	17	274	0	11	20	17	19	26	3	8.7	4.3	0.49	27.9	56.4
Southern Star	1172	11	6	19	8	0	4	301	25	8	4	3	17	0	2	11.5	5.5	0.48	30.1	56.0
Sovereign	2428	128	3	12	30	0	6	285	0	8	94	101	18	0	3	4.6	2.8	0.60	22.3	36.2
Spalter	1918	3	5	7	45	0	27	322	23	12	9	4	23	0	8	4.2	4.2	1.00	28.1	47.3

Variety	Myr-cene	2-m.-iso-butyrate	Sub. 14 b	Sub. 15	Lina-lool	Aroma-den-drene	Unde-canone	Humu-lene	Farne-sene	γ-muu-rolene	ß-seli-nene	α-seli-nene	Cadi-nene	Selina-diene	Gera-niol	α-acids	ß-acids	ß/α	Cohu-mulone	Colu-pulone
Spalter Select	3904	114	23	12	122	23	30	200	75	11	40	37	15	51	4	5.4	5.2	0.97	19.7	39.9
Sterling	1997	109	3	35	18	4	4	164	1	5	10	8	11	0	1	12.5	4.0	0.32	24.7	51.1
Strisselspalter	1329	67	9	11	43	34	12	191	0	13	45	44	16	59	3	3.5	7.0	2.00	14.6	33.1
Summit	4013	21	9	67	8	0	2	135	0	10	7	6	22	8	1	14.3	6.1	0.42	33.7	50.2
Super Alpha	1955	214	15	33	20	2	2	152	0	7	7	8	14	0	2	7.4	4.9	0.65	36.7	59.3
Super Galena	3206	166	24	71	7	2	2	168	0	7	3	2	14	0	4	11.3	8.4	0.75	40.0	58.7
Talisman	1903	88	2	34	9	0	5	222	0	7	5	3	15	0	2	10.1	4.6	0.46	25.6	50.7
Tettnang54er	1427	2	3	7	48	0	27	325	25	15	9	4	25	0	10	4.5	3.6	0.82	28.9	48.2
USDA 21055	2658	432	4	176	11	0	3	147	41	6	19	18	13	1	2	10.5	3.7	0.35	42.2	77.8
Vital	6007	278	10	25	51	18	67	14	0	3	92	94	7	0	5	14.7	5.7	0.39	21.4	43.8
Vojvodina	2407	166	3	25	18	0	13	247	4	8	6	4	16	0	5	5.4	3.0	0.55	28.8	48.7
WFG	1615	15	6	5	34	0	23	330	8	14	12	9	26	10	6	4.6	4.4	0.96	21.0	42.4
Willamette	1724	133	2	7	22	0	2	264	7	7	5	3	16	0	2	3.2	3.2	0.98	33.0	53.3
Wye Challenger	2348	415	7	33	43	1	14	263	8	8	56	60	16	0	3	5.3	5.0	0.94	23.9	43.6
Wye Northdown	1527	56	2	7	19	0	3	220	0	7	3	2	16	0	2	8.2	5.9	0.73	25.9	47.4
Wye Target	2431	403	7	28	37	1	17	169	0	17	12	9	34	9	4	12.6	5.7	0.45	34.7	58.6
Wye Viking	1927	100	5	35	15	0	14	250	31	8	46	46	16	0	3	6.7	5.1	0.75	22.6	44.3
Yeoman	2499	316	18	22	12	0	6	224	0	6	40	42	14	0	4	13.7	4.8	0.35	26.2	49.3
Zatecki	1486	82	2	7	27	0	7	277	11	8	4	2	17	0	3	5.4	3.2	0.58	26.9	47.6
Zenith	2761	106	3	24	33	2	10	268	0	8	81	86	17	0	3	9.7	3.7	0.38	20.7	49.0
Zeus	4951	151	11	12	11	0	1	144	0	17	12	10	33	13	1	12.8	4.4	0.34	34.5	56.4
Zitic	2485	2	2	13	14	5	11	273	6	7	4	2	15	0	7	7.2	6.2	0.87	19.1	42.5

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

7.3 Improved aroma characterisation of the new Hüll "Special-Flavor Hops"

Apart from sensory, organoleptic assessment, chemical analyses are also performed for aroma characterisation purposes. In Hüll, total oil content is determined using the EBC 7.10 steam distillation method and individual oil components determined via gas chromatography as per EBC 7.12. As these methods are very time-consuming, headspace gas chromatography is also used to select hops for breeding purposes.

The aim of this research project was to refine aroma characterisation methods in order to obtain sounder data that could also be used for breeding purposes. Cooperation partners in this project were Dr. M. Coelhan, Technical University of Munich, Weihenstephan Center of Life and Food Science, Weihenstephan Research Centre for Brewing and Food Quality.

7.3.1 Sample selection

The intention was to select the following hop varieties for the research project: Polaris, Mandarina Bavaria, Huell Melon and Hallertau Blanc (the four new Hüll "Special Flavor Hops") and, as reference varieties, Hall. Mittelfrüher, Cascade, Hall. Magnum and Nelson Sauvin.. The new "Special Flavor Hops" and the Hall. Mittelfrüher and Cascade (from Germany) varieties were provided by Hüll. The samples were divided up, vacuum-packed and stored at -18°C. It was not possible to obtain an American Cascade or a Nelson Sauvin sample.

7.3.2 Variety characterisation

The first goal was chemical characterisation of the varieties, irrespective of whether the substances are aroma-active and transferred to the beer or not. Fig. 7.4. shows the headspace gas chromatograms from the Hüll laboratory, which represent the latter's knowledge base.

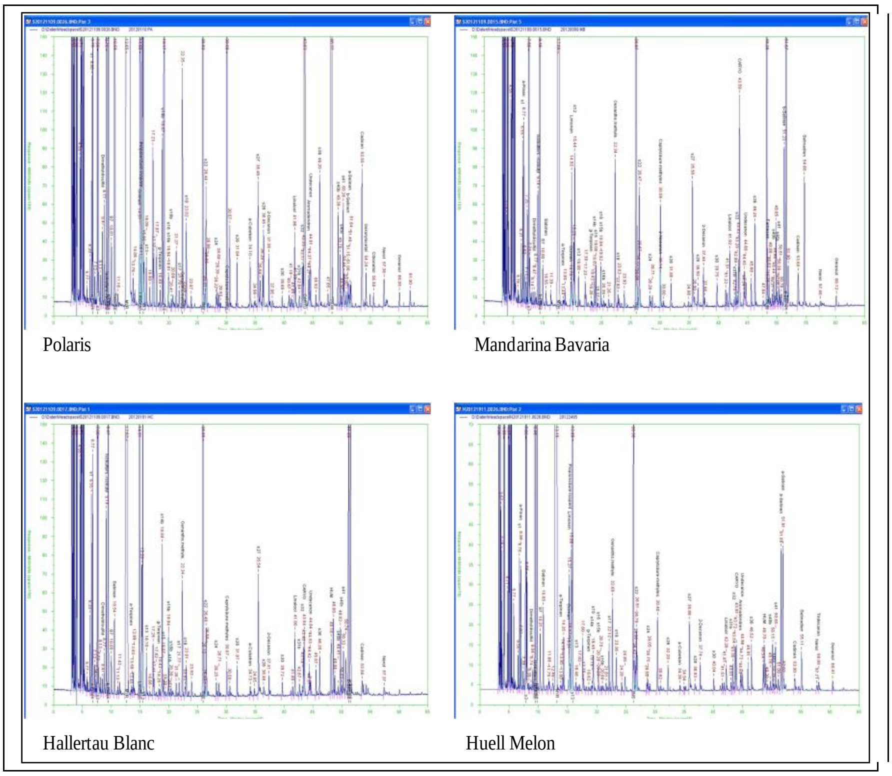


Fig. 7.4: Headspace gas chromatograms of the new Hüll "Special Flavor Hops"

Polaris is distinguished by a very high oil content, in some instances more than 5 ml/100 g hops. No other hop variety has such a high oil content. When it comes to oil composition, Polaris boasts high shares of the following esters: isobutyl isobutyrate, 2-methylbutyl-isobutyrate, methyl heptanoate, methyl octanoate, methyl 4-decenoate, 4.8-methyldecadienoate, and geranyl acetate. Monoterpene(E)-beta-ocimene is also typical of Polaris.

Madarina Bavaria has a very high peak following α- and β-selinene, with no other hop variety recording such a high value. The intention is to clarify this peak with the help of a mass spectrometer.

Hallertau Blanc and Huell Melon differ greatly from traditional hops. The β-caryophyllene and humulene peaks are very low, whereas the β- and α-selinene peaks are very pronounced. Huell Melon also exhibited relatively high levels of 2-methylbutyl isobutyrate.

7.3.3 Findings of Dr. Coelhan

The hop oils provided by the LfL were examined on three different GC systems. Two systems had a flame ionisation detector each, but different separation properties, as one used a DB-5 and the other an FFAP capillary column. The third GC system had a DB-5MS capillary column, and thus a somewhat different stationary phase to that of DB-5. A mass spectrometer was used here as a detector. Quantifications were performed on the GC system with an FFAP column using pure reference standards only.

7.3.4 Quantification of hop oil components:

Tab 7.2 shows quantitative evaluations of a number of aroma-active compounds of the new Hüll "Special-Flavor Hops" as compared with Cascade and Hall. Magnum. Hüll Melon has high levels of lower-molecular esters and its limonene content is very high, too. Limonene has a strong citrus aroma. Polaris is distinguished by especially high levels of methyl octanoate. Cascade and Polaris possess high levels of geranyl acetate, which has a floral aroma. Mandarina Bavaria boasts very high concentrations of geraniol, while Cascade, Hall. Magnum and Polaris exhibit fairly high shares of nerol, the cis-isomer of geraniol.

Tab. 7.2: Selected aroma-active oil components in % of total oil

	Cascade	Hall. Magnum	Polaris	Mandarina Bavaria	Hall. Blanc	Hüll Melon
Isobutyl isobutyrate	7.9	1.6	9.2	8.5	4.1	21.7
Myrcene	522.0	478.0	559.6	575.2	714.8	436.0
2-methylbutyl isobutyrate	19.0	12.4	10.3	14.1	12.0	31.2
Limonene	16.8	14.4	19.2	1.9	16.6	43.2
Methyl heptanoate	5.0	5.6	9.4	12.1	9.7	13.3
Methyl octanoate	1.6	3.6	17.2	6.4	2.7	8.0
Citronellal	3.9	5.8	5.4	2.6	1.1	2.0
Methyl nonanoate	1.9	3.3	5.8	8.0	3.5	8.6
Linalool	4.3	3.6	2.8	3.1	4.1	2.8
Methyl cis-4-decenoate	6.4	18.4	16.0	16.0	6.8	19.2
Geranyl acetate	48.4	22.4	33.1	12.6	18.8	7.2
Citronellol	8.9	12.0	10.4	6.2	2.7	4.6
Nerol	20.6	21.0	12.5	1.3	4.8	3.4
Geraniol	2.3	1.9	0.8	6.9	0.8	2.7

Tab. 7.3 shows the solubility of a number of aroma-active compounds in water. The more polar the compound, the more soluble it is in water. Solubility is even slightly higher in beer, as beer contains 5 % ethanol, which acts as a solubilizer.

Tab. 7.3: Solubility of various esters and terpene alcohols in water

Substance	Solubility in water
Isobutyl isobutyrate	1.0 g/l
2-methylbutyl isobutyrate	0.5 g/l
Methyl octanoate	0.064 g/l
Linalool	1.45 g/l
Geranyl acetate	< 0.01 g/l
Citronellol	< 0.01 g/l
Nerol	< 1 g/ l
Geraniol	0.69 g/l

GC-MS analyses

Typical of Mandarina Bavaria is a large peak in the vicinity of the selenines, preceded by a smaller one. These substances were identified by Dr. Coelhan with the help of a mass spectrometer.

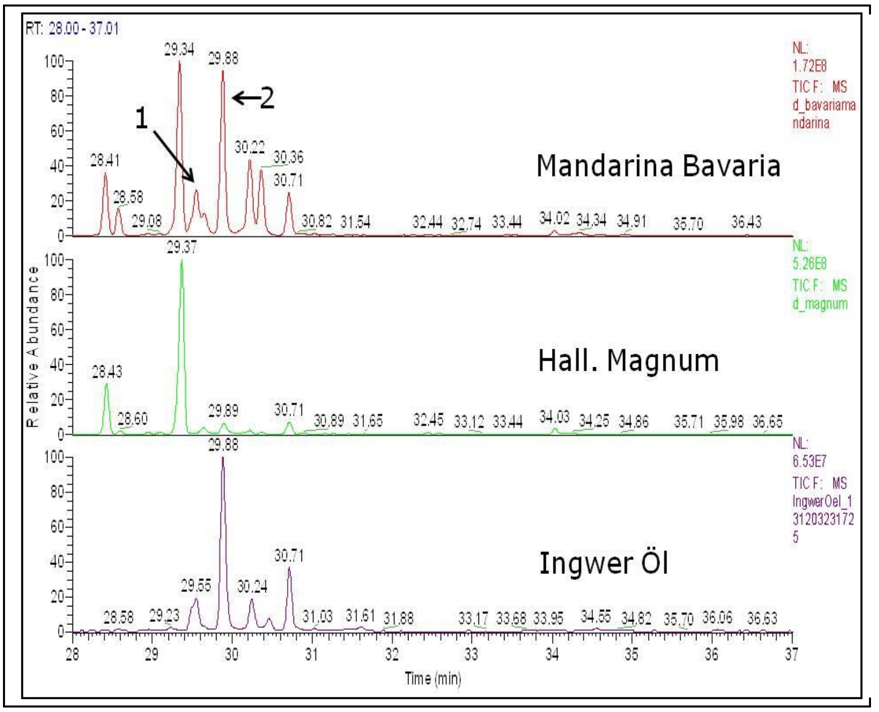


Fig. 7.5: Excerpts from the chromatograms of Mandarina Bavaria, Hall. Magnum and ginger oil

Peaks 1 and 2 are present in the case of Magnum (Fig. 7.5), but are less pronounced than with Mandarina Bavaria. Dr. Coelhan identified Peak 1 as α-curcumin and peak 2 as zingiberen. Zingiberen takes its name from ginger (Zingiber officinale). Fig. 7.6 shows the chemical structures of α-curcumin and zingiberen.

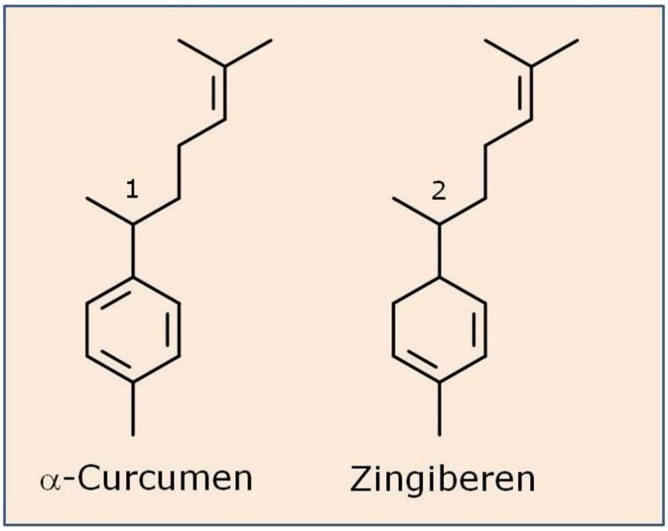


Fig. 7.6: Chemical structures of α-curcumin and zingiberen

7.3.5 Aroma-active substances

Dr. Coelhan used the GC sniffing method (gas chromatograph with olfactory detector) to identify aroma-active substances in the new Hüll "Special Flavor Hops". Tab. 7.4 shows the sniffing results of Ms. Weihrauch. The sniffing results obtained at the Weihenstephan Research Center for Brewing and Food Quality were also very similar.

Tab. 7.4: Sniffing results of Ms Weihrauch

RT	Substance	Polaris		Mandarina Bavaria		Hüll Melon		Hallertau Blanc		Cascade	
14.84	No peak									grassy	intensive
15.83	No peak	pleasant	light								
16.14	Propyl butyrate					fruity	light				
16.25	No peak					fruity	light				
19.33	No peak		light								
19.44	2-methylbutyl propionate				light						
19.64	Unknown				light						
20.13	Myrcene	grassy		grassy, like hay	intensive	grassy, like hay		grassy, like hay	intensive	grassy	intensive
20.39	Beta-pinene				light						
20.54	Isopentyl butyrate			gooseberry							
21.62	Beta-Phellandren?	grasig					light				
22.45	Unknown							citrus	light	citrus	intensive
22.58	Linalool									citrus	intensive
22.63	2-methylbutyl isovalerate	fruity				citrus	light			citrus	intensive
22.97	C8 methyl ester	very fruity	intensive	fruity	intensive	citrus	intensive	citrus	light	citrus	intensive
23.02	Unknown			fruity	unobtrusive						
23.53	Unknown		light								
23.94	No peak	grassy			light			fruity	light		
24.65	Methyl 4-nonenoate					citrus. fruity	light				
24.79	C9 methyl ester			fruity	strong	citrus. fruity	intensive				
25.15	Unknown					citrus. fruity	intensive				
25.44	Unknown			fruity							
26.88	Methyl geranate		light								
27.15	Octyl butyrate4?						light				
27.35	No peak			fruity	light						
27.50	Geranyl acetate?		light								
28.78	Unknown	citrus	intensive	fruity	intensive	melon		fruity	light	fruity	light
30.00	3.7-dimethyl-2.6-octadienyl propionate		light								
30.66	2-tridecanone	old hop									
31.49	Unknown									fruity	light

7.3.6 Sulphur compounds (thiols)

Sulphur compounds occur in hops in the ppb range and are very aroma-active. In the pure state, these compounds are malodorous, but, when present in trace amounts, they must be assessed as by all means positive (e.g. skatole in Chanel N°5). Their odour detection threshold is very low. The sulphur compounds have been the subject of numerous recent publications. Dr. Coelhan has conducted initial informative tests using a GC equipped with a flame-photometric detector. According to the literature, the substance 4-mercapto-4-methyl-2-pentanone (4MMP) is typical of the Cascade variety. A standard is available in Hüll. As yet, it has not been possible to identify this compound using a GC-FID. Apart from other sulphur compounds not yet identified, methyl sulfide and dimethyl sulfide have been detected in headspace GC-FPD chromatograms (Fig. 7.7).

More detailed research into the sulphur compounds in hops would have exceeded the scope of this project and will be performed in a follow-on project.

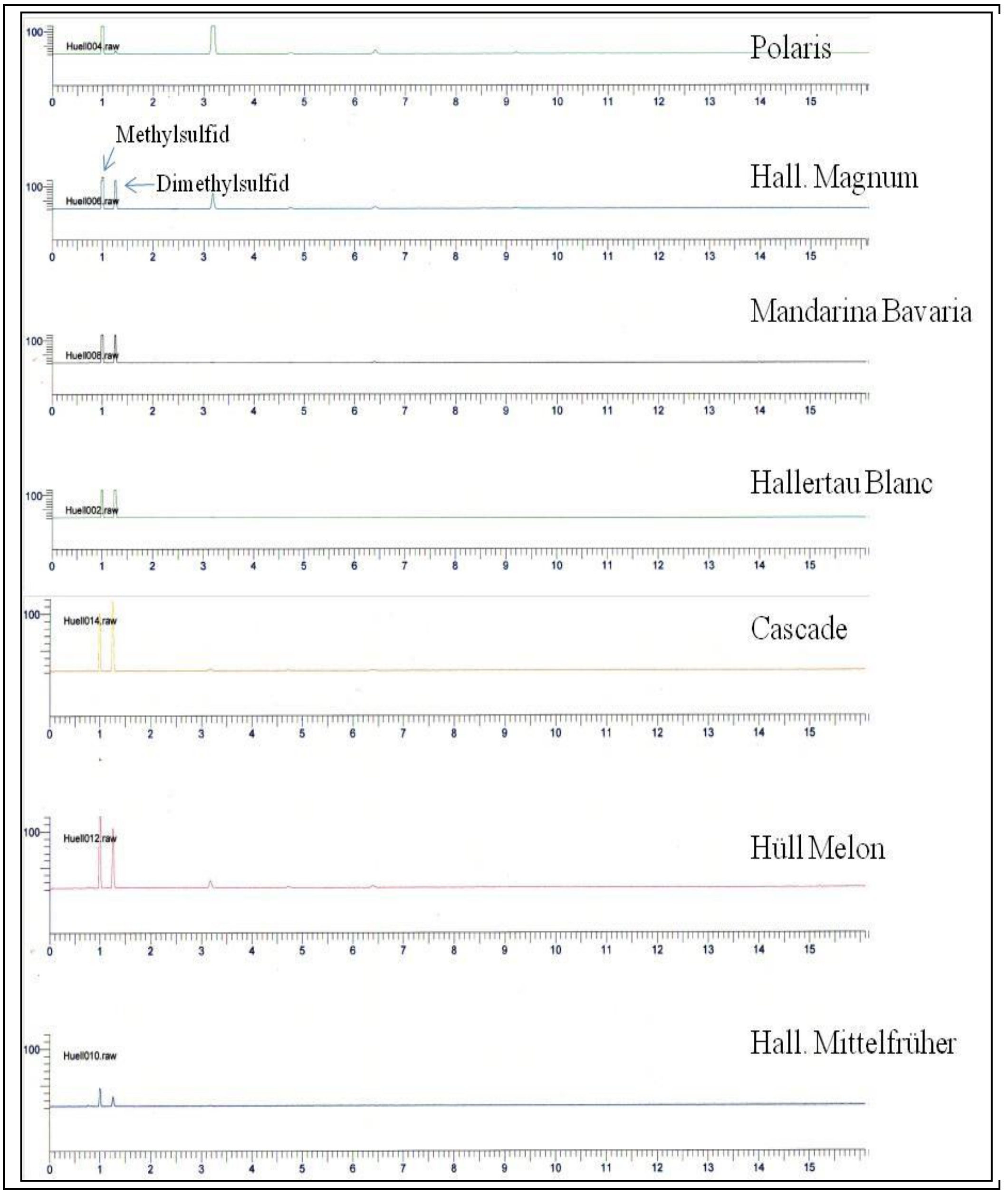


Fig. 7.7: Chromatograms recorded with a flame-photometric detector

7.3.7 Ring analyses of the 2013 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 2013, 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 2013 ring analyses:

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

The ring analyses commenced on 10th September 2013 and ended on 8th November 2013, as most of the hop lots were 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 34 samples were analysed in 2013.

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. 7.8. 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.

No. 13: HSD (01.10.2013)

Laboratory	KW		Mean	s	cvr
1	3.49	3.51	3.50	0.014	0.4
2	3.39	3.44	3.42	0.035	1.0
3	3.63	3.56	3.60	0.049	1.4
4	3.46	3.36	3.41	0.071	2.1
5	3.59	3.59	3.59	0.000	0.0
6	3.43	3.51	3.47	0.057	1.6
7	3.46	3.47	3.47	0.007	0.2

Mean	3.49
sr	0.042
sL	0.069
sR	0.081
vkr	1.19
vkR	2.32
r	0.12
R	0.23
Min	3.36
Max	3.63

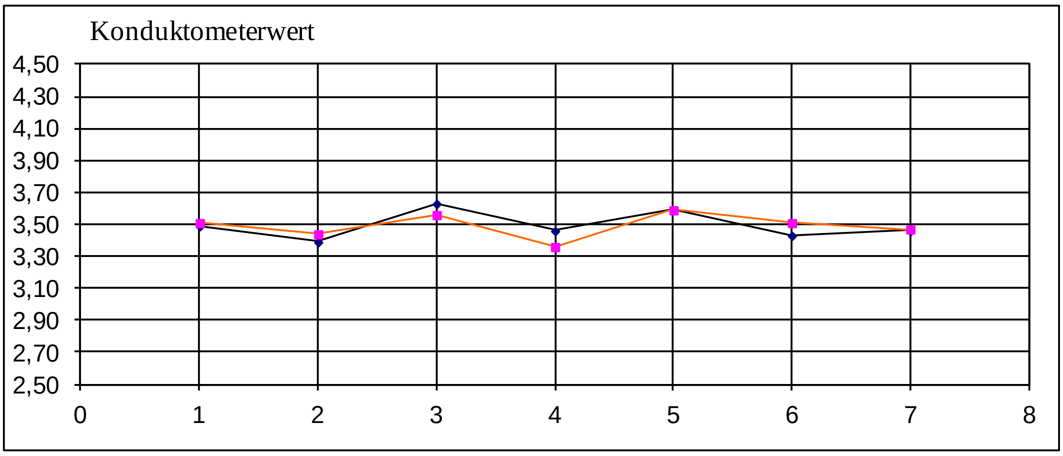


Fig. 7.8: Evaluation of a ring analysis

The outliers in 2013 are compiled in Tab. 7.5

Tab. 7.5: Outliers in 2013

	Cochran		Grubbs	
Sample	α = 0.01	α = 0.05	α = 0.01	α = 0.05
30	0	1	0	1
Total:	**0**	**1**	**0**	**1**

The IPZ 5d Work Group (WG Hop Quality and Analytics) decided to update the existing analytical tolerances, as new varieties with higher alpha-acid contents had changed the alpha ranges. There are now 5 alpha-acid classes and newly calculated CD tolerance limits (Tab. 7.6). The new alpha-acid classes and calculation of the new CD values were based on the results of the ring analyses performed by the Hüll laboratory from 2005-2012. The new classes and the outliers in 2013 are shown in Tab. 7.6.

Tab. 7.6: Updated alpha-acid classes and tolerance limits and outliers in 2013

	< 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 2013	0	0	0	0	0

In 2013, there were no outliers. Fig. 7.9 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 %. The chart clearly shows whether a laboratory tends to arrive at values that are too high or too low.

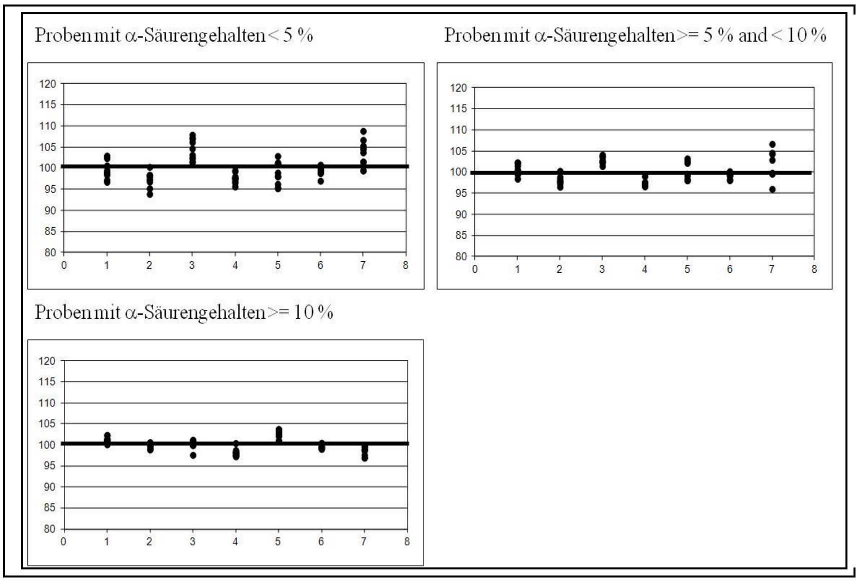


Fig. 7.9: Analysis results of the laboratories relative to the mean

The Hüll laboratory is number 5.

7.3.8 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. 7.7). The 2013 results are shown in Tab. 7.7. Since 2005, all initial test results have been confirmed.

Tab. 7.7: 2013 post-analyses

Sample designation	Initial test laboratory	Initial test	Post analysis 1	2	3	Mean value	Result confirmed
KW 37 HHT 1	HHV Au	4.8	4.6	4.7	4.8	4.70	yes
KW 37 HHT 2	HHV Au	4.8	4.6	4.7	4.9	4.73	yes
KW 37 HNB	HHV Au	6.0	5.8	5.8	6.2	5.93	yes
QK 896 HHT	NATECO2 Wolnzach	4.6	4.3	4.3	4.4	4.33	yes
QK 919 HPE	NATECO2 Wolnzach	5.5	5.3	5.3	5.3	5.30	yes
QK 925 HNB	NATECO2 Wolnzach	7.3	6.8	6.9	7.1	6.93	yes
HMR-KW 39	HVG Mainburg	10.0	9.7	10.0	10.1	9.93	yes
HHM-KW 39	HVG Mainburg	11.3	11.4	11.5	11.6	11.50	yes
HHT-KW 39	HVG Mainburg	6.4	6.2	6.3	6.4	6.30	yes
KW 40 HNU	HHV Au	9.6	9.4	9.6	9.7	9.57	yes
KW 40 HHM	HHV Au	12.5	12.3	12.3	12.4	12.33	yes
KW 40 HHS	HHV Au	16.3	16.0	16.2	16.3	16.17	yes
QK 2664 HHM 1	NATECO2 Wolnzach	13.1	12.7	12.8	12.9	12.80	yes
QK 2653 HHM 2	NATECO2 Wolnzach	12.9	12.6	12.6	12.7	12.63	yes
QK 2671 HHS	NATECO2 Wolnzach	14.9	14.4	14.5	14.5	14.47	yes
HHM-KW 41	HVG Mainburg	11.6	11.6	11.6	11.6	11.60	yes
EHM–KW 42	HVG Mainburg	13.4	13.0	13.0	13.1	13.03	yes
HHM-KW 42	HVG Mainburg	12.0	11.7	11.7	11.8	11.73	yes
KW 43 HHM 1	HHV Au	10.6	10.6	10.6	10.8	10.67	yes
KW 43 HHM 2	HHV Au	12.7	12.5	12.6	12.7	12.60	yes
KW 43 HHS	HHV Au	15.7	15.5	15.5	15.5	15.50	yes
QK 3701 HNU 1	NATECO2 Wolnzach	10.8	10.5	10.7	10.8	10.67	yes
QK 3702 HNU 2	NATECO2 Wolnzach	8.4	7.9	8.0	8.2	8.03	yes
QK3701 HNU 4	NATECO2 Wolnzach	9.9	9.5	9.5	9.6	9.53	yes
HHM 1-KW 44	HVG Mainburg	12.4	12.2	12.3	12.4	12.30	yes
HHM 2 KW 44	HVG Mainburg	12.5	12.5	12.6	12.6	12.57	yes
HHS 2-KW44	HVG Mainburg	15.1	15.0	15.1	15.1	15.07	yes

7.4 Production of pure alpha acids and their orthophenylendiamine complexes for monitoring and calibrating the HPLC standards

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 orthophenylenediamine complex is first prepared from a CO_2 hop extract with a high α-acid content by reaction with orthophenylenediamine (Fig. 7.10).

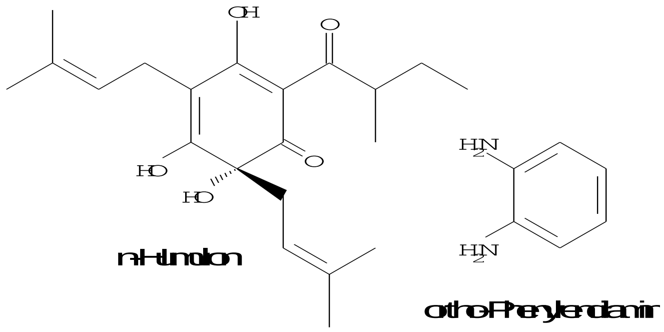


Fig. 7.10: ortho-phenylenediamine complex and its chemical structure

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.

7.5 Biogenesis of the Hüll "Special-Flavor Hops"

Research into the biogenesis of the essential oils and alpha-acids was once again conducted in 2013. Fig. 7.11 shows total oils; this time, the Hüll Melon variety was also included in the analysis.

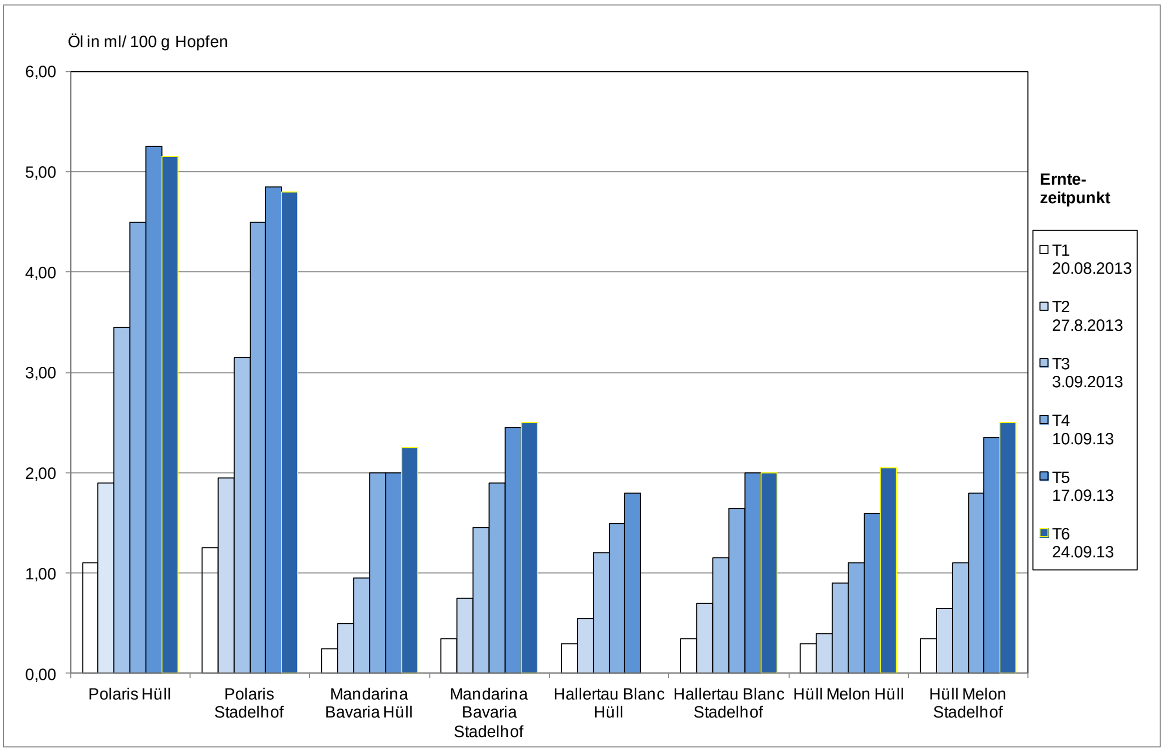


Fig. 7.11: Biogenesis of total-oil content of the new Hüll "Special Flavor Hops"

2013 was characterised by a long dry period. However, as there was sufficient rain in early September, total-oil levels made up ground and rose to their levels of 2012. Fig. 7.12 shows the biogenesis of alpha-acids.

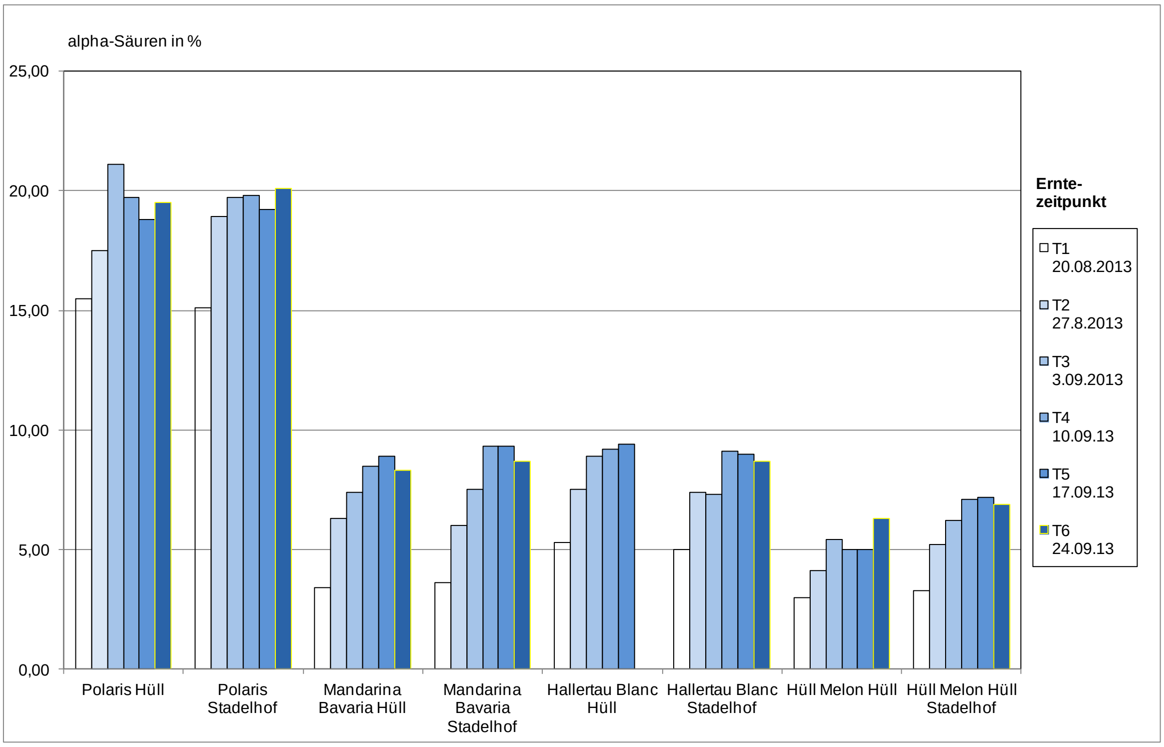


Fig. 7.12: Biogenesis of alpha-acids in the new Hüll "Special Flavor Hops"

The time of harvesting plays a less important role in alpha-acid content than in total-essential-oil content. As with all hop varieties, alpha-acid levels were lower than those of the previous year.
Evaluation of the individual oil components is still outstanding and will be published in the next annual report.

7.6 Analyses for Work Group 3d, "Medicinal and Aromatic Plants"

The following special analyses were performed for Work Group 3d, 'Medicinal and Aromatic Plants':
Salvia miltiorrhiza: 60 duplicate determinations of tanshinone

7.7 Monitoring of 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)	14
of which complaints	0

8 Publications and specialist information

8.1 Overview of PR activities

	Number		Number
Practice-relevant information and scientific articles	50	Guided tours	50
LfL publications	3	Exhibitions and posters	10
Press releases	-	Basic and advanced training sessions	5
Radio and TV broadcasts	5	Final-year university degree theses	-
Conferences, trade events and seminars	17	Participation in working groups	30
Talks	109	Foreign guests	265

8.2 Publications

8.2.1 Practice-relevant information and scientific papers

Cocuzza, S., Lutz, A. Müller-Auffermann, K. (2013): Influence of Picking Date on the Initial Hop Storage Index of Freshly Harvested Hops. Master Brewers Association of the Americas - Technical Quarterly, 50 (2), MBAA TQ, Edit.: Master Brewers Association of the Americas, 66 - 71

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Oberhollenzer, K. (2013): Histochemical and molecular studies of the interaction of hop with the hop powdery mildew fungus. Disssertation, Munich Technical Univ., Chair of Phytopatologie, 1 - 98

Oberhollenzer, K., Seigner, E., Eichmann, R,. Hückelhoven, R. (2013): Technique to Assess Gene Function in Hop (Humulus lupulus L.) - Powdery Mildew Interactions. Acta Horticulturae, 1010, Proceedings of the IIIrd International Humulus Symposium, Edit.: ISHS (International Society for Horticultural Science), J. Patzak and A. Koutoulis, 59 - 66

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8.2.2 LfL publications

Name	Work Group	LfL publications	Title
Hops Department IPZ 5	IPZ 5	LfL-Information (LfL publication)	Annual Report 2012 – Special Crop: Hops
Hops Department IPZ 5	IPZ 5	LfL flyer	Hopfen - Krankheiten - Schädlinge, Nichtparasitäre Schadbilder (Hops – Diseases – Pests – Non-parasitic forms of damage)
Portner, J.	IPZ 5a	LfL-Information	Hopfen 2013 - Grünes Heft (Hops 2013 – “Green Leaflet”)

8.2.3 Radio and TV broadcasts

Name/WG	Date of broadcast	Topic	Title of programme	Station
Lutz, A. IPZ 5c	23.04.2013	Special Hüll flavor hops		Radio Trausnitz
Lutz, A. IPZ 5c	02.06.2013	Four new flavor-hop varieties	B2	BR (Bavarian Broadcasting)
Weihrauch, F., IPZ 5b	26.08.2013	Guided hop tour	Teleschau	intv
Kammhuber, K., IPZ 5d and Möller, M. (GfH)	12.09.2013	Spotlight on hops	Die Abendschau	BR
Lutz, A., IPZ 5c and Doleschel, P., IPZ 5	12.09.2013	Hops – the green multitalent	Die Abendschau - Der Süden	BR

8.3 Conferences, talks, guided tours and exhibitions

8.3.1 Conferences, trade events and seminars

Organised by	Topic	Participants	Date/Venue
Seigner, E., IPZ 5	International Hop Growers’ Convention – Proceedings of the Scientific Commission	Hop scientists and experts from the hops and brewing industriese	04.- 08.06.2013 Kiew, Ukraine
Münsterer, J., IPZ 5a	Seminar: “Fundamentals of hop drying”	All German hop growers	17.01.2013 Wolnzach
Münsterer, J., IPZ 5a	Seminar: : “Fundamentals of hop drying”	All German hop growers	18.01.2013 Wolnzach
Münsterer, J., IPZ 5a	Optimising hop drying	Hop growers with comparable drying systems	05.02.2013 Wolnzach
Münsterer, J., IPZ 5a	Optimising hop drying	Hop growers with comparable drying systems	06.02.2013 Wolnzach
Münsterer, J., IPZ 5a	Optimising belt dryers for hops	Hop growers with belt dryers	07.02.2013 Wolnzach
Münsterer, J., IPZ 5a	Seminar: “Fundamentals of hop drying and conditioning”	All German hop growers	19.03.2013 Wolnzach
Münsterer, J., Graf, T., IPZ 5a	Workshop: “Irrigation”	Hop growers with irrigation means	28.06.2013 Karpfenstein
Niedermeier, E., IPZ 5a	Workshop: “Wilt”	Hop growers in the Hallertau growing area	25.-26.01.2013 Wolnzach
Niedermeier, E., IPZ 5a	Fundamentals of hop fertilisation and suitable fertilisers	Young Hop Growers’ Association – Hallertau growing area	25.03.2013 Wolnzach

Organised by	Topic	Participants	Date/Venue
Portner, J., IPZ 5a	Meeting “Grünes Heft” (Green Leaflet) Hops 2013	Colleagues from hop research and consultancy in Germany	04.03.2013 Hüll
Sichelstiel, W., Weihrauch, F. IPZ 5b	Work session: Commodity Expert Group Minor Uses Hops	International plant protection experts for hops	04.06.2013
Sichelstiel, W., Schwarz, J. IPZ 5b	Work session: Commodity Expert Group Minor Uses Hops	International plant protection experts for hops	08.-09.10.2013
Weihrauch, F. IPZ 5b	Work session: Commodity Expert Group Minor Uses Hops	International plant protection experts for hops	19.-20.02.2013
Lutz, A., IPZ 5c	Workshop: Experience sharing in the growing of special-flavor hops	Hop growers with experience in growing special-flavor hops	13.08.2013 Hüll
Lutz, A., IPZ 5c Portner, J., IPZ 5a	Workshop for growers of special-flavor hops	Hop growers with experience in growing special-flavor hops	13.08.2013 Hüll
Kammhuber, K., IPZ 5d	Assessment of hop samples from German hop-growing areas	Hop experts, hop growers, hop traders, brewers	16.10.2013 Hüll

8.3.2 Talks

WG	Name	Topic	Organiser Attendees	Date	Venue
IPZ 5a	Fuß, S.	Marginal cost calculation (hops) on the Internet	Niederlauterbach Quality Hops interest grou (IGN) 24 IGN members	13.03.13	Niederlauter-bach
IPZ 5a	Fuß, S.	Marginal cost calculation (hops) on the Internet	Young Hop Growers’ Association (Hopfenring e.V.) 20 members of the association	12.06.13	Wolnzach
IPZ 5a	Münsterer, J.	Trials aimed at optimising drying and picking techniques	LfL 5 LfL employees, Doctor Petr Hermanek, Czech University of Life Sciences Prague	21.03.13	Wolnzach
IPZ 5a	Münsterer, J.	Optimisation of hop drying	Comptoir Agricole 15 members of the Alsatian hop producers’ cooperative “Cophoudal/Comptoir”	11.07.13	Strasbourg
IPZ 5a	Münsterer, J.	Optimal hop drying – in 2013 still an ongoing challenge	IGN 42 members of the IGN, the Niederlauterbach Quality Hops interest group	23.10.13	Niederlauter-bach
IPZ 5a	Münsterer, J.	Evaluating field records with the new Bavarian hop-card-index (HSK) recording and evaluation program	LfL 25 members of the HSK working group	10.12.13	Wolnzach
IPZ 5a	Niedermeier, E.	Wilt: research status and control measures	Förderkreis Hopfen, Jura 112 hop farmers in the Hallertau growing region	01.02.13	Marching
IPZ 5a	Niedermeier, E.	Nutrient interplay	Bioland 30 organic hop farmers	06.02.13	Plankstetten monastery
IPZ 5a	Niedermeier, E.	Requirements for healthy planting stock (plant passport)	LfL + AELF Erding (nat. office for food, agric. and forestry) 60 hop farmers from the Hallertau growing area	18.02.13	Osseltshausen
IPZ 5a	Niedermeier, E.	Requirements for healthy planting stock (plant passport)	LfL + AELF Pfaffenhofen/Ilm 65 hop growers from the Hallertau growing area	19.02.13	Lindach

WG	Name	Topic	Organiser Attendees	Date	Venue
IPZ 5a	Niedermeier, E.	Requirements for healthy planting stock (plant passport)	LfL + AELF Abensberg 65 hop growers from the Hallertau growing area	19.02.13	Mainburg
IPZ 5a	Niedermeier, E.	Requirements for healthy planting stock (plant passport))	LfL + AELF Landshut 40 hop farmers from the Hallertau growing area	22.02.13	Oberhatzkofen
IPZ 5a	Niedermeier, E.	Requirements for healthy planting stock (plant passport)	LfL + AELF Roth 20 hop farmers from the Hallertau/ Hersbruck growing area	25.02.13	Hedersdorf
IPZ 5a	Niedermeier, E.	Requirements for healthy planting stock (plant passport)	LfL + AELF Roth 45 hop farmers from the Spalt growing area	25.02.13	Spalt
IPZ 5a	Niedermeier, E.	Requirements for healthy planting stock (plant passport)	LfL + AELF Abensberg 45 hop farmers from the Hallertau growing area	26.02.13	Biburg
IPZ 5a	Niedermeier, E.	Requirements for healthy planting stock (plant passport)	LfL + AELF Pfaffenhofen/Ilm 90 hop farmers from the Hallertau growing area	27.02.13	Niederlauter-bach
IPZ 5a	Niedermeier, E.	Requirements for healthy planting stock (plant passport)	LfL + AELF Abensberg 70 hop farmers from the Hallertau growing area	28.02.13	Marching
IPZ 5a	Portner, J.	The situation concerning heavy metal content in hop shoots	ARGE Hopfenland Hallertau (working partnership) 10 members of ARGE Hopfenland Hallertau	29.01.13	Pfaffenhofen
IPZ 5a	Portner, J.	Cutting hop pesticides consumption through use of sensors	BayWa 28 BayWa employees	05.02.13	Mainburg
IPZ 5a	Portner, J.	Cutting hop pesticides consumption through use of sensors	Beiselen GmbH 25 employees of the rural trading company	08.02.13	Hebrontshausen
IPZ 5a	Portner, J.	The situation concerning heavy metal content in hop shoots	ARGE Hopfenland Hallertau 10 producers and publicans	08.02.13	Wolnzach
IPZ 5a	Portner, J.	Cutting hop pesticides consumption through use of sensors	LfL + AELF Erding 60 hop farmers from the Hallertau growing area	18.02.13	Osseltshausen
IPZ 5a	Portner, J.	Registration of hop plant protectives in 2013	LfL + AELF Pfaffenhofen/Ilm 65 hop farmers from the Hallertau growing area	19.02.13	Lindach
IPZ 5a	Portner, J.	Cutting hop pesticides consumption through use of sensors	LfL + AELF Abensberg 65 hop farmers from the Hallertau growing area	19.02.13	Mainburg
IPZ 5a	Portner, J.	Cutting hop pesticides consumption through use of sensors	LfL + AELF Landshut 40 hop farmers from the Hallertau growing area	22.02.13	Oberhatzkofen
IPZ 5a	Portner, J.	Cutting hop pesticides consumption through use of sensors	LfL + AELF Roth 20 hop growers in the Hersbruck region of the Hallertau	25.02.13	Hedersdorf
IPZ 5a	Portner, J.	Cutting hop pesticides consumption through use of sensors	LfL + AELF Roth 45 hop farmers from the Spalt growing area	25.02.13	Spalt

WG	Name	Topic	Organiser Attendees	Date	Venue
IPZ 5a	Portner, J.	Cutting hop pesticides consumption through use of sensors	LfL + AELF Abensberg 45 hop farmers from the Hallertau growing area	26.02.13	Biburg
IPZ 5a	Portner, J.	Cutting hop pesticides consumption through use of sensors	LfL + AELF Pfaffenhofen/Ilm 90 hop farmers from the Hallertau growing area	27.02.13	Niederlauter-bach
IPZ 5a	Portner, J.	Cutting hop pesticides consumption through use of sensors	LfL + AELF Abensberg 70 hop farmers from the Hallertau growing area	28.02.13	Marching
IPZ 5a	Portner, J.	Erosion protection in hop growing	Hallertau Hop Growers' Association (HVH) 20 HVH advisers	07.03.13	Schönram
IPZ 5a	Portner, J.	Die Welthopfensituation	LfL 10 Project partners	07.05.13	Wolnzach
IPZ 5a	Portner, J.	Cutting hop pesticides consumption by using sensor technology in row treatments	International Hop Growers' Convention (IHB) 40 hop scientists	07.06.13	Kiew
IPZ 5a	Portner, J.	Erosion protection in hop growing	LfL and Barth 12 Barth employees	09.07.13	Mainburg
IPZ 5a	Portner, J.	Latest update on plant protection	AELF 38 hop farmers	19.07.13	Spalt
IPZ 5a	Portner, J.	Measures to reduce surface run-off and erosion in hop yards	LfL 8 hop farmers in the project area	23.07.13	Aiglsbach
IPZ 5a	Portner, J.	Latest update on plant protection	LfL 60 hop farmers	07.08.13	Niederlauter-bach
IPZ 5a	Portner, J.	Latest update on plant protection	LfL + Young Hop Growers' Association (Hopfenring) 50 hop farmers	08.08.13	Niederlauter-bach
IPZ 5a	Portner, J.	Scientific review of the 2013 Moosburg Hop Show	Town of Moosburg a.d. Isar 110 visitors and guests of the Moosburger Hop Show	19.09.13	Moosburg
IPZ 5a	Portner, J.	The situation concerning heavy-metal content in hop shoots	Hopfenland Hallertau tourist assoc. (ARGE) 10 District Administrators and ARGE members	05.11.13	Freising
IPZ 5a	Portner, J.	The situation concerning heavy-metal content in hop shoots	ARGE Hopfenland Hallertau 10 producers and innkeepers	17.12.13	Wolnzach
IPZ 5a	Schätzl, J.	Latest update on fertilisation and plant protection	Hopfenring + LfL 9 Ring consultants	23.05.13	Wolnzach
IPZ 5a	Schätzl, J.	2013 plant protection update – outlook for the future	LfL and AELF Roth 56 hop farmers and guests from Spalt	29.05.13	Spalt
IPZ 5a	Schätzl, J.	2013 plant protection update	LfL + AELF Roth 56 hop farmers and guests	29.05.13	Spalt
IPZ 5a	Schätzl, J.	Rosy rustic infestation - direct and indirect control options	Hopfenring + LfL 8 Ring consultants	05.06.13	Rudertshausen
IPZ 5a	Schätzl, J.	Downy mildew warning service – introduced 30 years ago	Hopfenring 14 hop farmers	12.06.13	Wolnzach

WG	Name	Topic	Organiser Attendees	Date	Venue
IPZ 5a	Schätzl, J.	Pests and diseases – Multiple-infection problems	Hopfenring + LfL 10 Ring consultants	19.06.13	Hüll
IPZ 5a	Schätzl, J.	Latest update on plant protection and irrigation	Hopfenring + LfL 9 Ring consultants	11.07.13	Hüll
IPZ 5a	Schätzl, J.	Final plant protection measures and update on harvesting dates	Hopfenring + LfL 9 Ring consultants	21.08.13	Hüll
IPZ 5a	Schätzl, J.	Tasks and role of the organisations at the House of Hops competence centre in Wolnzach	LfL 27 attendees – Upper Bavarian cross-compliance team	02.10.13	Wolnzach
IPZ 5b	Jereb, M.	Use and establishment of predatory mites for long-term spider-mite control in hop farming	Julius Kühn Institute (JKI) 55 scientists and plant protection consultants	09.12.13	Darmstadt
IPZ 5b	Schwarz, J.	Trials in 2013 - results	2nd meeting of the CEG Minor Uses Hops - 22 international colleagues	08.10.13	Paris
IPZ 5b	Sichelstiel, W	Current PPP registration situation in hop growing and plant protection problems	IGN 35 hop farmers, IGN members	22.01.13	Niederlauter-bach
IPZ 5b	Sichelstiel, W.	Current plant protection problems in hop growing	Federal Minstry of Food, Agriculture and Consumer Protection (BMELV) 15 representatives from the licensing authorities and hop trade associations	29.01.13	Bonn
IPZ 5b	Sichelstiel, W.	2013 hop PPP registration situation	BayWa AG 20 representatives from rural trading firms	05.02.13	Mainburg
IPZ 5b	Sichelstiel, W.	2013 hop PPP registration situation	Beiselen GmbH 25 representatives from rural trading firms	08.02.13	Hebrontshausen
IPZ 5b	Sichelstiel, W.	2013 hop PPP registration situation	LfL + AELF Erding 60 hop farmers from the Hallertau hop-growing area	18.02.13	Osseltshausen
IPZ 5b	Sichelstiel, W.	2013 hop PPP registration situation	LfL + AELF Landshut 40 hop farmers from the Hallertau hop-growing area	22.02.13	Oberhatzkofen
IPZ 5b	Sichelstiel, W.	2013 hop PPP registration situation	LfL + AELF Abensberg 45 hop farmers from the Hallertau hop-growing area	26.02.13	Biburg
IPZ 5b	Sichelstiel, W.	2013 hop PPP registration situation	LfL + AELF Abensberg 70 hop farmers from the Hallertau hop-growing area	28.02.13	Marching
IPZ 5b	Sichelstiel, W.	Plant protection situation and problems for hop growers	Assoc. of German Hop Growers; 16 attendees from the Hop Growers' Assoc., the	15.05.13	Wolnzach

WG	Name	Topic	Organiser Attendees	Date	Venue
			German Hop Industry Assoc., Bayer Crop Science, Hopfenring, LfL-IPZ 5a and LfL-IPZ 5b		
IPZ 5b	Sichelstiel, W.	The official pesticide efficacy test (Mittelprüfung) in plant protection	Hopfenring 14 hop farmers	12.06.13	Hüll
IPZ 5b	Sichelstiel, W.	Update on plant protection in hop growing	Assoc. of German Hop Growers; HVG Hop Processing Cooperative, Advisory Board of the Assoc. of German Hop Growers, Supervisory Board of the HVG Hop Processing Cooperative	23.07.13	Kelheim
IPZ 5b	Sichelstiel, W.	The new plant passport procedure for hops	Assoc. of German Hop Growers; HVG Hop Processing Cooperative, Advisory Board of the Assoc. of German Hop Growers, Supervisory Board of the HVG Hop Processing Cooperative	23.07.13	Kelheim
IPZ 5b	Sichelstiel, W.	Current plant protection problems and possible solutions in hop growing	Verband Deutscher Hopfenpflanzer, Zulassungsbehörden, Pflanzenschutzindustrie, Hopfenwirtschaft	27.08.13	Wolnzach
IPZ 5b	Sichelstiel, W.	Harmonized Pesticide Availability - A New Attempt	Society of Hop Research (GfH) 18 attendees, Advisory Board GfH	19.09.13	Munich
IPZ 5b	Sichelstiel, W.	Bee monitoring in hops	Syngenta, 6 attendees, registration and specialist consultancy for special crops at Syngenta	16.10.13	Maintal
IPZ 5b	Sichelstiel, W.	Occurrence and control of soil pests in hop growing	Fed. Office of Consumer Prot. and Food Safety (BVL) 10 attendees, authorisation authorities for plant protection products (PPP)	16.12.13	Braunschweig
IPZ 5b	Weihrauch, F.	2012 trials on copper minimisation in organic hop growing	Bioland 30 organic hop farmers	06.02.13	Plankstetten monastery
IPZ 5b	Weihrauch, F.	Use of predatory-mites for spider-mite control in organic hop farming: 2012 trial results	Bioland 30 organic hop farmers	06.02.13	Plankstetten monastery
IPZ 5b	Weihrauch, F.	2013 hop PPP registration situation	LfL + AELF Pfaffenhofen/Ilm 90 hop farmers in the Hallertau hop-growing area	27.02.13	Niederlauter-bach

WG	Name	Topic	Organiser Attendees	Date	Venue
IPZ 5b	Weihrauch, F.	Downy-mildew control in organic hops with minimal use of copper fungicides – how low can we go?	International Hop Growers' Convention 51 international hop research scientists	06.06.13	Kiew
IPZ 5b	Weihrauch, F.	Economic thresholds, warning service, plant protection strategies	Hopfenring 14 hop farmers	12.06.13	Hüll
IPZ 5b	Weihrauch, F.	Results of the research programme "Organic farming 2008-2012 and the need for future research" - programme component: Potatoes, hops, medicinal and spice plants.	LfL 40 organic-farming consultants and scientists	10.07.13	Hohenbercha
IPZ 5b	Weihrauch, F.	Reducing or substituting for copper-containing PPPs in organic hop farming	Pfaffenhofen a.d. Ilm district administration and Assoc. of German Hop Growers 220 representatives from the brewing industry, trading companies, ministries and political circles	26.08.13	Hüll
IPZ 5b	Weihrauch, F.	2013 trials to minimise the use of copper in organic farming and the implementation status of the copper minimisation strategy in hop growing.	JKI and the German Organic Food Industry Federation (BÖLW) 95 organic farming consultants and scientists, representatives from the PPP industry and the authorities	05.12.13	Berlin-Dahlem
IPZ 5c	Lutz, A.	Aromas and flavours of the Hüll special-flavor hops	Presiding committee and institute heads 20 attendees	21.01.13	Freising
IPZ 5c	Lutz, A.	Special-flavor hops – new challenges	LfL and AELF Erding 60 hop farmers from the Hallertau hop-growing area	18.02.13	Osseltshausen
IPZ 5c	Lutz, A.	Special-flavor hops – new challenges	LfL and AELF Abensberg 65 hop farmers in the Hallertau hop-growing area	19.02.13	Mainburg
IPZ 5c	Lutz, A.	Special-flavor hops – new challenges	LfL and AELF Abensberg 45 hop farmers in the Hallertau hop-growing area	26.02.13	Biburg
IPZ 5c	Lutz, A.	Special-flavor hops – new challenges	LfL and AELF Pfaffenhofen/Ilm 90 hop farmers in the Hallertau hop-growing area	27.02.13	Niederlauter-bach
IPZ 5c	Lutz, A.	Special-flavor hops – new challenges	LfL und AELF Abensberg 45 hop farmers in the Hallertau hop-growing area	28.02.13	Marching
IPZ 5c	Lutz, A.	Hüll special-flavor hops – new challenges	IPZ 5c 8 employees of the Hop Breeding Research work group (IPZ 5c)	04.03.13	Hüll
IPZ 5c	Lutz, A.	Hüll special-flavor hops	GfH 100 members of the society	21.03.13	Wolnzach

WG	Name	Topic	Organiser Attendees	Date	Venue
IPZ 5c	Lutz, A.	Special-flavor hops and their role in beer aroma	LfL 18 trainees	24.04.13	Freising
IPZ 5c	Lutz, A.	Hop aroma and beer aroma	German Society of Agronomy (GPW) and Technical University of Munich (TUM) 130 participants of the GPW's 2013 annual conference, LfL and the Technology and Support Centre in Straubing	05.09.13	Freising
IPZ 5c	Lutz, A.	Special-flavor-hop breeding activities	Alt-Weihenstephaner Brauerbund, 35 members	04.11.13	Freising
IPZ 5c	Lutz, A.	Special-flavor hops – new challenges for the Hüll hop breeding team	Stadt Mainburg 25 attendees	20.11.13	Mainburg
IPZ 5c	Seefelder, S.	Research activities against hop wilt in German hop-growing regions	Scientific Commission of the IHB 49 hop scientists and experts from the hop and brewing industries	06.06.13	Kiew
IPZ 5c	Seefelder, S.	Molecular biological hop research	HVG hop producer group 9 attendees, Prof. Wünsche and Prof. Weber from the University of Hohenheim	22.11.13	Hüll
IPZ 5c	Seigner, E.	Trial cultivation of new breeding lines	GFH 10 attendees, GfH managing committee	14.01.13	Hüll
IPZ 5c	Seigner, E.	Special-flavor hops – new challenges	LfL and AELF Pfaffenhofen/Ilm 65 hop farmers from the Hallertau hop-growing area	19.02.13	Lindach
IPZ 5c	Seigner, E.	Special-flavor hops – new challenges	LfL and AELF Landshut 40 hop farmers from the Hallertau hop-growing area	22.02.13	Oberhatzkofen
IPZ 5c	Seigner, E.	Special-flavor hops	LfL and AELF Roth 35 hop farmers from the Spalt hop-growing area	25.02.13	Spalt
IPZ 5c	Seigner, E.	Special-flavor hops – new challenges	LfL and AELF Roth 21 hop farmers from the Hersbruck hop-growing area	25.02.13	Hedersdorf
IPZ 5c	Seigner, E.	Cross-breeeding activities with the Tettnanger landrace variety	Baden-Württemberg Ministry of Land and Resources 15 attendees	05.03.13	Stuttgart
IPZ 5c	Seigner, E.	LfL hop research	LfL 18 trainees	24.04.13	Freising
IPZ 5c	Seigner, E.	Breeding of special-flavor hops to pave the way to the craft brewers	Scientific Commission of the IHB 49 hop scientists and experts from the hop and brewing industries	05.06.13	Kiew
IPZ 5c	Seigner, E.	Administrative meeting of the Scientific Commission	Scientific Commission 46 hop scientists and experts from the hop and brewing industries	06.06.13	Kiew

WG	Name	Topic	Organiser Attendees	Date	Venue
IPZ 5c	Seigner, E.	Report on the meeting of the Scientific Commission in Kiew	LfL 35 attendees	07.08.13	Hüll
IPZ 5c	Seigner, E.	LfL hop research	BraufactuM; Barth-Haas-Group 40 brewers, beer-sector journalists/bloggers and representatives from hop-trading companies	04.09.13	Hüll
IPZ 5c	Seigner, E.	Hop aroma characteristics – 2013 Harvest	GfH 18 attendees; Advisory Board and members of the society	19.09.13	Munich
IPZ 5c	Seigner, E.	Molecular-biological hop research	HVG hop producer group 9 attendees, Prof. Wünsche and Prof. Weber from the University of Hohenheim	22.11.13	Hüll
IPZ 5d	Kammhuber, K.	Analytical aroma charakterisation of the new Hüll "special-flavor hops" – research status	GfH 35 members of the society	21.03.13	Wolnzach
IPZ 5d	Kammhuber, K.	Analytical aroma charakterisation of the new Hüll special-flavor hops – research status	IHB 40 hop scientists	06.06.13	Kiew
IPZ 5d	Kammhuber, K.	Improvement of aroma characterisation for Hüll special-flavor hops	Pfaffenhofen a.d. Ilm district administration 220 representatives from the brewing industry, trading companies, ministries and political circles	26.08.13	Hüll
IPZ 5d	Kammhuber, K.	The importance of hop components in beer brewing and other applications	State board for crop production in Bavaria (LKP) 40 ISI-certified hop farmers	09.12.13	Aiglsbach
IPZ, IPZ 5a, 5b	Doleschel, P.	2013 hop PPP registration situation	Hop cultivation meeting 65 practicing hop farmers	25.02.13	Hedersdorf and Spalt
IPZ, IPZ 5a, 5b, 5c, 5d	Doleschel, P.	The LfL - Hop research and consultancy in Bavaria	GfH / Mitgliederversammlung der Gesellschaft für Hopfenforschung	21.03.13	Wolnzach

8.3.3 Guided tours

WG	Guided by	Date	Topic/Title	Guests	NP	Foreign guests
IPZ 5	Lutz, A. Seigner, E. Kammhuber, K.	20.02.13	LfL hop research	TUM, Chair of Food Chemistry, Prof. Schieberle, Dr. Steinhaus; VLB-Berlin, P. Wietstock	7	No
IPZ 5	Doleschel, P. Lutz, A. Seigner, E.	11.06.13	Low-trellis system and new hop varieties	Elbe-Saale hop farmers	6	No

WG	Guided by	Date	Topic/Title	Guests	NP	Foreign guests
IPZ 5	Lutz, A. Seigner, E. Sichelstiel, W.	13.06.13	LfL hop research, flavor hops	Hopunion and Comptoir Agricole	10	Yes
IPZ 5	Portner, J. Lutz, A. Schätzl, J.	14.06.13	LfL hop research, hop breeding, plant protection, production techniques, advisory service	Pfaffenhofen vocational school	13	No
IPZ 5	Doleschel, P. Lutz, A. Seigner, E. Sichelstiel, W.	26.06.13	LfL hop research, projects funded by the Federal Agency for Agriculture and Food (BLE) and the HVG hop producer group	Federal Agency for Agriculture and Food (BLE)	6	No
IPZ 5	Seigner, E. Sichelstiel, W.	03.07.13	LfL hop research, special-flavor hops	LfL staff council	15	No
IPZ 5	Lutz, A. Kammhuber, K. Seigner, E. Sichelstiel, W.	16.07.13	LfL hop research	TUM students from the Faculty of Brewing Science and Food Technology	40	No
IPZ 5	Seigner, E. Kammhuber, K. Graf, T.	23.07.13	LfL hop research, special-flavor hops, aroma analysis, irrigation management	TUM students and Prof. Schmidhalter, Chair of Plant Nutrition	25	No
IPZ 5	Lutz, A. Schätzl, J.	26.07.13	LfL hop research, hop breeding, plant protection, hop cultivation	Students from the Pfaffenhofen School of Agriculture	15	No
IPZ 5	Doleschel, P. Lutz, A. Seigner, E. Kammhuber, K. Sichelstiel, W.	09.08.13	LfL hop research, hop breeding, plant protection, chemical analysis	Kirin Brewery, Mitsubishi Corp.	10	Yes
IPZ 5	Fuss, St. Lutz, A. Portner, J. Seigner, E.	12.08.13	Tettnang breeding programme, sensor technology, hop drying	Tettnang hop farmes	48	No
IPZ 5	Lutz, A. Seigner, E. Kammhuber, K. Sichelstiel, W.	22.08.13	LfL hop research	China Resources Brewery Group	4	Yes
IPZ 5	Seigner, E.	15.09.13	LfL hop research	Barth Haas- Group, Hop Australia	33	Yes
IPZ 5	Lutz, A., Kammhuber, K.	21.09.13	LfL hop research	Guests from Nateco	15	No
IPZ 5	Seigner, E. Sichelstiel, W. Kammhuber, K.	24.09.13	Hop research, hop breeding, plant protection, chemical analysis	Sumitomo	2	Yes
IPZ 5	Seigner, E. Sichelstiel, W. Kammhuber, K.	07.11.13	LfL hop research	VLB Berlin, Brew-master Carlsberg Asia	20	Yes
IPZ 5	Kammhuber, K. Lutz, A. Seigner, E. Sichelstiel, W.	22.11.13	LfL hop research	University of Hohenheim, Tettnang Hop Growers' Association, HVG hop producer group	5	No

WG	Guided by	Date	Topic/Title	Guests	NP	Foreign guests
IPZ 5a	Schätzl, J.	14.06.13	Information session	Vocational school pupils from the Pfaffenhofen, Freising, Eichstätt and Kehlheim districts	15	No
IPZ 5a	Münsterer, J. Portner, J.	11.07.13	Picking techniques and hop drying	Hop farmers from France	32	Yes
IPZ 5a	Schätzl, J.	26.07.13	Diseases and pests, downy-mildew warning service, current plant protection situation	Agricultural-school students	13	No
IPZ 5a	Münsterer, J.	06.08.13	Optimal hop conditioning	Association of agricultural-college gradutates (VlF)	40	No
IPZ 5a	Münsterer, J.	07.08.13	Optimal hop conditioning	Association of agricultural-college gradutates (VlF)	60	No
IPZ 5a	Schätzl, J.	16.08.13	Latest update on plant protection, hop-farmland walkthrough in Lilling	Mitarbeiter des AELF Roth/AELF Hersbruck	58	No
IPZ 5c	Seigner, E.	11.01.13	LfL hop research, breeding, plant protection, flavor hops	HVG Hop Processing Cooperative	2	No
IPZ 5c	Lutz, A.	30.01.13	New breeding lines, special-flavor hops	Veltins brewery	2	No
IPZ 5c, 5d	Seigner, E. Lutz, A. Kammhuber, K.	20.02.13	Aroma substances in hops and beer	TUM, Institutes of Food Chemistry and of Brewing and Beverage Technology; Technical University of Berlin	9	No
IPZ 5c	Lutz, A. Seigner, E.	01.03.13	Hop research Screening for powdery mildew resistance	Institute of Soil Science and Plant Cultivation, State Research Institute, University of Hohenheim	2	Yes
IPZ 5c	Lutz, A.	11.04.13	Special-flavor hops, hop breeding	Ron Barchet, US brewer	1	Yes
IPZ 5c	Lutz, A. Seigner, E.	23.04.13	Hop research, hop bree-ding, special-flavor hops	AB Inbev	4	Yes
IPZ 5c	Lutz, A.	29.04.13	Breeding, Hüll special-flavor hops	US hop farmer	1	Yes
IPZ 5c	Lutz, A. Seigner, E.	11.06.13	Dwarf hops for low-trellis cultivation	Elbe-Saale hop farmers	6	No
IPZ 5c	Lutz, A.	18.06.13	LfL hop research, novel flavor hops, beer-tasting	Frauen Union Wolnzach	35	No
IPZ 5c	Seigner, E.	02.07.13	LfL hop research, male hops, special-flavor hops	DLG - plant breeders	15	No
IPZ 5c	Lutz, A.	07.08.13	Special-flavor hop varieties	IGN-Hopfenstammtisch	35	No
IPZ 5c	Lutz, A.	07.08.13	Special-flavor hops, harvesting date	ISO-certified hop farmers, Hopfenring	80	No
IPZ 5c	Lutz, A. Sichelstiel, W.	14.08.13	LfL hop research, hop breeding, special-flavor hops	Spalt hop farmers	10	No

WG	Guided by	Date	Topic/Title	Guests	NP	Foreign guests
IPZ 5c	Seigner, E.	30.08.13	LfL hop research	Visitors to Hallertau Hop Weeks	60	No
IPZ 5c	Lutz, A.	04.09.13	LfL hop research, special-flavor hops, Hüll cultivars	Participants of the 2013 Hops Conference with Braufactum and Barth	40	No
IPZ 5c	Seigner, E. Kammhuber, K.	05.09.13	Hop research, hop breeding, plant protection, hop harvest, chemical analysis	Hop experts, beer sales representatives	10	Yes
IPZ 5c	Lutz, A.	06.09.13	Hop cultivars, hop aroma	BayWa	1	No
IPZ 5c	Lutz, A. Münsterer, J.	09.09.13	Hop drying,	A US hop farmer and a German mechanical engineer	2	Yes
IPZ 5c	Lutz, A. Seigner, E.	19.09.13	Aroma assessment of hop cultivars and breeding lines – 2013 harverst	AB InBev	10	No
IPZ 5c	Seigner, E.	22.09.13	Hop research of the LfL	AB InBev	45	Yes
IPZ 5c	Lutz, A.	25.09.13	Hop aroma evaluation	A hop expert and a craft brewer	2	Yes
IPZ 5c	Seigner, E.	27.09.13	LfL hop research	AB InBev	33	Yes
IPZ 5c	Seigner, E.	29.09.13	LfL hop research	AB InBev	48	Yes
IPZ 5c	Lutz, A.	30.09.13	Dry hopping	Krones	3	No
IPZ 5c	Lutz, A.	02.10.13	hop aroma	AB InBev	5	Yes
IPZ 5c	Seigner, E. Lutz, A.	18.11.13	Hop breeding, special-flavor hops, aroma and beer	Carolyn Beeler, Agence France-Presse	1	Yes
IPZ 5d	Kammhuber, K.	23.08.13	Laboratory work on plant protection	Labor Sofia	2	No

8.3.4 Exhibitions and posters

Name of the exhibition	Exhibition objects and topics/posters	Organised by	Duration	WG
11th Intern. Verticillium Symposium, Göttingen	Molecular in planta test for the detection of *Verticillium* pathotypes in hops and initial steps towards biological control	German Phytomedical Society (DPG)	05.-08.05.2013	IPZ 5c
International Hop Growers' Convention (IHB), Kiew, Ukraine	Monitoring of hop stunt viroid and dangerous viruses in German hop gardens	Scientific Commission of the IHB	06.06.2013	IPS 2c and IPZ 5c
International Hop Growers' Convention (IHB), Kiew, Ukraine	EU Commodity Expert Group Minor Uses Hops - A cooperation to close gaps and harmonize plant protection at EU level	Scientific Commission of the IHB	06.06.2013	IPZ 5b
Guided hop tour of the Tettnang Hop Growers' Association, Hüll	Cross breeding with the Tettnanger landrace	Tettnang Hop Growers' Association	12.08.2013	IPZ 5c
Drinktec, Munich	Special-flavor hops - hop aroma and aroma in beer	Messe München GmbH	16.-20.09.2013	IPZ 5c
Drinktec, München	Special-flavor hops - hop aroma and aroma in beer	Messe München GmbH	16.-20.09.2013	IPZ 5c

Name of the exhibition	Exhibition objects and topics/posters	Organised by	Duration	WG
Craft Brewers Conference, Washington, D.C., USA	Hallertau Blanc – Special-flavor aroma and brewing trials	US Brewers Association	26.-30.09.2013	IPZ 5c
Craft Brewers Conference, Washington, D.C., USA	Huell Melon - Special-flavor aroma and brewing trials	US Brewers Association	26.-30.09.2013	IPZ 5c
Craft Brewers Conference, Washington, D.C., USA	Mandarina Bavaria - Special-flavor aroma and brewing trials	US Brewers Association	26.-30.09.2013	IPZ 5c
Craft Brewers Conference, Washington, D.C., USA	Polaris - Special-flavor aroma and brewing trials	US Brewers Association	26.-30.09.2013	IPZ 5c

8.4 Basic and advanced training

Name, WG	Topic	Target group
Münsterer, J., Schätzl, J., IPZ 5a	04.07.2013 – Final professional-farming examination, Attenhofen	Examination candidates from the Pfaffenhofen, Freising and Kehlheim districts + AELF Abensberg
Portner, J., IPZ 5a	07. to 28.11.2013 – Hop-production training for farmers, Abensberg	23 farmers
Portner, J., IPZ 5a	15. to 18.10.2013 – Hop-growing instruction, Pfaffenhofen	17 farmers
Schätzl, J. IPZ 5a	14.06.2013 – Info session for vocational-school students	15 students
Schätzl, J. IPZ 5a	26.07.2013 – Farming instruction	13 agricultural-school students

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)
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"
Sichelstiel, W.	Member	Society of Hop Research
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	Society of German-Speaking Odonatologists
Weihrauch, F.	Member	German Society for Tropical Ecology
Weihrauch, F.	Member	Society of Hop Research
Weihrauch, F.	Member	Münchner Entomologische Gesellschaft e.V.
Weihrauch, F.	Editorial board member	Worldwide Dragonfly Society

9 Current research projects financed by third parties

WG Project manager	Project	Dur- ation	Cooperation	Sponsor
IPZ 5a J. Portner	Optimisation of irrigation management in hop growing	2011- 2014	Dr. Michael Beck - Weihenstephan-Triesdorf Univ., Dept. of Hort; Prof. Urs Schmidhalter - Munich Tech. Univ., Plant Nutrition; Christian Euringer - ATEF.ONE GmbH; Dr. Erich Lehmair - HVG, Wolnzach	Deutsche Bundesstiftung Umwelt (DBU)
IPZ 5a J. Portner	Development and optimisation of an automatic hop-picking machine	2011- 2013	ILT, Freising Fuß - Fahrzeug- und Maschinenbau GmbH & Co. KG, Schkölen	Bundesanstalt für Landwirtschaft und Ernährung (BLE) *(Federal Agency for Agriculture and Food)*, project sponsor: innovation funding
IPZ 5b Dr. F. Weihrauch	Reducing or replacing copper-containing PPPs in organic hop farming	2010- 2014	An organic hop farmer	Bundesanstalt für Landwirtschaft und Ernährung (BLE)
IPZ 5b Dr. F. Weihrauch	Use and establishment of predatory-mite populations for sustained spider-mite control in hop farming	2013- 2016		Bundesanstalt für Landwirtschaft und Ernährung (BLE)
IPZ 5c Dr. S. Seefelder	Genotyping of *Verticillium* pathotypes in the Hallertau	2008- 2013	Dr. Radisek, Slovenian Institute of Hop Research and Brewing, Plant Protection Department, Zalec, Slowenia; Prof. G. Berg, Graz University of Technology, Environmental Biotechnology, Graz, Austria	Wissenschaftsförderung der Deutschen Brauwirtschaft; (Wifö) *(Scientific Promotion of the German Brewing Industry)*; HVG Erzeuger-gemeinschaft Hopfen e.G. *(HVG hop producers' group)*
IPZ 5c Dr. E. Seigner, A. Lutz	PM isolates and their use in breeding PM-resistant hops	2006- 2014	EpiLogic GmbH, agrobiological research and consultancy, Freising	Society of Hop Research (GfH); HVG Erzeugergemeinschaft Hopfen e.G.; Wissenschaftliche Station für Brauerei in München *(Scientific Station for Brewing in Munich)*
IPZ 5c Dr. E. Seigner, A. Lutz und IPS 2c Dr. L. Seigner	Monitoring for dangerous hop virus and viroid infections in Germany	2011- 2014	Hop-growing consultants	Wissenschaftliche Station für Brauerei in München e.V. *(Scientific Station for Brewing in Munich)*

WG Project manager	Project	Dur-ation	Cooperation	Sponsor
IPZ 5c Dr. E. Seigner, A. Lutz	Cross breeding with the Tettnanger landrace	2011-2016	Straß experimental station, Franz Wöllhaf	Ministerium für ländlichen Raum, Verbraucherschutz und Ernährung, Baden-Württemberg; (MLR-BW) *(Ministry of Rural Affairs, Food and Consumer Protection)*; Hopfenpflanzerverband Tettnang *(Tettnang Hop Growers' Assoc.);* HVG Erzeugergemeinschaft Hopfen e.G.; Society of Hop Research
IPZ 5c Dr. E. Seigner, A. Lutz	Continuation of the "Special-Flavor Hops" breeding programme	2012-2013		HVG Erzeugergemeinschaft Hopfen e.G.
IPZ 5d Dr. K. Kammhuber	Improving aroma characterisation of the new Hüll Special-Flavor Hops	2012-2013	Dr. Coelhan, Munich Technical University	HVG Erzeugergemeinschaft Hopfen e.G.

10 Main research areas

WG	Project	Dur-ation	Cooperation
5a	Testing of the Adcon weather model for the downy-mildew warning service	2008-2013	Hopfenring e. V., Wolnzach
5a	Testing and establishing technical aids for optimising the drying and conditioning of hops	2003-2015	
5a	Evaluation of the specific water requirements of different hop varieties irrigated as a function of soil moisture tension	2012-2014	
5a	Hallertauer model for resource-saving hop cultivation	2010-2014	Landesamt für Wald- und Forstwirtschaft; Bavarian 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. for Agricultural Ecology, Organic Farming + Soil Protection (IAB)
5b	Documentation of the worldwide organic hop-growing situation	2011-	Joh. Barth & Sohn GmbH & Co. KG, Nuremberg
5b	Click-beetle (Elateridae) monitoring and diagnosis in Hallertau hop yards	2010-	Julius Kühn Institute, Braunschweig Syngenta Agro GmbH, Maintal
5c	Brewing trials with special-flavor hops – the LfL as brewers' cooperation partner	2011-	IPZ 5d; hop-trading companies; Assoc. of German Hop Growers; Munich Technical University, Chair of Brewing and Beverage Technology; breweries worldwide
5c	Promoting quality through the use of molecular techniques to differentiate between hop varieties	2007-2022	The GfH's propagation facility; hop trade

WG	Project	Dur-ation	Cooperation
5c	Development and optimisation of screening systems for assessing hop tolerance towards downy mildew	2012-2014	Prof. Dr. Thomas Ebertseder, Weihenstephan-Triesdorf University, Department of Agriculture and Food Economy
5c	In situ maintenance and expansion of the Bavarian hop gene pool	2001-2025	
5c	Meristem cultures for producing healthy hop planting stock	2008-2016	IPS 2c - Seigner, L. amd team IPZ 5b - Ehrenstraßer, O.
5c	Testing planting stock for *Verticillium*	2013-2022	
5c	Breeding of hops with special components	2006-	BayWa, Dr. Dietmar Kaltner; HVG Hop Processing Cooperative; Hopsteiner, Dr. Martin Biendl; Barth-Haas Group, Dr. Christina Schönberger
5c	Breeding of hop cultivars particularly suited to low-trellis cultivation	2012-2020	
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	Ring tests for checking and standardising important analytical parameters within the AHA laboratory (e.g. linalool, nitrate, HSI)	Ongoing	AHA working group
5d	Varietal authenticity checks for the food control authorities	Ongoing	Landratsämter (Lebensmittel-überwachung) *(District food control authorities)*

11 Personnel at IPZ 5 – Hops Department

The following staff members were employed at the Bavarian State Research Centre for Agriculture, Institute for Crop Science and Plant Breeding, at Hüll, Wolnzach and Freising in 2013 (WG = Work Group):

IPZ 5

Coordinator:
Directorat the LfL Dr. Doleschel Peter (provisionally)

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
LAR Niedermeier Erich (until 30.06.13)
LR Schätzl Johann

IPZ 5b

WG Plant Protection in Hop Growing
LD Sichelstiel Wolfgang

LTA Ehrenstraßer Olga
Felsl Maria
Dipl.-Ing. (FH) Jereb Marina (as of 01.06.13)
LI Meyr Georg
Dipl.-Ing. (FH) Schwarz Johannes
Weiher Johann
Dr. rer. nat. Weihrauch Florian

IPZ 5c

WG Hop Breeding Research
RD Dr. Seigner Elisabeth

Dandl Maximilian
CL Eichinger Barbara (06.02. to 14.04.13)
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
MS Biotech. (Univ.) Maurer Katja
Pflügl Ursula
Presl Irmgard
B.Sc. Schmid Helena (until 31.07.13)
ORR Dr. Seefelder Stefan
Suchostawski Christa

IPZ 5d

WG Hop Quality and Analytics
ORR Dr. Kammhuber Klaus

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