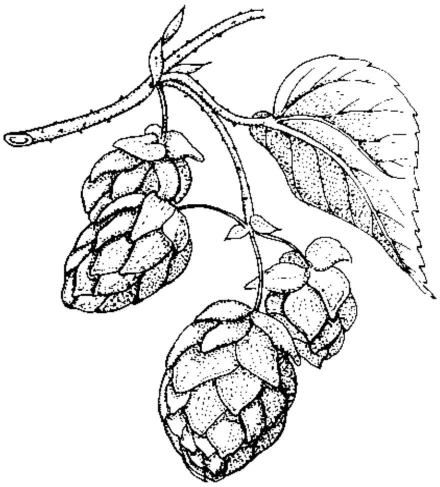
Bayerische Landesanstalt für Landwirtschaft

Gesellschaft für Hopfenforschung e.V.

Annual Report 2009

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

Translated by: J. Pockrandt (B.Sc.) and M. Eisenberger (B.A. Hons.)

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Mastering Challenges Through Research

The Annual Report of the Hüll Hop Research Centre documents the comprehensive research and experimental activities performed by the centre for the hop growing sector. In a pioneering public-private partnership, the Free State of Bavaria, represented by the Institute for Crop Science and Plant Breeding of the LfL, and the Society of Hop Research work together with the mutual aim of finding solutions to topical issues surrounding the future of hops.

The small village of Hüll, situated near Wolnzach in the Hallertau region, has been <u>the</u> centre of hop research in Germany since 1926. At that time, a previously unknown disease, *Pseudoperonospora humuli*, threatened the future existence of the hop growing industry and the supply of breweries with this characteristic raw material for brewing beer. The Society of Hop Research was founded above all by brewers, concerned about the supply of hops. Today it is a synonym for far-sighted hops research.

New and modified plant diseases still represent a constant challenge for hop growers. The integrated approach to research pursued at Hüll has made it possible to meet these challenges unfailingly: support in the fields of production technology, plant protection, hop breeding, quality research and transfer of knowledge to actual practice, all from a well-coordinated single source. Research and experimental results are implemented rapidly and effectively to the benefit of all concerned.

The debate about climate change has also had an impact on hops research. Documented changes in regional climate place new demands on cultivation measures, plant protection and varieties. Irrigation projects and projects focussing on reduced energy consumption, sophisticated disease forecasting systems, pest control and the development of adapted varieties are the logical result.

The current market situation represents an even greater challenge for the hop growing industry in the short term. With unforeseen speed, the global hop market, previously characterised by undersupply, has evolved into a market now facing structural overproduction. As a result, hop growing is under extreme pressure to adapt, involving the need for a range of varieties fully tailored to market requirements, sophisticated cost-efficient production and uniform, reliable yields and quality.

The current research, experimental and consulting projects described in this publication meet these challenges in a far-sighted manner. For us, they are linked with the expectation and assurance that we are well prepared for the future, too. This is by no means a matter of course. The commitment and skills of our staff in Hüll, Wolnzach and Freising are an indispensable requirement for the success of our hops research and we take the opportunity to express our sincere thanks to them for their efforts.

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

Dr. Peter Doleschel
Head of the Institute for
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

Breeding of dwarf hops for low trellis systems

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtungsforschung Hopfen und AG Hopfenqualität/Hopfenanalytik *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Breeding Research and WG Hop Quality/Hop Analytics*
Financed by:	Bundesanstalt für Landwirtschaft und Ernährung (BLE) *(Federal Agency for Agriculture and Food)* HVG Hopfenverwertungsgenossenschaft e.G. *(HVG Hop Processing Cooperative)*
Project managers:	Dr. E. Seigner, A. Lutz
Project staff:	A. Lutz, J. Kneidl; A. Bogenrieder (all from IPZ 5c) Dr. K. Kammhuber, C. Petzina, B. Wyschkon, S. Weihrauch, E. Neuhof-Buckl (all from IPZ 5d)
Cooperation:	Gesellschaft für Hopfenforschung (GfH); *(Society of Hop Research)* Hop farms: J. Schrag and M. Mauermeier
Duration:	01.04.2007 - 31.12.2010

Objective

The aim of this research project is to breed hops which, by virtue of their shorter height, broad disease resistance and excellent brewing quality, are particularly suitable for profitable cultivation on low trellis systems. Until now, the absence of adapted varieties of this kind has stood in the way of achieving substantial reductions in production costs using 3-metre trellis systems. This new method of growing hops could also have considerable environmental benefits because the required pesticide and fertiliser volumes are lower. Plus, recycling tunnel sprayers can be employed and potential spray drift thus reduced.

Results

The preliminary selection of seedlings from seventeen crosses performed in 2008 (6 aroma- and 11 bitter-type) for powdery mildew (PM) resistance began in March. Of the 32,000 seedlings that came up, about 1,190 proved to be PM-resistant. In addition, 2,730 seedlings that had not been tested for PM resistance were transferred from the seed dishes to single pots. After the subsequent downy mildew test, 1,280 seedlings were planted out in the vegetation hall in mid-May.

On account of the damp autumn weather, planting out of the female seedlings in the Hüll breeding yards and of the male seedlings in the Freising breeding yard was delayed until spring.

From among 40 seedlings from nine crosses with the potential to produce dwarf progeny, four were selected during the 2008 seedling assessment in the Hüll breeding yard. In terms of potential yield, alpha-acid content and their growth properties, these four were found to be promising candidates for growing on 3-meter trellises. Once confirmed virus-free, they will be propagated in spring, allowing small-plot, low-trellis trials to be commenced in 2010.

In July, a further 21 crosses (8 aroma- and 13 bitter-type) were carried out as part of the research project. Seeds were obtained from all the crosses in autumn.

Powdery mildew 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:	Wissenschaftliche Station für Brauerei in München e.V. *(Scientific Station for Brewing in Munich)*
Project managers:	Dr. E. Seigner, A. Lutz, Dr. S. Seefelder
Project staff:	A. Lutz, J. Kneidl, Dr. S. Seefelder S. Hasyn (EpiLogic)
Cooperation:	Dr. F. Felsenstein, EpiLogic GmbH Agrarbiologische Forschung und Beratung, Freising
Duration:	01.05.2006 - 30.04.2011

Objective

Disease-resistant hop cultivars are important to growers and brewers alike. The use of innovative selection and assay methods in the greenhouse and the lab in tests for PM resistance in breeding lines, wild hops and cultivars makes it possible to breed hop cultivars that guarantee optimum brewing and food quality along with reliable supplies even in years marked by high levels of fungal attack.

Results

Currently, a range of 13 different single-conidia isolates of *Podosphaera macularis* (formerly called *Sphaerotheca humuli*), the fungus that causes powdery mildew in hops, is available as inoculation material for breeding PM-resistant cultivars. This range of PM pathotypes with characteristic virulence properties can be used to test the efficacy of all known resistance genes used in hop breeding.

The PM isolates and resistance-testing systems were used for the following purposes from February until September 2009:

- To assess the resistance properties of some 125,000 seedlings from 73 crosses, 12,300 wild hops, 214 breeding lines and 9 foreign varieties in the greenhouse and in laboratory leaf tests. The reaction to PM races already widespread throughout the Hallertau region of Bavaria was tested in the greenhouse. Fungal strains from the US and Great Britain that have not yet occurred in Germany were tested in the lab at EpiLogic so as not to endanger the hop-growing region. Assessing resistance properties in this way permits selection of hops that show broad resistance to powdery mildew. Only PM-resistant hops are used for advanced breeding purposes.
- To obtain reliable resistance data for 140 seedlings from a mapping population in order to develop molecular selection markers for two different PM resistance genes.
- To assess the virulence situation of PM populations in the Hallertau region and worldwide. This must be done every year to establish the effectiveness of the resistances shown by varieties under cultivation and by breeding stock. It has been found, for instance, that resistance in the Hüll cultivar "Hallertauer Merkur" is still fully effective, whereas in the "Herkules" cultivar, it has already broken down in certain regions.
- To characterise PM/hop interaction on and under the leaf surface. The aim is to obtain closer insight into the various resistance responses found in Hüll varieties and in breeding stock. Such knowledge is essential if different resistance mechanisms with mutually complementary effects are to be combined successfully in future varieties.
- To assess the function of suspected resistance genes using the transient leaf expression system. Gene transfer techniques are used to introduce potential resistance genes into hop leaf cells. The reactions of the fungus and of the transient transgenic leaf cell are then monitored in the lab. The main aim is to identify hop-specific genes that are involved in PM resistance and could therefore be used as selection markers in conventional resistance breeding.
- To establish a PM forecasting system and thus to ensure environmentally compatible use of plant protectives against powdery mildew.

Characterisation of hop/hop powdery mildew interaction at cell level and functional analysis of defence-related genes

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:	Erzeugergemeinschaft Hopfen HVG e.G. *(HVG hop producer group)*
Project manager:	Dr. E. Seigner
Project staff:	K. Oberhollenzer, B. Forster, A. Lutz
Cooperation:	Professor R. Hückelhoven of Munich Technical University, Chair of Phytopathology at the Wissenschaftszentrum Weihenstephan *(Centre of Life and Food Sciences)* Dr. F. Felsenstein, EpiLogic GmbH Agrarbiologische Forschung und Beratung, Freising
Duration:	01.04.2008 - 31.03.2011

Objective

The aim of this research project is to microscopically investigate the hop/hop powdery mildew interaction in various wild hop varieties from around the world that are to be used as new resistance carriers for breeding. The defence responses will be charted in terms of time and location.

A further aim is the functional characterisation of PM-defence-related genes by way of transient gene transfer at leaf level (transient assay). Gene sequences verified by this approach as having a PM-defence-related function may be of assistance in the development of reliable molecular selection markers for conventional resistance breeding. They might also be used, via gene transfer, to improve the resistance properties of hop varieties susceptible to powdery mildew.

Methods

- Inoculation of hop leaves with PM isolates
- Various staining techniques for the PM fungus and detection of hop-cell defence responses
- Microscopic investigation with fluorescence and confocal laser microscopes (Prof. Hückelhoven, Technical University Munich)
- RNA isolation and semi-quantitative PCR (polymerase chain reaction) to determine the expression of selected gene-sequences
- Transient transformation of individual epidermal cells of hop leaves using a gene gun

Results

- The microscopic investigations confirmed that different resistance mechanisms, such as apoptosis and cell-wall apposition, can be identified with the existing methods, as illustrated by the PM resistance of a wild hop variety from the USA, which was shown to be due primarily to hypersensitive hop cells that react by undergoing apoptosis. Only a few interactions here were found to involve cell-wall apposition.
  In future cross-breeding work, all the findings from this project will be used to selectively combine different resistance mechanisms with mutually complementary effects.
- It was observed for the first time in the previously investigated, phenotypically resistant hops that, although the epidermal cells are resistant, the microscopic hairs on the upper leaf surface are susceptible.
- Candidate genes for functional characterisation were selected on the basis of their sequence similarity with resistance-associated genes that have already been described for other cultivated plants. Semi-quantitative PCR provided more detailed information concerning the activity of these genes following PM infection.
  The level of expression following PM infection may be an indication of gene function in the hop/hop powdery mildew interaction. The intention is to use the most promising candidate genes for functional characterisation.

Development of molecular markers linked to powdery mildew resistance genes in hops to support breeding for resistance

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:	EHRC (European Hop Research Council - Carlsberg Breweries, Heineken, InBev (until April, 2008), Hopfenveredelung St. Johann, Hallertauer Hopfenveredelungsgesellschaft/Hopsteiner)
Project managers:	Dr. S. Seefelder; Dr. E. Seigner
Project staff:	V. Mayer, S. Petosic, J. Kneidl, Dr. S. Seefelder, A. Lutz, K. Oberhollenzer
Cooperation:	Dr. F. Felsenstein, EpiLogic GmbH Agrarbiologische Forschung und Beratung, Freising
Duration:	01.12.2004 - 30.04.2009

Objective

The aim of this research project is to develop molecular selection markers for the resistance genes of PM-resistant wild hops.

Results

The analyses were continued in 2009, building on the differential expression work conducted on genes activated by contact with powdery mildew in the case of PM-resistant hops but not of susceptible hops.

- cDNA-AFLP fragments that occur after contact with the PM fungus only in resistant hop plants and are possibly involved in the fungus defence response or in pathogen recognition were screened more closely. The search for homologies between the TDFs (transcript derived fragments) found and known resistance genes in other crop plants was continued with BLAST Search.
- A number of TDFs possibly involved in the resistance response by virtue of their expression kinetics and demonstrating sequence similarities with known resistance genes were selected for closer study of their activity patterns. This will be performed shortly in semi-quantitative PCRs. Promising gene sequences will be tested for their role in hop/hop powdery mildew interaction (see 4.2.1) using what is known as a transient knock-down approach.
- Initially, pyrosequencing was performed on the identified defence-correlated TDFs in order to screen the entire genome for SNPs (Single Nucleotide Polymorphisms, created by the exchange of individual bases). The latter might provide a means of differentiating between PM-resistant and PM-susceptible hops.

The project ended before this work could be concluded.

Genotyping of *Verticillium* pathotypes in the Hallertau – findings concerning *Verticillium*-infection risk assessment

Sponsored by: Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtungsforschung Hopfen und AG Hopfenbau/Produktionstechnuk
(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Breeding Research and WG Hop Cultivation/Production Techniques

Financed by: Erzeugergemeinschaft Hopfen HVG e.G.
(HVG hop producer group)

Project managers: Dr. S. Seefelder; Dr. E. Seigner (IPZ 5c)

Project staff: S. Petosic, Dr. S. Seefelder (both from IPZ 5c),
E. Niedermeier (IPZ 5a)

Cooperation: Dr. S. Radisek, Slovenian Institute of Hop Research and Brewing, Slovenia

Duration: 01.03.2008 - 28.02.2010

Objective

Hop wilt, caused by the *Verticillium* fungus, has been responsible for considerable yield reductions in some regions of the Hallertau since 2005. This is true even of varieties that had previously been wilt-tolerant. The purpose of this project is therefore to assess the potential risk to the Hallertau hop-growing region by investigating the race spectrum of this fungal pathogen, thus allowing suitable protective measures to be taken against the disease.

Methods

- Conventional breeding techniques to produce single-spore *Verticillium* isolates from hop bine samples
- Microscopic and molecular examinations to differentiate between *Verticillium albo-atrum* and *V. dahliae*
- Molecular analytical characterisation of the *Verticillium* isolates using AFLP and SCAR markers
- Infection test to determine virulence in Slovenia

Results

Specific, already published PCR primers were used along with AFLP markers to differentiate genetically between mild and lethal forms of *Verticillium albo-atrum.* It was shown that the German *Verticillium* isolates investigated so far are not known lethal races introduced into German hop-growing regions from the United Kingdom or Slovenia.

During subsequent intensive AFLP screening of altogether 161 *Verticillium* single-spore isolates with currently 10 AFLP primer combinations, 47 were shown to contain specific DNA fragments found neither in the other isolates from the Hallertau growing region nor in the mild English isolates, but only in lethal English and lethal Slovenian isolates.

In an initial artificial *Verticillium* infection test carried out in Slovenia, the virulence of four Hallertau *Verticillium* isolates towards varieties such as Celeia, Hallertauer Mittelfrüher, Hallertauer Tradition, Northern Brewer and Hallertauer Magnum was assessed. Besides the Slovenian reference isolates (mild and lethal), two Hallertau isolates from only slightly damaged hop yards and two from seriously damaged hop yards were used in this test. One noteworthy finding in this test was that, on average, the levels of virulence of both the mild and the more aggressive Hallertau isolates lay somewhere between those of the mild and lethal Slovenian references. These results will be verified in a repetition test.

Outlook

Culturing and genotyping of the *Verticillium* samples collected in the summer of 2009 are continuing. Centre-stage, in addition, are further artificial *Verticillium* infection tests. The intention is to use the results from these tests to help assess the extent to which the *Verticillium* race spectrum currently prevalent in the Hallertau region poses a risk to hop varieties under cultivation there. Infected hop yards are being monitored in the hope that this will help determine the extent to which the *Verticillium* infection has already spread.

Monitoring for Hop Stunt Viroid (HSVd) infections in hops in Germany

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenschutz, AG Pathogendiagnostik und Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtungsforschung Hopfen *(Bavarian State Research Center for Agriculture, Institute for Plant Protection, WG for Pathogen Diagnostics, and Institute for Crop Science and Plant Breeding, WG Hop Breeding Research)*
Financed by:	Erzeugergemeinschaft Hopfen HVG e.G. *(HVG hop producer group)*
Project managers:	Dr. L. Seigner, Institute for Plant Protection (IPS 2c); Dr. E. Seigner, A. Lutz (both from IPZ 5c)
Project staff:	M. Kappen, C. Huber, M. Kistler, D. Köhler (all from IPS 2c); M.A. Fend, student (IPS 2c) J. Kneidl (IPZ 5c)
Cooperation:	Dr. K. Eastwell, Washington State University, USA
Duration:	01.04.2009 - 30.09.2009

Objective

Hop stunt viroid (HSVd) causes huge losses in hop yield and quality and is therefore a very serious disease. It first appeared during the 1940s in Japan and Korea. HSVd infections were confirmed for the first time in US hop yards in 2004 and in China in 2007. This viroid, which is very easily spread mechanically, e.g. during cultivation, and is also spread via vegetative propagation, must be prevented from entering the country at all costs, especially since there are currently no effective chemical control agents available and HSVd infection of hop-growing areas in Germany would result in dramatic economic losses for the hops and brewing industries.

Method

To permit reliable identification of HSVd, a two-stage RT-PCR (Reverse Transcriptase Polymerase Chain Reaction) detection process using HSVd-specific primers (Eastwell und Nelson 2007) and an additional internal, hop-specific, mRNA-based RT-PCR control (Seigner et al. 2008) has been established under the direction of Dr. L. Seigner in the LfL's pathogen diagnostic lab.

Results

In 2009, 224 hop samples of various origins, including the USA, were investigated by RT-PCR. No HSVd was detected by RT-PCR in 202 of these 224 hop samples, which were taken from the Hop Research Centre's breeding yards in Hüll, from the Society of Hop Research's (GfH) Hallertau propagation facilities and from various field crops in the Hallertau, Elbe-Saale and Tettnang hop-growing regions. These hops were accordingly rated as HSVd-free. The HSVd infection status of the remaining 22 samples remained unclear because the internal, hop-specific control band that signalizes a correctly functioning PCR reaction could not be detected. Possible reasons for the unsuccessful RT-PCR reactions include leaf samples that are too old and rich in polyphenols, and/or long transport times, in which case uncooled leaf samples may have started to decompose.

These results suffice to rule out massive HSVd infestation in Germany. However, our monitoring system involving the screening of hop samples clearly has weaknesses. For this reason, HSVd monitoring will definitely continue next year, and we will endeavour to refine the method, especially for older hop samples.

Development of an innovative forecasting model for the control of powdery mildew (*Podosphaera macularis*) in hops (*Humulus lupulus*)

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)* Erzeugergemeinschaft Hopfen HVG e.G. *(HVG hop producer group)*
Project manager:	B. Engelhard
Project staff:	S. Schlagenhaufer
Duration:	01.05.2007 - 31.12.2009

Objective

Collection of basic data on the biology and epidemiology of the fungus in laboratory and field tests. Review and adaptation of a preliminary forecasting model. Introduction of a forecasting model for hop powdery mildew.

Results

Some of the experiments conducted in small climatic chambers to investigate biological references were repeated with a different objective. The major factors influencing infection levels were confirmed: temperature, day/night temperature difference and light intensity.

It was not possible to obtain a verified lower temperature limit (< 10°C; 10°C; 11°C) for high infection probability because the technical equipment for such fine-tuning was not available.

A weather-based disease forecast was computed continuously and tested at eleven trial locations. Three variants were tested at each location: V1 = untreated; V2 = according to forecast; V3 was reserved for other possible variants. In addition, one plot at each location was left untreated for the entire season.

Unfortunately for this research project, only one location experienced a notable outbreak of powdery mildew in 2009. The outbreak was kept under control on plots treated in accordance with the forecasting model.

In 2009, powdery-mildew spray warnings based for the first time on the forecasting model were faxed by the Hop Producers' Ring to the Hallertau hop growers. Growers who sprayed according to these spray warnings had no problems.

Long-term optimization of aphid (*Phorodon humuli*) control in hops (*Humulus lupulus*) by means of control thesholds and breeding of aphid-tolerant hop cultivars

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, *(Bavarian State Research Center for Agriculture,* Institut für Pflanzenbau und Pflanzenzüchtung, AG Pflanzenschutz Hopfen *(Institute for Crop Science and Plant Breeding, WG Hop Plant Protection)*
Financed by:	Deutsche Bundesstiftung Umwelt (DBU)
Project manager:	B. Engelhard
Project staff:	Dr. F. Weihrauch
Cooperation:	Hop growers
Duration:	01.04.2008 - 31.03.2011

Objective

To investigate whether, and if yes, under what conditions (e.g. variety, growth stage, time until harvest), a certain number of aphids per leaf or cone can be tolerated without their being qualitatively and quantitatively detrimental to the cones by harvest time (establishment of a control threshold).

The LfL's Hops Department plans to make better use in future of genetic aphid-resistance resources, and to incorporate these in the planning of crosses. To breed selectively for aphid resistance, genetically defined resistances in individual plants need to be identified, if possible while the seedlings are still at the juvenile stage. During the second part of the overall project, the intention is to standardize a promising model.

Methods

Sixty hop yards on a total of 27 farms in the Hallertau growing region were involved in the establishment of a scientifically-based control threshold. Four hop varieties with different degrees of susceptibility were selected: Spalter Select (SE), Hallertauer Tradition (HT), Herkules (HS) und Hallertauer Magnum (HM). In the hop yards, plots were marked out in which no insecticides were used (P0) and plots in which either only one control measure was implemented (P1) or else the customary number of control measures (P2). The plots were monitored at fortnightly intervals. At each of three locations, yield and quality were determined for each variety in a trial harvest.

To permit standardized monitoring of aphid attack on the cones from the time of their formation until harvesting, a modified Berlese funnel was constructed. This was extremely easy to use and efficient. With the help of a light source, aphids and other arthropods can be driven out of freshly harvested, still-green hop cones, allowing the intensity of the infestation to be accurately determined. During the second phase of the project, use was made of the "aphid cage", familiar from tests for aphid resistance to insecticides.

Results

The aphid situation in 2009 differed significantly from that of 2008. Migration was weak and spread out over an extended period, which meant that not only leaf infestation but also the density of the corresponding beneficial organisms – including entomopathogenic fungi – remained relatively low on many untreated plots for a long time. In many cases, particularly among the bitter varieties, this resulted in cone infestation that led to yield losses by harvest time. In the case of HM, for example, yield losses to the tune of 25 to 75% on 9 out of 15 plots had to be compensated for. Compensation had to be paid in six cases for HS (25-100 %) and in four cases for HT (40-60 %). There were no cases of damage to SE. A single aphid treatment sufficed in most instances. Of all the plots that were sprayed just once, only two HM plots sustained damage of 10 %. It is already becoming apparent that SE only requires insecticide treatment in exceptional years.

As in 2008, the aphid-resistance tests on different cultivars did not indicate any definite trend.

Development of integrated methods of plant protection against the Lucerne weevil (*Otiorhynchus ligustici*) in hops

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)*
Project manager:	B. Engelhard
Project staff:	U. Lachermeier, J. Schwarz
Cooperation:	Part of the integrated project "Erarbeitung von integrierten Pflanzenschutzverfahren gegen Bodenschädlinge" *(Development of integrated methods of plant protection against soil pests)*
Duration:	01.03.2008 – 31.12.2010

Objective

- To control weevil larvae in the soil by means of entomopathogenic nematodes (EPN), with the aim of possibly obtaining a permanent EPN colony.

- To identify and log those *Otiorhynchus* species that actually occur as pests in German hop-growing areas.

Results

From an experimental point of view, beetle colonisation in the field trials was pleasingly dense, meaning that the clover sods (protected from hares by fencing) had been accepted well as bait plants. Only at the Untermantelkirchen location, however, was a statistically significant difference detected between the "Tamaron" variant and other variants.

Larvae evaluation was disappointing: Despite the dense beetle colonisation, the average larvae count per clover sod was only 0.08 to 0.23. At the time of counting, in autumn, larvae had presumably already migrated into deeper layers.

Pot trials conducted under semi-outdoor conditions were highly successful. Beetles from hop-field soils were kept in containers to lay eggs. 100 eggs were then transferred from the containers into each experimental pot, along with entomopathogenic nematodes (EPN) and fungi. The efficacy of these biocontrol agents, measured as the number of live larvae, was between 58 and 95 %, with the entomopathogenic fungi proving to be more efficient than the EPN.

Testing the suitability of a Streptomycetes strain for controlling *Verticillium* hop wilt

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Pflanzenschutz Hopfen und AG Züchtungsforschung Hopfen *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Plant Protection and WG Hop Breeding Research)*
Financed by:	Erzeugergemeinschaft Hopfen HVG e.G. *(HVG hop producer group)*
Project manager:	B. Engelhard
Project staff:	Dr. S. Seefelder, A. Lutz (both from IPZ 5c); J. Schwarz, G. Meyr (both from IPZ 5b)
Cooperation:	Julius-Kühn-Institut (JKI), Darmstadt
Duration:	2009

Objective

A Streptomycetes strain (a bacterium) had shown to be fully effective against *Verticillium spp.* in so-called "Hemmhoftests" (microbiological tests with specific zones of inhibition), was isolated from a Hallertau soil sample. In 2009, hop wilt again caused pronounced damage to almost all hop varieties, making the search for potential control methods particularly urgent.

Results

20 cuttings of the highly susceptible Hallertauer Mittelfrüher cultivar were planted in strongly infected soil from the Hüll breeding yard. The cuttings were dipped into undiluted Streptomyces fermentation broth, potted and then watered with a 1:10 dilution of the broth. The cuttings were watered again twice at four-weekly intervals.

No differences in height or infestation index were found in comparison with untreated hop plants. Sophisticated PCR analysis did not indicate any differences, either. It must be concluded that hop wilt cannot be controlled with this Streptomycetes strain.

Development of fully automated wire-stringing equipment for hop-growing

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Hopfenbau/Produktionstechnik *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Cultivation/Production Techniques)*
Financed by:	Bundesanstalt für Landwirtschaft und Ernährung (BLE) *(Federal Agency for Agriculture and Food)*
Project manager:	J. Portner
Project staff:	Dr. G. Fröhlich, Dr. Z. Gobor, ILT *(Institute for Agricultural Engineering and Animal Husbandry)*
Cooperation:	Soller GmbH, Geisenfeld
Duration:	01.01.2008 – 30.04.2010

Objective

To automate the stringing of training wire, which is currently done manually. To this end, the company Soller, assisted by the LfL, has been commissioned to develop a prototype and test it in the field. The plan is to attach the fully-automated wire-stringing equipment to the tractor's loading shovel. As the tractor moves forward, the sensor-controlled equipment attaches the training wire to the trellis at given intervals and a height of 7 m. The great advantage of automation is that there is need for workers (often seasonal workers) on the elevated platform, or "crow's nest", the risk of accidents is lower and the job less dependent on weather conditions.

Results

In 2008, hydraulics and mechatronics specialists from the LfL’s Institute for Agricultural Engineering and Animal Husbandry tested a Soller prototype for weaknesses and carried out a fault analysis. At the end of 2009, a second prototype with improved hydraulics and a redesigned winding head fitted with hydraulic swivel motors was tested in the field for the first time. A stringing rate of 0.17 ha/h (= 6 h/ha) was measured. It is anticipated that the improved prototype will be largely free of teething problems by spring 2010, when the project ends.

Automatic hop-yield recording and mapping

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtung *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Cultivation/ Production Techniques)*
Financed by:	Erzeugergemeinschaft Hopfen HVG e.G. *(HVG hop producer group)*
Project manager:	J. Portner
Project staff:	J. Portner
Cooperation:	Rottmeier, Erding; A. Widmann, Hüll
Duration:	01.01.2008 – 31.12.2010

Objective

To develop an automatic yield-measuring system on the cone conveyor belt. The intention is to match up the yield with the position in the field by means of an RFID (radio frequency identification) transponder, or, alternatively, a GPS tracking unit.

If the yield data is successfully recorded and matched up with the position in the field, the recorded data could be processed (with software yet to be developed) and depicted in colour as a yield map based on a 10 x 10 m grid. Potential application fields would include advisory services relating to the detection of problems caused by viral attack, soil differences and micronutrient deficiency, and optimization of fertilisation and plant-protection measures.

Measuring the yield in test hop stands could be an easy way of showing the influence of different production techniques. The yield maps would provide information about the homogeneity of a hop yard, thus facilitating the selection of trial plots for scientific tests. An additional spin-off might include documentation of harvest date and duration, crop volume, etc.

Results

The Rottmeier engineering agency installed an RFID transponder system and a bine counter on the intake arm of the picking machine at a commercial hop farm. A belt weigher was installed between the cone delivery belt and the conveyor belt to the green-hop silo in order to automatically monitor the yield. As an alternative monitoring system, ultrasonic sensors that determined the yield volumetrically were fitted above the conveyor belt. The advantage of measuring volumes is that differences in hop moisture content, which may falsify weights, are irrelevant. The continuous yield data were recorded automatically.

To match up the yield with the rows in the field, use was made of RFID responders that were attached in each case to the last bine (the first to be hooked up later to the picking machine's feed conveyor) of the row to be harvested. Before the topmost bine (the last to be cut down) of a new load was hooked into the machine, the transponder was removed and the data supplied to the identification system so as to register the row just harvested.

The position of the measured yield within the row was calculated by means of the bine counter.

As an alternative to RFID transponders, a GPS tracking system was tried out. To this end, a highly sensitive GPS receiver was installed on the tractor and tested to see whether the position of the tractor, and hence of the row being harvested, can be determined during hop harvesting. The results of the initial trials were promising.

Response of various hop cultivars to reduced trellis height (6 m) and testing of new plant-protective application techniques

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Hopfenbau/Produktionstechnik *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Cultivation/ Production Techniques)*
Financed by:	Erzeugergemeinschaft Hopfen HVG e.G. *(HVG hop producer group)*
Project manager:	J. Portner
Cooperation:	Mitterer, Terlan
Project staff:	S. Fuß, E. Niedermeier
Duration:	01.01.2008 – 31.12.2010

Objective

In this 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 is to study the reaction of various cultivars to reduced trellis height (plant growth, susceptibility to disease/pests, yield and quality). Tests are being conducted on the following aroma varieties: Perle und Hallertauer Tradition, and on the following bitter varieties: Hallertauer Magnum, Hallertauer Taurus and Herkules.

During the second phase of the project, Mitterer sprayers adapted to low trellis heights (of the kind used in fruit growing) will be tested in a 6-meter trellis system and compared with conventional hop sprayers. The plan is to investigate the extent to which water consumption can be cut, active-agent adhesion improved and environmental risks caused by drift reduced.

Results

The hail storm on May 26th, 2009 destroyed four of the six trial locations, making any yield evaluation impossible. This means that no conclusions can be drawn as yet concerning the influence of reduced trellis height on growth and yield. Further investigations will be necessary during the next few years.

The new Mitterer sprayer was tested in 2009 in a 7-meter trellis system and compared with a conventional sprayer. The tops of the hop plants were wetted well by the new sprayer. The trials will be continued in 2010 with slight modifications to the sprayer.

1.2 Main research areas

1.2.1 Hop breeding

Breeding of high-quality aroma and bitter varieties containing optimised hop components (e.g. bitter acids, xanthohumol and anti-oxidative substances)

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

Project staff: A. Lutz, J. Kneidl, IPZ 5c team

Cooperation: Dr. K. Kammhuber, IPZ 5d team

Objective

The diversity of the essential oils, bitter compounds and polyphenols contained in hop cones makes for a range of potential applications that extends far beyond the use of hops in beer brewing. On account of their bacteriostatic and antimicrobial effects, bitter acids, in particular beta acids, are used, for example, as harmless, environmentally compatible preservatives in the food and ethanol industries. In animal feed, too, they are becoming increasingly important as substitutes for antibiotics. In addition, hops are of interest to the pharmaceutical/medical sector because of their health-promoting components, such as xanthohumol and bitter acids.

Measures and results

During 2009, 12 crosses were carried out with the specific aim of optimising hop components for alternative fields of application. Research activities were focused on increasing beta-acid and xanthohumol content.

Crossing parents	Alpha-acid content	Beta-acid content	Alpha-+ beta-acid content	Xanthohumol
2003/067/002	9.5 – 14.5	11.0 – 14.0	20 – 27	0.6 – 0.8
2003/067/005	12.0 – 16.5	9.0 – 12.0	21 – 26	0.6 – 0.8
2001/101/704	10.0 – 15.0	3.2 – 4.7	13 – 19	1.4 – 2.1
2000/109/728	16.5 – 23.5	5.0 – 6.4	21 – 29	0.7 – 1.0
Hall. Taurus	13.0 – 20.0	4.0 – 6.0	17 – 26	0.7 – 1.0

- Laboratory and greenhouse testing of seedlings for disease resistance
- Cultivation testing of disease-resistant seedlings
- Selection of agronomically interesting seedlings
- Component analysis by means of HPLC, NIRS and GC

The high-alpha Herkules cultivar – huge performance potential only under optimum conditions

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

Project staff: A. Lutz, J. Kneidl, IPZ 5c team

Cooperation: Dr. K. Kammhuber, IPZ 5d team;
HVG Hopfenverwertungsgenossenschaft e.G.
(HVG Hop Processing Cooperative)

Objective

Since the commencement of commercial Herkules production in 2005, the area under cultivation has increased from 30 to 2388 ha. The plan is to show, by means of a farmscale comparison of Herkules with Hallertauer Magnum und Hallertauer Taurus, the other two high-alpha Hüll cultivars, the extent to which the findings obtained for Herkules in "Stammes- und Hauptprüfungen" (field trials with less or more advanced selections, with several replications) in the two breeding yards and in "Anbauprüfungen" (trials with highly promising selections on farms) can be confirmed in practice under a wide range of soil and farming conditions.

Methods

- Yield determination (in kg/ha)
- Alpha-acid determination by conductometric titration (as per EBC 7.4)
- Alpha-acid yield as the product of alpha-acid content (kg α-acids/kg hops) and yield (kg/ha)

Results

The farmscale comparison with the two high-alpha Hüll cultivars, Hallertauer Magnum and Hallertauer Taurus, also showed Herkules to have a clear-to-very-clear breeding edge in all performance characteristics. The following table summarizes the mean values – based on the farmscale comparison from 2007 to 2009 – for yield (in kg/ha), alpha-acid content (in %) and alpha-acid yield (kg α-acids/ha). These mean values are proof of the performance edge.

Jahr	Ertrag in kg/ha			α-Säurenwerte (KW, AHA)			kg α-Säuren/ha		
	Magnum	Taurus	Herkules	Magnum	Taurus	Herkules	Magnum	Taurus	Herkules
2007	1850	2075	*2900*	12,6	16,1	16,1	233	334	467
2008	2480	2170	*2900*	15,7	17,9	17,3	389	388	502
2009	*1850*	*2030*	*3100*	14,6	17,1	17,3	270	347	536
Mittel abs.	2060	2092	2967	14,3	17,0	16,9	295	356	501
Mittel rel.	69	71	100	85	101	100	59	71	100

Due to the high proportion of young hop plants, the yields for Herkules had to be estimated. The alpha-acid values were determined by the *Arbeitsgruppe für Hopfenanalytik (AHA)* by means of conductometric titration (as per EBC 7.4).

The data confirm the fact that, with the new Herkules cultivar, a high-performance, robust, high-alpha variety characterised by very high yields and alpha-acid content has been made available to growers

It guarantees a reliable supply of premium-quality hops – now and in the future. It was found, however, that Herkules reacts extremely sensitively and very unforgivingly to cultivation flaws, such as injuries to the stock, herbicide burns or premature harvesting.

1.2.2 Hop cultivation and production techniques

Trials to investigate irrigation control in hop growing

Project staff: J. Münsterer

An irrigation trial is being conducted in Schafhof to determine how much water is needed to obtain optimum hop yields and when it is needed. The trial involves a number of experimental variants and stages. In this trial, conventional irrigation-control systems were compared with computer-aided water-supply models and methods of measuring soil moisture.

Positioning of drip hose in hop irrigation

Project staff: J. Münsterer

Trials are being conducted at Ilmendorf, Kolmhof und Oberempfenbach, which have different types of soil, to determine the extent to which growth and yield are affected by differences in drip-hose positioning during routine hop irrigation. Irrigation via hoses laid on top of the hilled row is being compared with a technique where the drip hoses are inserted permanently in the ground alongside the row.

Increasing hop drying performance

Project staff: J. Münsterer

The drying performance of floor kilns depends on the hop variety, drying surface area and drying temperature, cone depth and cone moisture content or stage of maturity, and speed of the drying air. In order to compare the drying performance of kilns on different farms or kilns fed different hop varieties, it is necessary to first define a uniform drying-performance unit. A suitable unit is kg dry hops / m^2 drying surface / h drying time.

The aim of the 2009 trials was to vary cone depth – while keeping the other parameters constant – until drying performance reached a maximum. However, since the moisture content of green hops fluctuates greatly depending on the weather, cone weight (rather than cone depth) was used to calculate maximum drying performance.

In hop-kiln trials, drying performance was significantly increased by adhering to the ideal cone weight. Section 5 contains a more detailed report.

Spacing and bine-training trial with the Herkules cultivar

Project manager: J. Portner

Project staff: E. Niedermeier

Optimum growing space or within-row spacing depends on a bine's habitus and must be determined for each variety. Bine-training trials are conducted on newer varieties to determine the ideal number of bines per wire. This is necessary because the time needed to train and retrain the bines increases with the number of bines per wire, as does the risk of disease stemming from the dense foliage.

From an economic point of view, however, maximum yield and alpha-acid content remain crucial. To clarify the issues, the new high-alpha Herkules cultivar was planted using within-row spacing of 1.44 m and 1.62 m and twisting 2 or 3 bines up each wire respectively.

Three years of harvests from the trial stands (of which there were several for each trial variant) provided no reliable data on yield differences between the variants. Section 5 contains a more detailed report.

Fungicide treatments with and without strobilurins

Project staff: J. Schätzl, S. Fuß

Duration: 2007 – 2010

In addition to their fungicidal effect, plant protectives from the stobilurin group are said to positively influence yield and component formation. A certain “greening effect” can be demonstrated.

To substantiate the results, two downy mildew treatments (one with a strobilurin preparation and one with a reference preparation from another group of active agents) were applied to a field crop. The harvest was measured in terms of yield and alpha-acid content. The trial will be continued for another year due to contradictory results.

Testing alternative training materials

Project staff: J. Schätzl

For many years, hop growers have been hoping to find an alternative training material to conventional iron wire. The main reason is the problems caused by metal spikes when bine choppings are returned to the hop yard. Non-ferrous training material would also cause less wear on cutting tools and would increase the service life of the barbed wires.

Degradable material would furthermore be suitable for fermentation together with bine choppings in biogas plants. Paper-based training string of three different thicknesses was accordingly tested in a commercial hop yard and compared with conventional iron training wire. The main problem was the speed at which the paper string rotted in the soil-air transition zone. Section 5 contains a more detailed report.

Nitrogen enrichment trial to compare broadcast and banded fertiliser application

Project manager: J. Portner

Project staff: E. Niedermeier

Duration: 2007 – 2011

Earlier trials in the Hallertau and in Thuringia show that if fertiliser is applied by banding rather than by broadcasting, the same yield can be achieved with up to a third less fertiliser. In addition to beneficial environmental effects, there are advantages for any hop farmers who run the risk of exceeding the acceptable nutrient balance surplus as defined by the German regulation on fertiliser use with their nitrogen fertilisation activities. The nitrogen enrichment trial will investigate whether the surplus limit of 60 kg N/ha for hop farms is sufficient and whether nitrogen can really be saved via banded fertiliser application.

Leaf fertilisation with Pentakeep

Project manager: J. Portner

Project staff: E. Niedermeier

Duration: 2008 – 2010

In addition to various primary nutrients and micronutrients, Pentakeep leaf fertiliser contains the compound aminolevulin acid, which is said to have a stress-compensating effect that increases yield and alpha-acid content. The leaf fertiliser is being tested on the aroma variety Perle and the bitter variety Hallertauer Magnum in two commercial hop yards. It is applied by spraying (the control plot remains unsprayed) according to two different regimens specified by the manufacturer.

The one treatment involves spraying 6 times, each time with a Pentakeep solution of 0.5 kg/ha in 1,000 l water/ha. The alternative treatment involves spraying 3 times, once with a Pentakeep solution of 0.5 kg/ha in 1,000 l water/ha, once with a solution of 1.0 kg/ha in 2,000 l water/ha and once with a solution of 1.5 kg/ha in 3,000 l water/ha.

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, the number of zoosporangia is determined daily with spore traps at 5 locations in the Hallertau, one in Spalt and one in Hersbruck. In the event that the economic threshold is exceeded and the weather conditions are favorable 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. The infection potential is ignored. The 5-year trial is intended to determine the extent to which the time-consuming and labour-intensive counting of zoosprangia at the downy mildew locations is necessary. To this end, the index calculated by the Adcon weather stations will be compared with the warnings based on the Kremheller model in order to determine Adcon thresholds for susceptible and tolerant varieties. Scientific tests will then be performed to determine whether the different methods of generating spray warnings have influenced yield and quality.

1.2.3 Hop quality and analytics

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

Project manager: Dr. K. Kammhuber

Project staff: E. Neuhof-Buckl, S. Weihrauch, B. Wyschkon, C. Petzina, B. Sperr, 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 particularly for their components. Component analysis is therefore essential to successful hop research. The IPZ 5d work group (WG Hop Quality and Analytics) 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, Dr. K. Kammhuber

Duration: September 2000 – (open-ended)

An HPLC-data-based NIRS calibration equation for alpha-acid content had been under development in Hüll and the laboratories of the hop-processing firms as of 2000. 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 *Arbeitsgruppe für Hopfenanalytik (AHA)* (the Hallertau work group in which the four laboratories involved collaborate) that this method would be suitable for routine use and as an analytical method for hop supply contracts once it was at least as accurate as conductometric titration according to EBC 7.4.

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

Development of analysis methods for hop polyphenols

Project manager: Dr. K. Kammhuber

Cooperation: Arbeitsgruppe für Hopfenanalytik (AHA)

Project staff: Neuhof-Buckl, Dr. K. Kammhuber

Duration: 2007 to (open-ended)

Primarily on account of their health-promoting properties, polyphenols are attracting increasing attention within the context of alternative uses of hops. It is therefore important to have suitable analysis methods available. To date, however, no officially standardised methods exist. The *AHA* has been working on standardising the analysis methods for total polyphenol and total flavonoid contents in hops since 2007.

The variation coefficients (cvr's) are still relatively high, and work is being done to improve them. In an initial ring test, an HPLC method was tested on quercetin and kaempferol. The results obtained were comparable. The next step is to develop an HPLC method for the entire range of low-molecular polyphenols.

Introduction and establishment of UHPLC in hop analytics

Project manager: Dr. K. Kammhuber

Project staff: B. Wyschkon, C. Petzina, Dr. K. Kammhuber

Duration: May 2008 to (open-ended)

In May 2008, a UHPLC system was set up in Hüll. UHPLC stands for Ultra HPLC and is a refinement of conventional HPLC. The system can generate pressures of up to 1,000 bar, making it possible to use columns filled with particles measuring less than 2 µm. Analysis runs are much shorter, without any loss in resolution. The HPLC method according to EBC 7.4 takes 4 minutes. This makes for significantly faster throughput and less solvent waste. Procurement of the UHPLC system means that the Hüll laboratory is again equipped with the latest state of the art. The Bavarian State Ministry for Food, Agriculture & Forestry is funding a project entitled "Differentiation within the global range of hop varieties on the basis of low-molecular polyphenols". The project is scheduled for 2010 and 2011 and will be carried out using the UHPLC system.

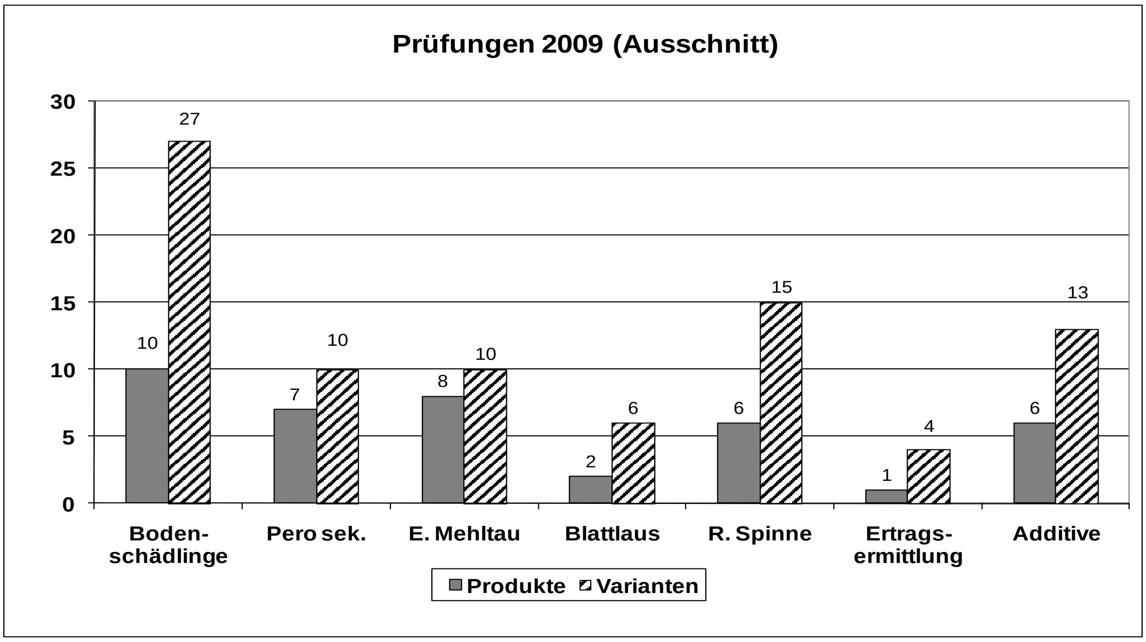
1.2.4 Plant protection in hops

Testing of plant protectives for licensing and approval, and for the 2009 advisory-service documentation

Project manager: B. Engelhard

Project staff: J. Schwarz, G. Meyr

Fig.. 1.1: Tests



Activities focused on the testing of new akaricides and use of additives in pest control. Downy mildew-control products with a reduced copper content were found to be effective. Of the many pesticides tested over a period of several years, only Actara provided effective control against soil pests. It is also suitable for combating initial flea-beetle outbreaks.

2 Weather conditions in 2009 – hail destroys 4,000 ha of hops in the Hallertau growing region on May 26th

Ltd. LD Bernhard Engelhard, Dipl. Ing. agr.

Hail damage is usually localised, affecting only narrow strips of land and a few square kilometres. The storm on the evening of May 26th reached hitherto unknown dimensions, totally destroying the hop stands in the centre of its path. This was a further indication of the increasing prevalence of weather extremes associated with climate change.

Weather conditions in 2009 and the effects on hops

- A pronounced Christmas thaw was followed by an ongoing freeze that lasted until 20th February. As there was no snow cover, the ground froze to a depth of 50 cm; during the second half of February, snow fell on frozen ground:
  - Mellow soil
  - Good wire-hanging conditions
  - Difficult conditions for establishing new hop stands
- Thaw weather set in punctually on March 1st, the meteorological start of spring, and caused a certain amount of flooding. Apart from the first few days, the rest of March was wet and cold, and included snowfalls:
  - Very difficult conditions for rootstock pruning
- April 1st saw in the spring, or early summer. The phenological start of the vegetation cycle was on April 2nd. Interrupted only by showers on 17/18 April (8 to 20 mm), summer temperatures prevailed throughout April:
  - Vegetation literally exploded
  - Depending on the variety and pruning depth, there are huge differences in the times at which fresh hop shoots emerge. On sandy ground, Northern Brewer (NB) was already 2 m high by the end of April. Every further centimetre that rootstocks were pruned back caused a pronounced delay in emergence.
  - Stripping and training were often highly problematic because seasonal workers had been ordered for later.
  - Unusually high numbers of alfafa weevils
  - Very high flea-beetle populations
  - Aphids identified as early as 28th April!
- Precipitation (more than) sufficient throughout May; hail storm on May 26th:
  - Rapid growth; in the breeding yard, male and female flower-setting commenced as early as May 25th
  - Serious primary downy mildew infection in many hop yards

- First spray warning according to the new PM forecasting model on May 15th
- Soil compaction

- June brought thunder storms with precipitation that varied in intensity from locality to locality:
  - Extremely short periods during which plant-protection measures were possible From 18th – 29th June, the most important period for disease control, continual rain and wind made protective action almost impossible.
  - Downy mildew explosion in the area affected by hail
- The July weather, with 130 mm of rain, was ideal for crop yields.
- However, the hops were also adversely affected by the weather of the preceding months:
  - Ambisexuality, which prevented the commencement of cone formation
  - Phyllody (retrograde metamorphosis of cones into foliage)
  - (Magnum, in particular, suffered from the effects of the extreme spring weather)
  - Wilt in almost all varieties
- In August, conditions were perfect for very high quality! 60 mm of rain on ground that was already sufficiently damp and slightly above-average temperatures and number of hours of sunshine
- Harvesting conditions:
  - Pleasant temperatures with practically no rain provided an ideal environment
  - Low incidence of disease or pests
  - The dry weather meant that cones matured rapidly; there was even some drought damage to late varieties and young plants.

2.1 Weather data (monthly means or monthly totals) for 2009 compared with 10- and 50-year means

Month		Temp. 2 m above ground Mean (°C)	Min.∅ (°C)	Max.∅ (°C)	Relat. humid. (%)	Precipi-tation (mm)	Days with precipitn. >0.2 mm	Sun-schine (h)
January	2009	-4.1	-7.7	0.5	85.2	24.8	6.0	88.7
∅	10-yr.	-0.4	-3.9	3.3	88.7	54.4	12.1	74.5
	50-yr.	-2.4	-5.1	1.0	85.7	51.7	13.7	44.5
February	2009	-0.9	-4.5	2.8	84.9	48.5	15.0	52.2
∅	10-yr.	0.7	-3.9	5.6	85.2	42.3	12.6	97.8
	50-yr.	-1.2	-5.1	2.9	82.8	48.4	12.8	68.7
March	2009	3.6	0.3	7.7	82.6	81.6	21.0	65.6
∅	10-yr.	4.2	-0.9	9.8	81.2	74.3	13.1	147.2
	50-yr.	2.7	-2.3	8.2	78.8	43.5	11.3	134.4
April	2009	11.9	4.5	20.0	69.3	39.1	7.0	246.5
∅	10-yr.	8.9	2.9	15.2	74.5	64.3	11.9	189.8
	50-yr.	7.4	1.8	13.3	75.9	55.9	12.4	165.0
May	2009	14.4	8.0	21.1	76.7	137.9	21.0	223.2
∅	10-yr.	14.1	7.8	20.5	73.6	93.4	12.7	222.1
	50-yr.	11.9	5.7	17.8	75.1	86.1	14.0	207.4
June	2009	15.8	10.1	21.6	76.0	111.0	16.0	201.9
∅	10-yr.	17.2	10.4	23.9	72.9	85.7	13.5	247.2
	50-yr.	15.3	8.9	21.2	75.6	106.1	14.2	220.0
July	2009	17.9	12.1	24.7	80.2	136.2	16.0	221.8
∅	10-yr.	18.0	11.8	24.8	75.7	103.1	15.7	235.0
	50-yr.	16.9	10.6	23.1	76.3	108.4	13.9	240.3
August	2009	18.6	12.2	26.2	79.4	57.8	9.0	262.7
∅	10-yr.	17.5	11.5	24.4	78.7	94.2	12.9	208.6
	50-yr.	16.0	10.2	22.5	79.4	94.9	13.3	218.4
September	2009	14.5	8.7	21.7	82.9	27.6	7.0	190.1
∅	10-yr.	13.4	8.0	19.9	83.1	72.0	11.9	163.9
	50-yr.	12.8	7.4	19.4	81.5	65.9	11.4	174.5
October	2009	7.9	3.7	12.5	88.1	87.8	16.0	98.7
∅	10-yr.	9.3	4.8	14.8	87.6	59.7	11.6	117.2
	50-yr.	7.5	2.8	13.0	84.8	60.0	10.4	112.9
November	2009	5.6	1.6	10.3	89.6	65.6	12	82.3
∅	10-yr.	3.4	0.1	7.2	91.7	63.8	12.9	62.5
	50-yr.	3.2	-0.2	6.4	87.5	58.8	12.6	42.8
December	2009	-0.1	-3.6	2.9	90.2	79.8	19	44.9
∅	10-yr.	0.2	-2.7	3.4	90.8	49.4	13.9	60.5
	50-yr.	-0.9	-4.4	1.6	88.1	49.1	13.3	34.3
∅ 2009		8,8	3.8	14.3	82.1	897.7	165.0	1778.6
10-year mean		8,9	3.8	14.4	82.0	856.7	154.8	1826.4
50-year mean		7,4	2.5	12.5	81.0	828.8	153.3	1663.2

The 50-year mean is based on the period from 1927 through 1976.
The 10-year mean is based on the period from 1999 through 2008.

3 Statistical data on hop production

LD Johann Portner, Dipl. Ing. agr.

3.1 Production data

3.1.1 Pattern of hop farming

Table. 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
1963	13 259	0.68	1991	3 957	5.70
1973	8 591	2.33	1992	3 796	6.05
1974	8 120	2.48	1993	3 616	6.37
1975	7 654	2.64	1994	3 282	6.69
1976	7 063	2.79	1995	3 122	7.01
1977	6 617	2.90	1996	2 950	7.39
1978	5 979	2.94	1997	2 790	7.66
1979	5 772	2.99	1998	2 547	7.73
1980	5 716	3.14	1999	2 324	7.87
1981	5 649	3.40	2000	2 197	8.47
1982	5 580	3.58	2001	2 126	8.95
1983	5 408	3.66	2002	1 943	9.45
1984	5 206	3.77	2003	1 788	9.82
1985	5 044	3.89	2004	1 698	10.29
1986	4 847	4.05	2005	1 611	10.66
1987	4 613	4.18	2006	1 555	11.04
1988	4 488	4.41	2007	1 511	11.70
1989	4 298	4.64	2008	1 497	12.49
1990	4 183	5.35	2009	1 473	12.54

Table. 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 - 2009 to 2008				Increase + / Decrease - 2009 to 2008			
	2008	2009	ha	%	2008	2009	Farms	%	2008	2009
Hallertau	15 678	15 485	- 193	- 1.2	1 213	1 197	- 16	- 1.3	12.92	12.94
Spalt	382	361	- 21	- 5.5	81	77	- 4	- 4.9	4.72	4.69
Tettnang	1 233	1 221	- 12	- 1.0	172	168	- 4	- 2.3	7.17	7.27
Baden, Bitburg and Rhine Pal.	19	19	± 0	± 0	2	2	± 0	± 0	9.50	9.50
Elbe-Saale	1 383	1 387	+ 3	+ 0.2	29	29	± 0	± 0	47.69	47.83
Germany	**18 695**	**18 473**	**- 223**	**- 1.2**	**1 497**	**1 473**	**- 24**	**- 1.6**	**12.49**	**12.54**

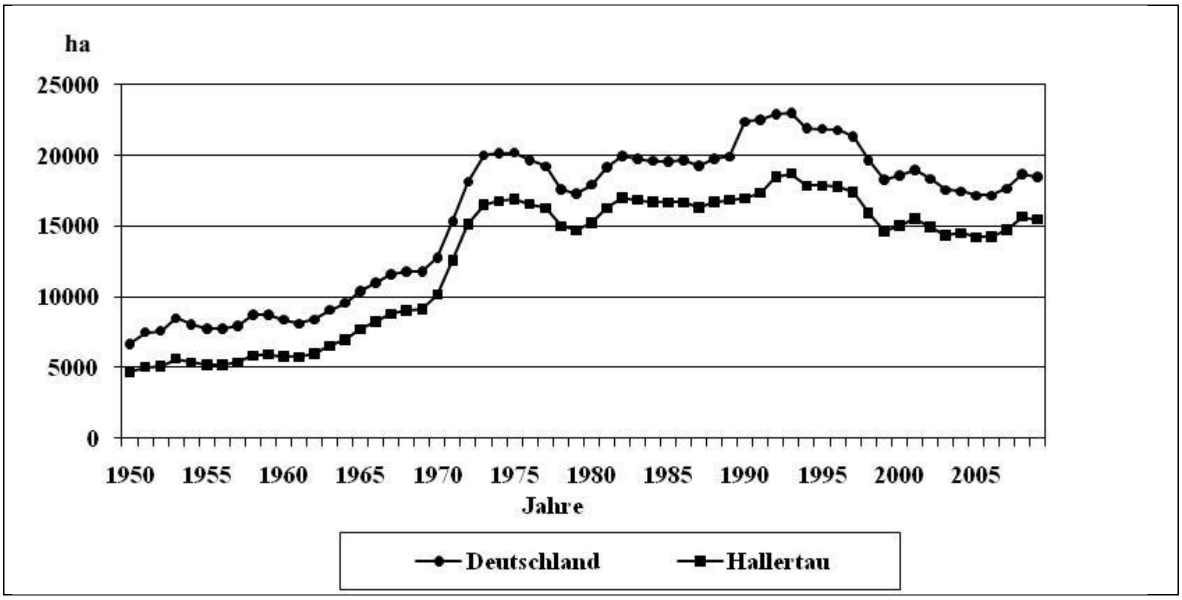


Fig.. 3.1: Hop acreages in Germany and in the Hallertau

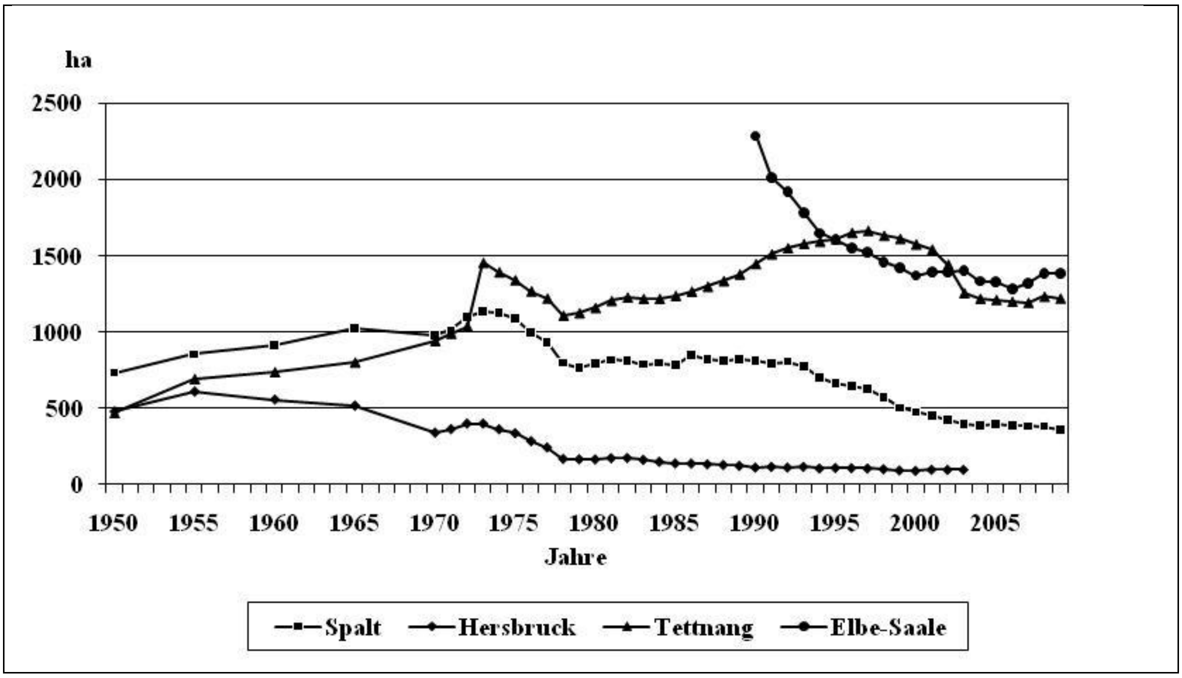


Fig. 3.2: Hop acreages in the Spalt, Hersbruck, Tettnang and Elbe-Saale regions

The Hersbruck hop-growing region has been part of the Hallertau since 2004.

3.1.2 Hop varieties

The 2008 production shift away from aroma varieties towards bitter varieties continued in 2009. This is due, firstly, to a further increase of 520 ha in the acreage planted with the new, high-alpha Herkules cultivar. Altogether 2,388 ha, or 12.9 % of the total acreage under hop production, are now planted with Herkules, making it the second-most widely planted bitter variety and the fourth-most widely planted variety overall in Germany. The second reason is the huge decrease of 883 ha in the acreage planted with Hallertauer Mittelfrüher, a move initiated by the Anheuser-Busch InBev group of brewing companies. In 2009, aroma varieties accounted for only 53.4 % of the total area under hops, compared with 56.2 % in 2008. The acreage planted with bitter varieties had thus increased from 43.8 % to 46.6 % by 2009.

In 2009, the area under hop production fell by 223 ha, to 18,473 ha, as a result of the decerease in acreage planted with Hallertauer Mittelfrüher and the saturated market. Among the aroma cultivars, noteworthy increases were posted for Hallertauer Tradition (+101 ha), Perle (+83 ha), Hersbrucker Spät (+28 ha) und Tettnanger (+34 ha). The new aroma cultivars Saphir, Opal and Smaragd were just able to maintain their production acreages or increase them very slightly. The acreage planted with aroma varieties saw a decrease of 643 ha in 2009, while that planted with bitter varieties saw an increase of 421 ha. All of this increase involved the Herkules variety.

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

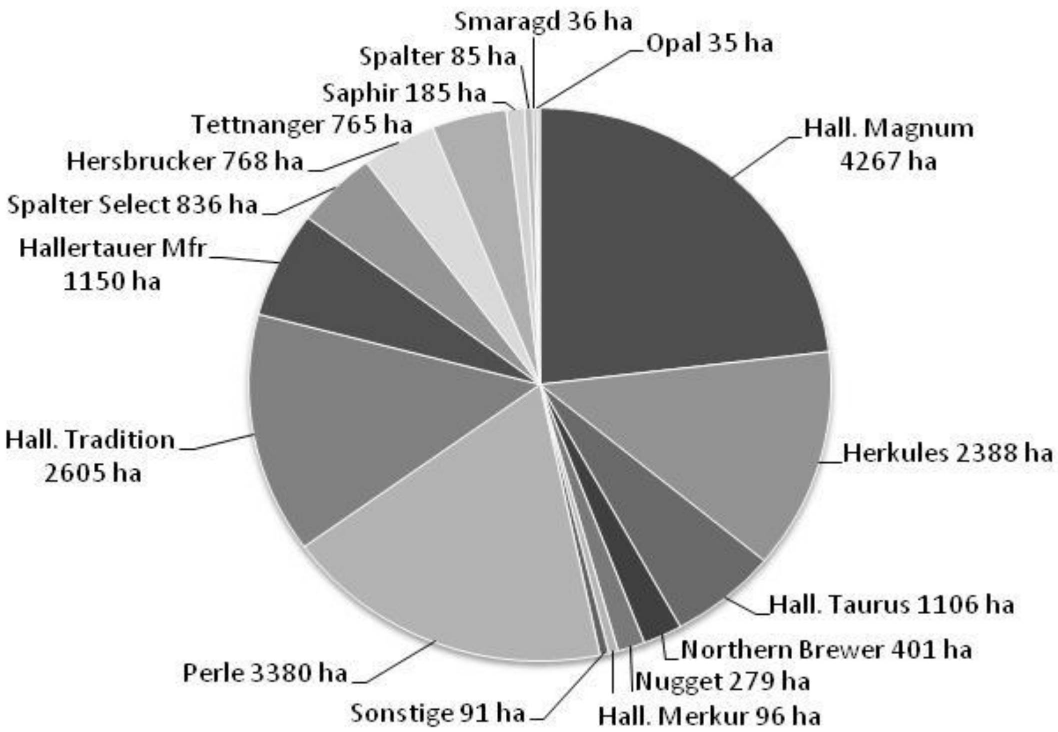


Fig. 3.3: Distribution of hop varieties in Germany in 2009

Table 3.3: Hop varieties by German hop-growing region in ha in 2009 Aroma varieties

Region	Total acreage	HA	SP	TE	HE	PE	SE	HT	SR	OL	SD	Other	Aroma varieties	
													ha	%
Hallertau	15,485	761	5		766	3,128	731	2,493	185	35	31	7	8,142	52.6
Spalt	361	86	80		3	24	103	32					327	90.7
Tettnang	1,221	302		765		70		43			5		1,184	96.9
Baden, Bitburg and Rhine. Pal.	19	1				8	2	5					16	85.8
Elbe-Saale	1,387					150		33				8	191	13.8
Germany	**18,473**	**1,150**	**85**	**765**	**768**	**3,380**	**836**	**2,605**	**185**	**35**	**36**	**15**	**9,861**	**53.4**
% acreage by variety		6.2	0.5	4.1	4.2	18.3	4.5	14.1	1.0	0.2	0.2	0.1		

Variety changes in Germany

2008 ha	18,695	2,034	90	731	740	3,297	842	2,503	187	30	36	13	10,504	56.2
2009 ha	18,473	1,150	85	765	768	3,380	836	2,605	185	35	36	15	9,861	53.4
Change in ha	- 223	- 883	- 5	+ 34	+ 28	+ 83	- 6	+101	- 2	+ 5	- 1	+ 2	- 643	- 2.8

Table 3.4: Hop varieties by German hop-growing region in ha in 2009 Bitter varieties

Region	NB	BG	NU	TA	HM	TU	MR	HS	Other	Bitter varieties	
										ha	%
Hallertau	268	27	249	6	3,415	1,077	68	2,208	24	7,342	47.4
Spalt					4		9	21		34	9.3
Tettnang					1	6		24	6	37	3.1
Baden, Bitburg and Rhine. Pal.					2			0		3	14.2
Elbe-Saale	132		30	4	844	23	19	134	8	1195	86.2
Germany	**401**	**27**	**279**	**10**	**4,267**	**1,106**	**96**	**2,388**	**39**	**8,611**	**46.6**
% acreage by variety	2.2	0.1	1.5	0.1	23.1	6.0	0.5	12.9	0.2		

Variety changes in Germany

2008 ha	438	32	281	13	4,277	1,140	107	1,868	35	8,191	43.8
2009 ha	401	27	279	10	4,267	1,106	96	2,388	39	8,611	46.6
Change in ha	- 38	- 6	- 2	- 3	- 10	- 33	- 11	+ 520	+ 3	+ 421	+ 2.8

3.2 Crop situation in 2009

Approximately 31,343,670 kg (= 626,873 cwt.) hops were harvested in Germany, as compared with 39,676,470 kg (= 793,529 cwt.) in 2008. The crop thus weighed 8,332,800 kg (= 166,656 cwt.) less than in the previous year, a decrease of 21 %.

With an overall per-hectare yield of 1,697 kg, the crop appears to be below average. However, it was in fact slightly above average if the estimated loss in crop volume caused by the hail on 26th May is taken into account. Alpha content was also above average in 2009.

Table 3.5: Per-hectare yields and relative figures in Germany

	2004	2005	2006	2007	2008	2009
Yield kg/ha and (cwt./ha)	1,900 kg (38.0 cwt.)	2,006 kg (40.1 cwt.)	1,660 kg (33.2 cwt.)	1,819 kg (36.4 cwt.)	2,122 kg (42.4 cwt.)	1,697 kg (33.9 cwt.) (massive hail damage
Relative to 100% (long-term ∅ = 35 cwt.)	108.6	114.6	94.9	103.9	121.3	97.0
Acreage in ha	17,476	17,179	17,170	17,671	18,695	18,473
Total crop in kg and cwt.	33,208,000 kg =664,160 cwt.	34,466,770 kg =689,335 cwt.	28,508,250 kg =570.165 cwt.	32,138,870 kg =642.777 cwt.	39,676,470 kg =793.529 cwt.	31,43,670 kg =626.873 cwt.

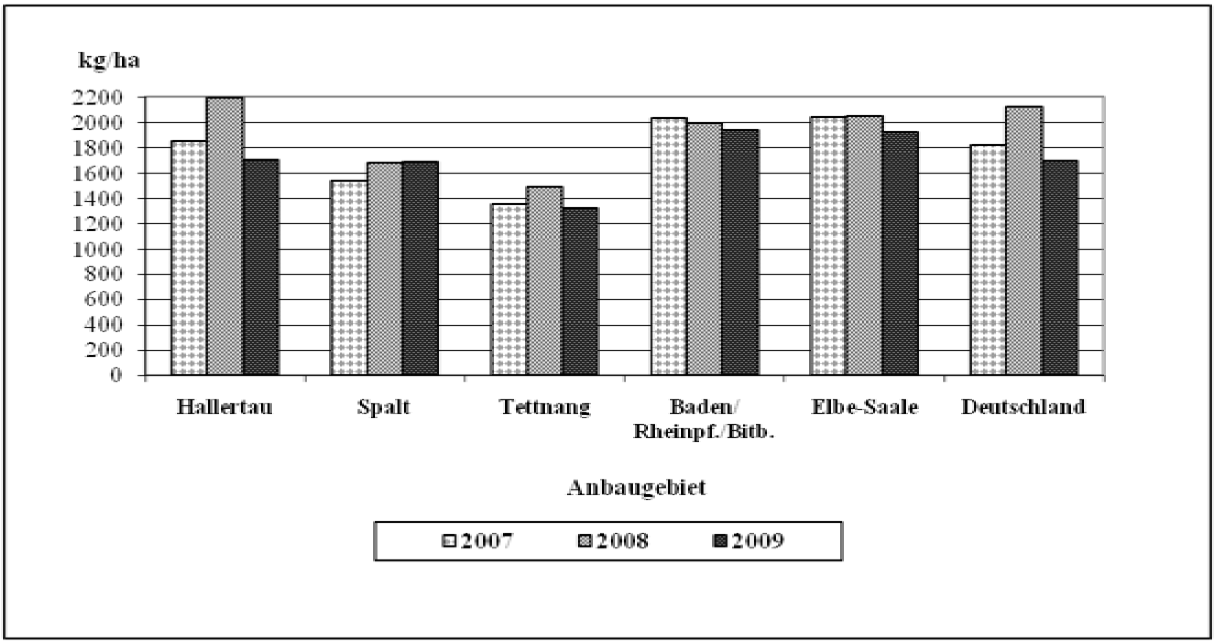


Fig. 3.4: Average yields by hop-growing region in kg

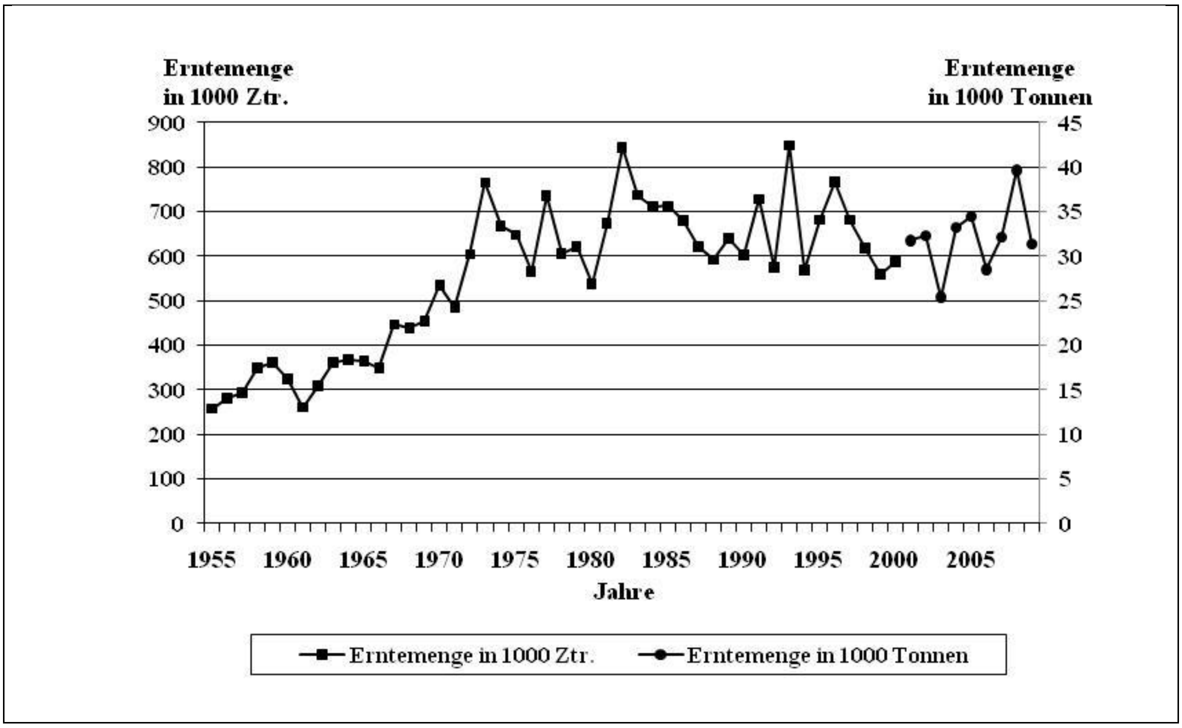


Fig. 3.5: Crop volumes in Germany

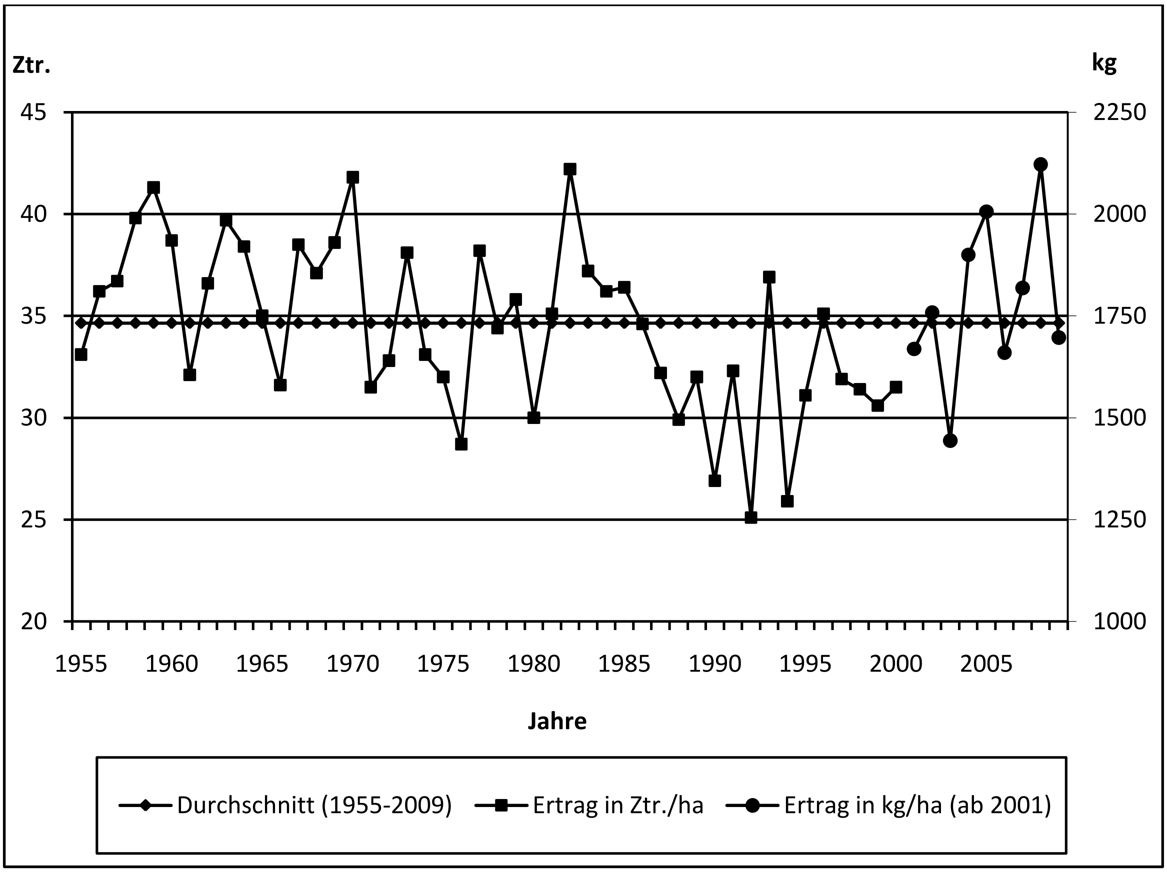


Fig. 3.6: Average yields (cwt. and kg/ha) in Germany

Table. 3.6: Yields per hectare by German hop-growing region

Region	Yields in kg/ha total acreage								
	2001	2002	2003	2004	2005	2006	2007	2008	2009
Hallertau	1724	1825	1462	1946	2084	1701	1844	2190	1706
Spalt	1298	1464	1131	1400	1518	1300	1532	1680	1691
Hersbruck	1233	1306	983	- *	- *	-*	- *	- *	- *
Tettnang	1212	1360	1216	1525	1405	1187	1353	1489	1320
Baden, Bitburg, and Rhine. Pal.	1445	1763	1936	1889	1881	1818	2029	1988	1937
Elbe-Saale	1594	1576	1555	1895	1867	1754	2043	2046	1920
∅ yield / ha Germany	1669 kg	1758 kg	1444 kg	1900 kg	2006 kg	1660 kg	1819 kg	2122 kg	1697 kg
Total crop Germany (t and cwt.)	31 739 t 634 782	32 271 t 645 419	25 356 t 507 124	33 208 t 664 160	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
Acreage Germany	19 020	18 352	17 563	17 476	17 179	17 170	17 671	18 695	18 473

* The Hersbruck hop-growing region has been part of the Hallertau since 2004.

Table 3.7: Alpha-acid values for the various hop varieties

Region/Variety	2000	2001	2002	2003	2004	2005	2006	2007	2008	**2009**	∅ 5 years	∅ 10 years
Hallertau Hallertauer	4.9	4.6	4.6	3.1	4.3	4.4	2.4	3.9	4.4	**4.2**	3.9	4.1
Hallertau Hersbrucker	4.9	3.0	3.2	2.1	3.0	3.5	2.2	2.6	2.9	**3.4**	2.9	3.1
Hallertau Hall. Saphir					3.4	4.1	3.2	4.6	5.1	**4.5**	4.3	
Hallertau Opal								7.4	9.4	**9.0**		
Hallertau Smaragd								6.1	6.7	**6.4**		
Hallertau Perle	8.1	7.0	8.6	3.9	6.4	7.8	6.2	7.9	8.5	**9.2**	7.9	7.4
Hallertau Spalter Select	6.4	4.8	6.0	3.2	4.9	5.2	4.3	4.7	5.4	**5.7**	5.1	5.1
Hallertau Hall. Tradition	7.1	6.3	7.2	4.1	6.3	6.3	4.8	6.0	7.5	**6.8**	6.3	6.2
Hallertau North. Brewer	10.1	9.6	10.1	6.0	9.8	9.8	6.4	9.1	10.5	**10.4**	9.2	9.2
Hallertau Hall. Magnum	14.4	13.9	14.6	11.7	14.8	13.8	12.8	12.6	15.7	**14.6**	13.9	13.9
Hallertau Nugget	12.9	11.9	12.4	8.5	10.6	11.3	10.2	10.7	12.0	**12.8**	11.4	11.3
Hallertau Hall. Taurus	15.6	15.7	16.5	12.3	16.5	16.2	15.1	16.1	17.9	**17.1**	16.5	15.9
Hallertau Hall. Merkur					13.5	13.3	10.3	13.0	15.0	**14.8**	13.3	
Hallertau Herkules								16.1	17.3	**17.3**		
Tettnang Tettnanger	4.9	4.4	4.6	2.6	4.7	4.5	2.2	4.0	4.2	**4.2**	3.8	4.0
Tettnang Hallertauer	4.8	4.5	4.8	3.1	5.0	4.8	2.6	4.3	4.7	**4.5**	4.2	4.3
Spalt Spalter	4.0	4.4	4.6	3.1	4.4	4.3	2.8	4.6	4.1	**4.4**	4.0	4.1
Elbe-S. Hall. Magnum	14.0	13.9	13.9	10.2	14.0	14.4	12.4	13.3	12.2	**13.7**	13.2	13.2

Source: *Arbeitsgruppe Hopfenanalyse (AHA)*

4 Hop breeding research

RDin Dr. Elisabeth Seigner, Dipl. Biol.

4.1 Classical breeding

New hop varieties have to meet the requirements of the hop and brewing industries, making maximum yield, resistance and brewing quality the major breeding goals. The Hüll breeding stock comprises over 15,000 female and 4,000 male breeding lines, 150 varieties of domestic and foreign origin, as well as hundreds of pre-selected wild hops from around the world. This breeding stock provides ample genetic potential for carrying out around 100 crosses every year, thus providing the basis for achieving major breeding advances in new varieties – both of the aroma and the high-alpha type. Biotechnology and genome-analyical methods have been used for years to support classical cross-breeding.

4.1.1 Crosses in 2009

A total of 95 crosses were carried out during 2009. The major breeding goals are stable resistance / tolerance towards downy mildew, powdery mildew, crown rot and wilt. Table 4.1 shows the number of crosses performed for each breeding goal.

Table 4.1: Cross-breeding goals in 2009

Breeding direction combined with resistance / tolerance towards various hop diseases	Further requirements	Number of crosses
Aroma type	Exceptional aroma	5
	New powdery mildew (PM)-resistance qualities from wild hops	32
	Aphid resistance	1
	High beta-acid content	2
	Suitability for low trellis systems	8
	Suitability for developing molecular markers	1
High-alpha-acid type	None	21
	New PM-resistance qualities from wild hops	2
	Aphid resistance	1
	High xanthohumol content	3
	High beta-acid content	7
	Suitability for low trellis systems	12

4.1.2 Biogenesis studies – ideal harvesting time

Objective

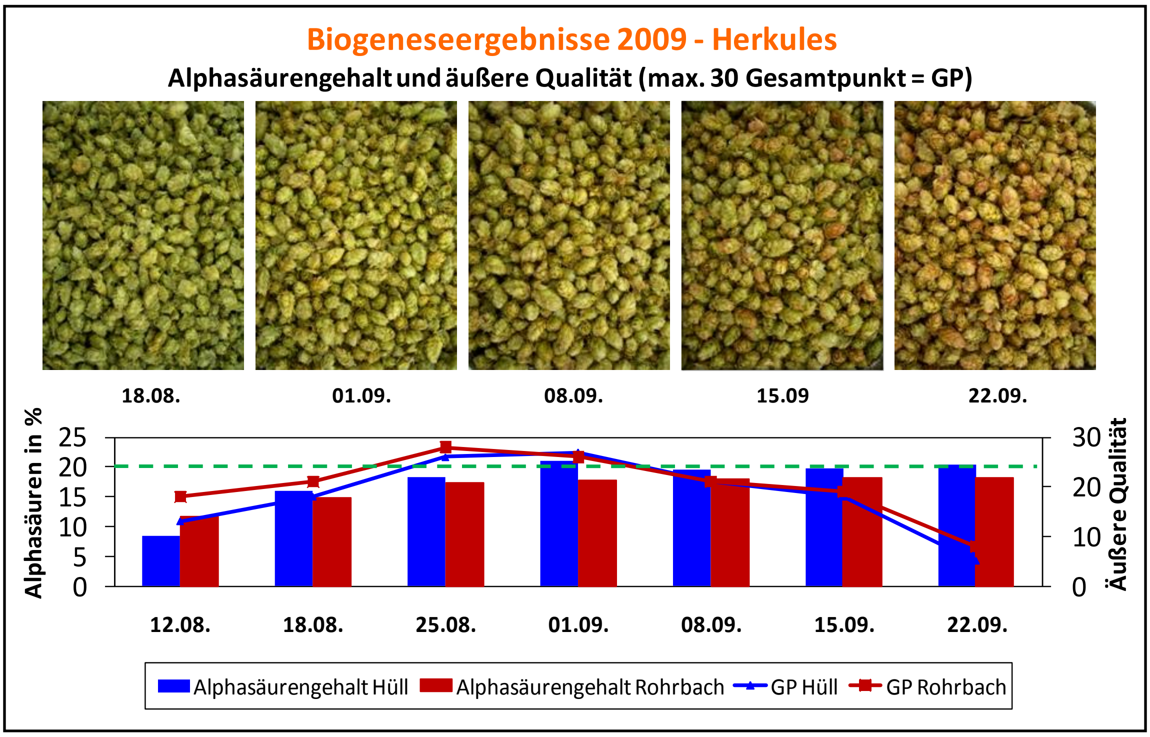
Ideal hop harvesting times, at which maximum yield, alpha-acid content and aroma are obtained, range from late August to mid/late September and differ from variety to variety.

Harvesting times are additionally influenced by the weather, the time of rootstock pruning in spring and location-specific factors such as soil properties, geographical site of the particular hop stand and exposure. Harvesting time has a major influence on all the main quality parameters in the following year, such as yield, alpha-acid content, aroma, external quality, growth vigour and plant vitality, making it immensely important to always harvest at the ideal time. Biogenesis studies based on the findings of multi-year harvesting-time tests of several years' duration are accordingly conducted every year, providing information about the current stage of development of the various varieties. The Hop Advisory Service uses this information to make harvesting recommendations to growers and dealers.

Method

In Hüll and Rohrbach, individual bines are harvested from the major hop varieties each week from mid August until late September. In addition to yield determination, cone samples are subjected to organoleptic testing and chemical analysis, and the data pertaining to aroma, components and external quality evaluated.

Results



Alpha-acid content in the Hüll high-alpha variety Herkules reached maximum values of 18-20 % around September 8th and remained constant until September 22nd. Scientific tests with the various Hüll cultivars have shown that the yield curve follows the alpha-acid trend with a time delay of some days. It was accordingly recommended that Herkules be harvested as from September 12th. External quality is often already on the decrease by this time, making it almost impossible for farmers to achieve maximum values for all hop parameters at any one harvesting time. Whereas external quality remains important for aroma varieties, per-hectare yields (calculated in kg alpha acids per ha) are the primary criterion for high-alpha cultivars. As illustrated here for Herkules, these assessments are carried out each year for all major hop varieties and the results used to recommend harvesting times to growers.

4.1.3 Breeding of dwarf hops for low trellis systems

Objective

Lower production costs and hence improved competitiveness are anticipated for hops grown on low trellis systems. However, there are currently no varieties adapted to this cultivation method. The aim of a research project funded by Germany's Federal Agency for Agriculture and Food (BLE) is thus to breed hops which, by virtue of their shorter height, broad disease resistance and excellent brewing quality, are particularly suitable for profitable cultivation on low trellis systems. Raising hops in this way might also have environmental benefits because the required plant-protective and fertiliser volumes are lower. Furthermore, recycling tunnel sprayers can be employed for pesticide and liquid-fertiliser application and potential spray drift thus reduced. As part of this research project, selective crosses have been made every year since 2007 and endeavours subsequently made to select breeding lines that have the above qualities and thus the potential to make this innovative cultivation system profitable.

Results

2009 seedling batch reared from crosses made in 2008

Approximately 34,700 seedlings were reared from 6 aroma-type and 11 bitter-type crosses made in 2008. Preliminary selection commenced in early March.

- **Testing for PM resistance and downy mildew tolerance**

32,000 greenhouse seedlings in seed dishes were inoculated with four PM (*Podosphaera macularis*) races typical of the Hallertau region. Seedlings not visibly infected with PM were transferred from the seed dishes into individual pots. They were kept in the greenhouse under conditions conducive to PM infection and monitored for PM until mid-April. Altogether 1,190 seedlings were ultimately classified as PM-resistant. These seedlings were then tested for tolerance towards downy mildew (*Pseudoperonospora humuli*). To this end, the PM-resistant seedlings and also 2,700 seedlings that had not been pre-selected as PM-resistant were sprayed with a suspension of fungal spores and tested for tolerance. Resistance to *Verticillium* cannot be tested until much later under field conditions because this test requires the plant's root system to be fully developed.

- **Assessments in the vegetation hall: disease and pest tolerance, growth type and sex determination**

In mid-May, 1,280 seedlings pre-selected for disease resistance/tolerance were planted out in the vegetation hall, where their growth vigour and disease resistance were monitored under natural conditions until autumn. The plants were also classified as male or female on the basis of flowers that formed as from July. A DNA marker was used to sex any seedlings that had not produced any flowers by autumn. Plants which showed considerable weaknesses such as severe aphid infestation, mildew or root rot, or which were of unsuitable growth type, were discarded by autumn.

- **Planting of the 2009 seedlings in the high-trellis breeding yards**

On account of the damp autumn weather, the seedlings were not planted out in the Hüll and Freising breeding yards until spring 2010.

Tests will be conducted on the seedlings for the next three years and will show whether any of these seedlings are also suitable for selection.

- **Seedlings from 2006 – 2008 with dwarf-growth potential**

From altogether 40 harvested seedlings, five were selected during the 2009 seedling assessment in the Hüll breeding yard. In terms of potential yield, alpha-acid content and their growth properties, these five were found to be promising candidates for growing on low trellises. Once confirmed virus-free, they were due to be propagated in spring 2010, allowing rapid commencement of small-plot, low-trellis trials.

- **Crosses in 2009**

The goal of 21 (8 aroma-type and 13 bitter-type) of the 95 crosses carried out in 2009 was to breed hops suitable for low-trellis systems. Seeds were obtained from all the crosses in autumn.

- **Results from breeding lines being cultivated in low-trellis yards on the Schrag and Mauermeier hop farms**

Breeding lines from various breeding programmes are now being cultivated in two low-trellis yards. Shorter-stature breeding line trials conducted over several years on low-trellis systems are essential because the cultivation experience and analytical results form the basis for planning crosses made within the context of this project.

Low trellis (LT) yard in Pfaffenhofen at the Schrag hop farm

For some years, five shorter-stature breeding lines have been cultivated conventionally at this yard in rows (163 plants/row; 75 cm within-row spacing) (Table 4.2). The bines are trained up galvanised wires.

In 2008, a further two rows of each of the two most interesting breeding lines were planted in order to compare four methods of cultivation: “conventional”, “non-cultivation”, “training wires” or “netting”. The entire trial stand was harvested on September 14th, 2009, this being the first time that harvest yields could be compared in terms of cultivation methods employed. The results (Table 4.3) are therefore still inconclusive.

Table. 4.2: LT-Pfaffenhofen – breeding line yields in 2009

Breeding line	Type	Yield in kg/ha	α-acids in %	β-acids in %	Cohumulone in %	Aroma 1-30
2000/102/005	B	1342	16.3	5.5	29.5	22
2000/102/008	B	1840	12.2	6.1	22.9	23
2000/102/019	B	1489	16.7	3.9	25.4	23
2000/102/032	B	1143	14.7	5.4	34.3	23
2000/102/791	B	1654	16.7	5.4	30.4	21

A= aroma type; B= bitter type; aroma assessment up to a maximum of 30 points for a particularly fine aroma. Components were analysed by the WG Hop Quality/Hop Analytics (IPZ 5d). LT= low-trellis yard

Table.4.3: LT Pfaffenhofen – yields in terms of cultivation methods employed

Breeding line	Cultivation method	Yield in kg/ha	α-acids in %	kg α-acids/ha	β-acids in %
2000/102/008	conventional, wire	2048	11.2	228	6.1
2000/102/008	conventional, netting	2134	10.9	232	5.7
2000/102/008	non cultivation, wire	1865	11.2	209	5.7
2000/102/791	conventional, wire	1703	17.4	296	6.0
2000/102/791	non cultivation, wire	1727	16.6	286	5.7

The use of systematic fungicides in spring 2009 prevented the occurrence of severe primary downy mildew infection, which had been typical of this location with clayey soil in previous years. No other problems concerning diseases or pesticides occurred.

The technically outdated mobile picking machine procured for the R&D project that ran from 1993 – 2002 is still being used for harvesting although its picking performance is unsatisfactory. Some of the harvested hops fall to the ground through the lower cover and are lost. Yield losses fluctuate between 18 and 20 % depending on cone shape and breeding line. Round cones roll better from the lower cover onto the conveyor belt than do conical ones, which get stuck on the cover and are apt to fall to the ground.

Low trellis yard in Starzhausen at the Mauermeier hop farm

In addition to the English dwarf hop varieties and four Hüll high-trellis cultivars (reference), 39 shorter-stature breeding lines from a variety of resistance breeding programmes are being tested on 46 plots (Table 4.4) with 10-12 plants on each (75 cm within-row spacing; bine training up wires). No harvests have yet been obtained from ten of these breeding lines because they were only planted out in May 2009. This part of the yard is worked using conventional pruning and hilling methods.

As in Pfaffenhofen, a further two rows of each of the two most interesting breeding lines were planted in 2008 in order to compare the four cultivation methods: “conventional”, “non-cultivation”, “training wires” and “netting”. The small, individual plots were harvested between 10th and 21st September, depending on the ripening time of the breeding lines. The trial stand involving a comparison of cultivation methods was harvested for the first time on September 15th, 2009 (Table 4.5).

Table. 4.4: LT Starzhausen – breeding line yields in 2009

Breeding line/ variety	Type	Yield[3] in kg/ha	α-acids in %	β-acids in %	Cohumulone in %	Aroma 1-30
First Gold[1]	A	855	8.1	3.0	28.3	24
Herald[1]	A	779	10.9	3.5	29.5	21
Pioneer[1]	A	1197	10.5	3.2	30.3	21
Perle[2]	A	1144	9.1	4.7	28.4	25
Hall. Magnum[2]	B	894	18.8	6.7	26.2	22
Hall. Taurus[2]	B	1068	18.9	4.9	23.0	20
Herkules[2]	B	2058	16.6	5.6	27.4	22
99/097/702	B	974	6.3	3.3	22.5	22
99/097/706	B	1092	5.8	3.7	33.6	24
99/097/725	B	762	11.8	4.1	31.1	22
2000/102/004	B	791	5.3	2.1	24.0	21
2000/102/005	B	1211	13.6	5.0	29.0	22
2000/102/008	B	2205	10.7	5.6	24.6	23
2000/102/012	B	1179	11.9	4.0	32.8	22
2000/102/019	B	1460	16.8	3.9	24.0	22

Breeding line/ variety	**Type**	**Yield[3] in kg/ha**	**α-acids in %**	**β-acids in %**	**Cohumulone in %**	**Aroma 1-30**
2000/102/032	B	1389	15.5	5.3	31.9	23
2000/102/043	B	1227	12.2	3.9	24.9	21
2000/102/054	B	1522	16.2	4.5	28.8	22
2000/102/074	B	1234	10.9	3.1	22.5	20
2000/102/791	B	1951	15.6	5.3	31.2	22
2001/040/002	A	710	11.4	3.9	24.4	26
2001/045/702	A	700	7.2	4.8	20.6	24
2003/039/022	B	1382	10.3	6.3	35.6	20
2004/098/010	A	1030	9.8	3.6	30.2	24
2004/107/719	B	1502	12.4	5.2	31.3	22
2004/107/736	B	704	5.7	2.6	30.0	21
2005/085/703	B	No harvest due to severe leaf burn				
2005/098/005	B	1548	13.3	4.4	26.8	19
2005/098/744	B	1136	8.4	2.8	31.9	23
2005/100/718	B	1087	18.8	5.0	25.0	22
2005/101/001	B	923	6.6	2.8	36.7	20
2005/102/009	B	1313	4.2	1.6	38.8	22
2005/102/028	B	1461	14.1	5.4	34.6	20
2005/102/710	B	1066	13.9	5.6	30.1	19
2006/048/720	B	868	11.3	5.0	23.9	19

A = aroma-type; B = bitter-type; [1] = English dwarf hops; [2] = Hüll high-trellis cultivars; [3] = yield from 12 plants/plot, extrapolated to 1 ha. Aroma: aroma assessment up to a maximum of 30 points for a particularly fine aroma. Components were analysed by the WG Hop Quality/Hop Analytics (IPZ 5d). LT= low-trellis yard

Table. 4.5: LT Starzhausen – yields in terms of cultivation methods employed

Breeding line	Cultivation method	**Yield in kg/ha**	**α-acids in %**	**kg α-acids/ha**	**β-acids in %**
2000/102/008	Conventional, wire	2160	9.7	210	5.4
2000/102/008	Conventional, netting	2242	10.2	229	5.4
2000/102/008	Non cultivation, wire	2645	10.2	269	5.6
2000/102/791	Conventional, wire	2423	15.9	385	5.2
2000/102/791	Non cultivation, wire	2044	15.5	316	5.2

In contrast to the Pfaffenhofen location, primary downy mildew infection is negligible on the sandy soil in Starzhausen. However, this south-inclined stand had massive spider-mite problems as of the end of May 2009, largely due to the age of the stand. Unlike high-trellis hop harvesting, the mobile picking machine only picks the cones and some of the leaves. The rest of the plant is left standing. This has several advantages: the plant can continue assimilating until autumn, allowing it to store reserve substances in its rootstock, with fertiliser requirements thus being much lower in the following year.

There is also a disadvantage, however, because the hollow main and lateral shoots, which dry out over the winter, offer ideal overwintering conditions for spider mites. This problem becomes exacerbated with increasing age of the stands on the trial plots, as more and more dried-out material is left clinging to the support wires.

The support or training wires on the newly established plots (Fig. 4.1) were still free of dry material, and spider-mite infection levels were no higher than in high-trellis stands throughout the season. By contrast, the degree of infestation on the “older” plots was already so high by May 20th that, despite immediate Ordoval treatment, the spider mite population continued to increase rapidly. All in all, despite three treatments against spider mites, levels of infestation were so high in some susceptible breeding lines and varieties that the crop was no longer marketable.

The only solution is to remove old bines. This is done using a rotating roller that is attached to the front of the tractor and knocks off frozen bine material in winter. This additional work does add to costs, but considerably reduces the volumes of acaricides needed.

Fig. 4.1: Newly established, homogeneous stand with no shoots in ground proximity and no spider-mite problems

Another positive side effect is that the following year's new shoots can climb much more easily. High-trellis systems use black iron wire which corrodes slightly during the season. This makes it easier for the hop bines to gain a grip. Low-trellis systems use galvanised iron, making it unnecessary to renew the wires every year. Galvanised wires do not corrode and accordingly provide less of a hold. The presence of too much old bine material makes climbing even more difficult (Fig. 4.2). A further problem is that shoots grow outwards on the old laterals and then fall down when the latter can no longer hold their weight.

Fig. 4.2: The remains of old bines from previous years make it difficult for new shoots to climb. The bines keep slipping down as a result, forming thickets of shoots on the ground and making it extremely difficult to control hop red spider.

This problem also becomes especially obvious just before harvesting. Bine weight increases steadily during cone formation. Only bines that have grown right to the top of the trellis and have hooked themselves over the top wire have a secure hold. Depending on their twining ability, the weather and the weight of the old bine material, the remaining bines will collapse to varying degrees by harvest time.

- **Assessment of results to date**

All findings concerning hop cultivation on low-trellis systems have so far been obtained using traditional high-trellis varieties, English dwarf-hop varieties and shorter-stature breeding lines derived from earlier resistance-breeding programmes. Seedlings obtained from special crosses in the context of this project are scheduled for cultivation on low-trellis systems in 2010.

2000/102/008 and 2000/102/791, the two sisters selected in the two trial hop gardens described above, appear to be the most interesting of the high-alpha breeding lines. With a yield of over 2 t/ha under favourable growing conditions, the semi-dwarf 2000/102/008 is currently front runner. It has good growth properties and develops a homogeneous bine with slight head formation. Cone formation is extremely homogeneous over the entire bine. Unfortunately, alpha-acid content (10-12 %) is not competitive. By contrast, the breeding line 2000/102/791 has a very high alpha-acid content that reaches levels approximately equivalent to those of Taurus and Herkules. However, this dwarf is characterised by weaker growth and only an average number of cones. Potential yields are limited as a result. This breeding line is, moreover, highly susceptible to downy mildew and crown rot. Despite these drawbacks, both breeding lines are highly interesting crossing partners for the current R&D project.

Nothing can be said as yet concerning the best method of cultivation because all the young hop plants were pruned in 2009. Only after hoeing were the plots farmed in different ways. It also remains to be seen whether the plastic netting employed is suitable for several years' use.

Despite remarkable progress, no breeding line is yet available that combines all the criteria for a marketable variety. All the lines selected so far show relatively high susceptibility to downy mildew and red spider mite, which is not conducive to future profitability. After 2-3 years of cultivation, in particular, the old bine remains on the support wires hinder the new shoots from twining their way up.

Cone formation on low-trellis systems starts very low down, meaning that only the very bottom leaves of the plant can be removed with herbicides. This makes it extremely difficult to apply adequate coatings of plant protectives to the undersides of the leaves. Soil-borne infections and pests that come up from the soil are accordingly hard to control, making plant protection measures more difficult. Picking techniques also need to be improved significantly.

4.1.4 Monitoring for Hop stunt viroid (HSVd) infections in hops in Germany

Hop stunt viroid (HSVd) is an extremely serious hop disease. Depending on the variety and weather conditions, it leads to massive losses in crop volumes and quality. Stunted Japanese hop varieties with curled, chlorotic leaves and small cones were first observed in Japan and Korea during the 1940s. It took years before a connection was established between these symptoms and HSVd infection. In 2004, this viroid was found for the first time in hop yards in the USA, and in 2007 in China, too. When infected with hop stunt viroid, the US varieties “Willamette" and “Glacier” show alpha-acid losses (kg α-acid per ha) of 60 and 75 % respectively.

As the typical symptoms of an HSVd infection often appear only 3-5 years after infection, symptom-free hops infected with HSVd constitute the greatest risk (due to their highly infectious sap) for unhindered spread of the viroid. During cultivation work, the viroid can be easily spread mechanically within a hop stand, and, via contaminated machines and equipment, even from stand to stand. There are no effective plant protectives or disinfection agents available, and even heat cannot inactivate the virus. To date, effective tissue-culture techniques with which healthy planting stock can be generated (as is possible in the case of virus infections) are not available, either.

The primary aim of initial monitoring for HSVd, which was commenced in 2008 and continued in 2009 on farmland and experimental ground in the German hop-growing regions and, particularly, in the breeding yards of the LfL’s Hop Research Centre in Hüll, was to establish whether HSVd is already present in Germany. This knowledge is a basic requirement for effective risk management of this dangerous hop disease.

Monitoring for HSVd with a molecular technique

The RT-PCR (Reverse Transcriptase Polymerase Chain Reaction) detection process for HSVd using primers developed at Washington State University, Prosser, USA, provided a reliable molecular method of identifying the viroid. This technique requires technical expertise and is relatively expensive, but permits reliable and rapid diagnosis in one-to-two days.

The tests for HSVd, which were begun at the LfL's diagnostics lab in 2008, were continued in 2009 with more extensive monitoring. For the tests, fresh young leaves were selected, when possible, from hop plants with a "suspicious" appearance, for example with chlorosis, stunted growth, curled leaves or noticeably small cones.

Table 4.6 shows the various origins of the 224 hop samples that were collected. 64 samples came from the Hüll Research Centre's breeding yards in Hüll, Schrittenlohe, Rohrbach and Freising; a greenhouse sample from Hüll was also included. The aim was to rule out systematic spreading of the viroid from these breeding yards, in which new breeding stock and varieties from hop breeders all over the world are cultivated, to the Society of Hop Research (GfH) propagation facilities and thence to the growers. A further 30 samples taken from mother plants at the GfH's propagation facilities and 58 from field crops in the Hallertau, Elbe-Saale and Tettnang hop-growing regions were included in the study.

The leaves from the selected hop plants were taken as quickly as possible, or sent by post, to the diagnostics lab in Freising, where they were immediately stored at minus 80 °C until further examination. The nucleic acids (viroid RNA and hop RNA) were extracted from the freeze-dried leaves and then used in the RT-PCR to identify HSVd. On completion of the RT-PCR reaction, the reaction products were separated on electrophoretic gel; in the event of HSVd infection, the typical reaction products would be visible as bands on the electrophoretic gel (Fig. 4.3).

Table 4.6: Hop samples examined and HSVd results

Origin and nature of the samples	**Number of hop samples**	**RT-PCR HSVd negative**	**Not evaluable due to absence of an internal control band**
Hüll, Rohrbach and Freising breeding yards: cultivars, male and female breeding lines	54	49	5
Schrittenlohe breeding yard: wild hops from all over the world	10	9	1
GfH Hallertau propagation facilities: mother plants	30	28	2
Elbe-Saale field crop : cultivars	4	2	2
Hallertau field crops: cultivars	44	39	5
Tettnang experimental station and field crops: cultivars	10	3	7
Foreign cultivars	72	72	0
Total	**224**	**202**	**22**

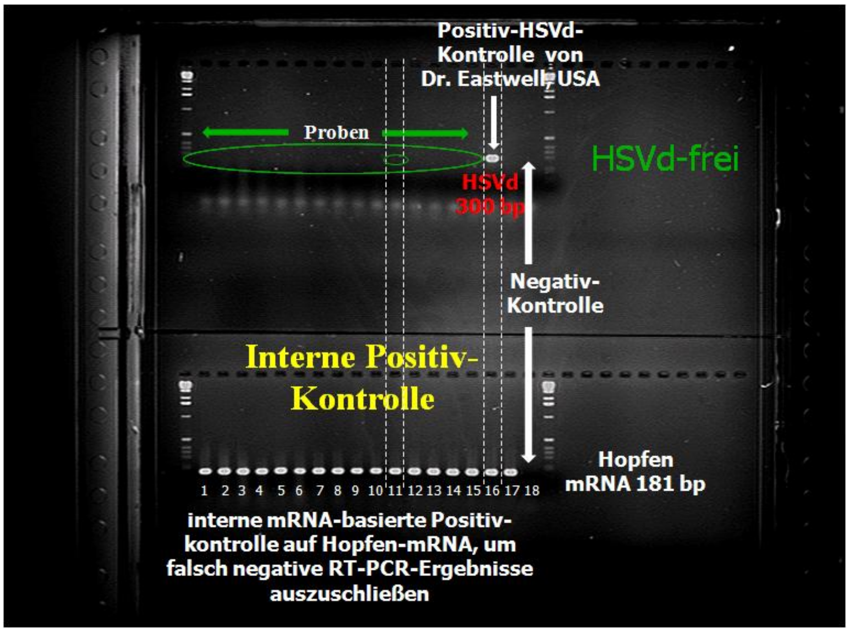


Fig. 4.3: The HSVd-free condition of 15 hop samples (No. 1-15; Ellipse) was confirmed by absence of the typical HSVd band on the electrophoretic gel image. In the positive control (No. 16; HSVd-infected leaf material from Dr. Eastwell), the specific, 300-base-pair HSVd band is visible at the same gel level. A hop-mRNA-based internal control (181-base-pair (bp) band in the lower part of the gel image) was run for every sample to ensure that the missing HSVd band was not the result of a non-functioning RT-PCR. Number 17 is the HSVd-free control sample (from HSVd-free hops), and No. 18 is a water-based control (no typical bands).

In 202 of the 224 hop samples tested (Table 4.6), the 300-bp HSVd band was absent and the hop-mRNA-based internal control band indicating a fully functional RT-PCR was visible on the gel image at the same time. These hops were therefore identified as definitely HSVd-negative, i.e. free of infection. The HSVd infection status of the remaining 22 samples remained unclear because the internal, hop-specific control band was missing. Possible reasons for the unsuccessful RT-PCR reactions include leaf samples that are too old and rich in polyphenols, and/or long transport times, in which case uncooled leaf samples may have started to decompose.

In accordance with our instructions, the hop farmers had mostly sent in suspicious-looking plants for HSVd testing. These had growth disorders, curled leaves or virus symptoms, all of which, according to the literature, may be caused by HSVd infection. However, such symptoms can also be due to other factors. Some of the hops that had been confirmed HSVd-negative were in fact found to be infected with apple mosaic and/or hop mosaic virus, providing an explanation for the symptoms observed.

Assessment of results to date

No HSVd was detected by RT-PCR in 256 hop samples taken from the Hop Research Centre’s breeding yards in Hüll, the Hallertau propagation facilities of the Society of Hop Research (GfH) and from various field crops in the Hallertau, Elbe-Saale and Tettnang hop-growing regions. These hops have been categorized as HSVd-free.

22 samples could not be evaluated. These results suffice to rule out massive HSVd infestation in Germany. However, our monitoring system involving the screening of hop samples clearly has weaknesses. It is thus imperative that HSVd testing be continued next year. Work is also being done to improve the technique still further, especially for older hop samples.

The continued cooperation and sharing of information on HSVd testing with Dr. Ken Eastwell of Prosser, USA will be of great value to us in future, too, as will his experience with practical measures to control this viroid disease.

The aim of this monitoring project is to reduce the likelihood of initial HSVd infection centres developing and to prevent the disease from spreading, there being no way as yet to control the disease in the hop plants themselves once HSVd has established itself in a crop. The economic consequences of an HSVd infection, bringing losses of up to 75 % in alpha-acid yield, would be dramatic for German hop growers and the brewing industry alike.

Eastwell, K.C. and Nelson, M.E., 2007: Occurrence of Viroids in Commercial Hop (*Humulus lupulus* L.) Production Areas of Washington State. Plant Management Network 1-8.

Seigner, L., Kappen, M., Huber, C., Kistler, M., Köhler, D., 2008: First trials for transmission of Potato spindle tuber viroid from ornamental Solanaceae to tomato using RT-PCR and an mRNA based internal positive control for detection. Journal of Plant Diseases and Protection, 115 (3), 97–101.

4.2 Biotechnology

4.2.1 Characterisation of hop/hop powdery mildew interaction at cell level and functional analysis of defence-related genes

Objective

Hop powdery mildew (*Podosphaera macularis*) has been a problem in international hop production for decades. The aim of this research project is to characterise the hop/hop powdery mildew interaction in various wild hop varieties that are to be used as new resistance sources for breeding. The wild hops are examined microscopically along with the PM-resistant cultivar Wye Target, with the focus on characterising the spatio-temporal defence responses at the single cell level. This research into "new" resistance sources and their use in breeding PM-resistant hops is of enormous importance. Another component of this project supports resistance breeding via a molecular biological approach in which the functions of genes involved in defence responses are characterised. This involves the use of what is known as a transient assay system. To this end, EST (*expressed sequence tags*) databases were searched for hop-specific genes that might be connected with PM resistance. A transient knock-down approach, or overexpression at leaf level, is expected to provide information about the function of these genes in the hop/hop powdery mildew interaction.

Methods

PM resistance was assessed microscopically by inoculating various hop varieties with PM and stopping the infection 24 or 48 h after inoculation. Various staining techniques were developed to visualize the fungus and cell-level defence responses.

Various hop ESTs were selected as candidate genes for the transient assay. They were identified by researching the literature and comparing sequences of known defence-related genes from other plants with EST databases. To obtain more information about these genes, gene expression, i.e. gene activity, following PM infection was examined in susceptible and resistant varieties. To this end, *in vitro* plants were inoculated with PM, and the RNA isolated at various points in time after inoculation.

Results

- **Microscopic investigation**

A number of wild hop varieties from the USA, Japan, Turkey and Germany are currently being investigated. Fig. 4.4 A and B illustrate the resistance of a wild hop from the USA. Compared with the control, there were, as expected, no compatible ("susceptible") interactions between the PM fungus and the hop cell. 24 hours after inoculation it is evident that the wild hop's resistance is due mainly to a hypersensitive response (apoptosis) of the cells under attack. Haustoria are visible in most of the cells showing a hypersensitive response. Only a few interactions involved cell-wall apposition. In Figs. 4.4 E and F, a wild hop cell that is under attack and is demonstrating a hypersensitive response and cell-wall apposition can be seen. In addition to resistance in various wild hop varieties, different types of tissue were investigated for their susceptibility. In the previously investigated, phenotypically resistant hops, the hairs (Fig. 4.4 D) on the upper leaf surface were found to be susceptible (Fig. 4.4 C), whereas the epidermal cells were resistant.

- **Transient assay**

Once the various parameters for the transient assay had been adapted as required, a search was performed for genes suitable for functional characterisation, and a list of these candidate genes drawn up. Semi-quantitative PCR was set up to provide more accurate information about these genes following infection with PM. Fig. 4.5 illustrates the activity of a gene demonstrating strong similarity with resistance genes of other plants. In the resistant variety, this gene is "switched on", showing maximum activity between eight and ten hours post inoculation. In the susceptible variety, the gene shows practically no activity. This gene is accordingly a promising candidate for transient assay.

Outlook

Now that effective methods of characterising different resistance mechanisms have been established, microscopic investigation of various resistant wild hop varieties and cultivars will be intensified. Work might include, for example, further tests on the susceptibility of different cell types and cells at different development stages, as well as investigation of progeny and of other genotypes.

The most promising candidate genes for the transient assay are currently being cloned and sequenced. They will then be used for transformation and functional characterisation.

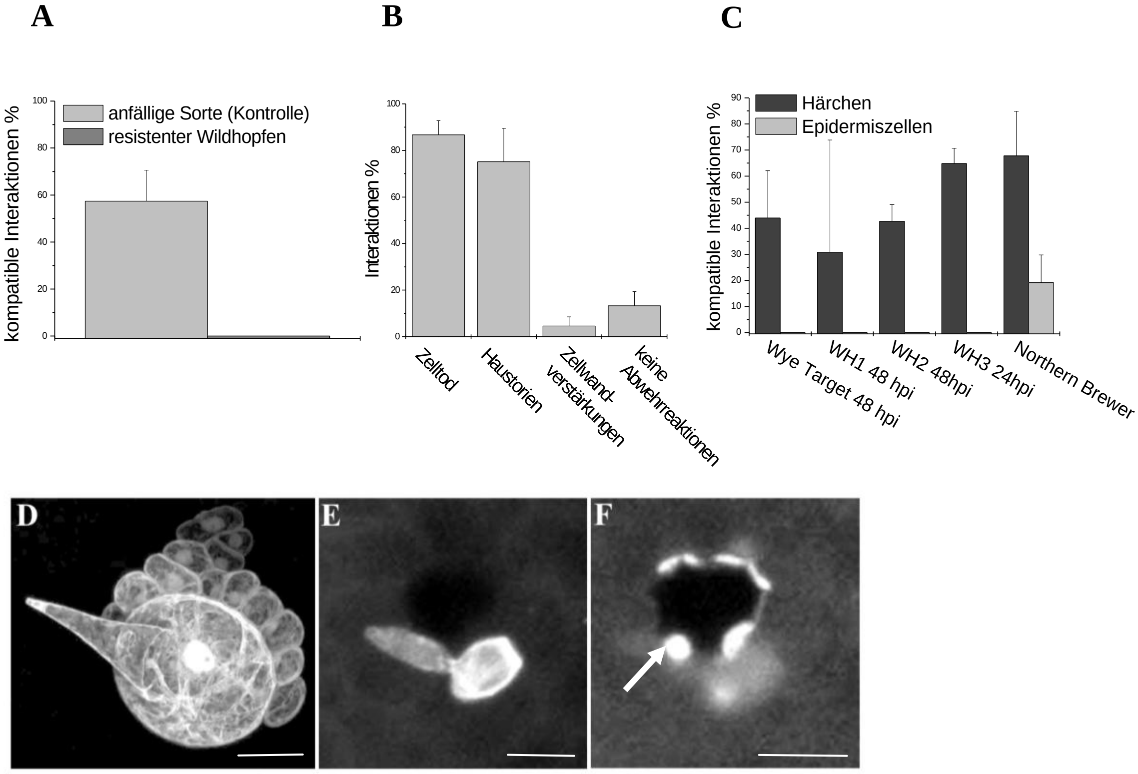


Fig. 4.4: ***A*** *- Percentage of compatible ("susceptible") interactions in a resistant wild hop and the susceptible control variety.* ***B*** *- Defence responses of the resistant wild hop (A): cells showing a hypersensitive response (apoptosis) and/or cell-wall apposition were observed. A haustorium was visible in most of the cells showing a hypersensitive response.* ***C*** *– Susceptibility of leaf hairs compared with that of epidermal cells in the resistant cultivar Wye Target, various wild hop varieties (WH) and the susceptible cultivar Northern Brewer: in the resistant cultivar and the wild hops, the hairs are susceptible, while the epidermal cells are not. In the susceptible cultivar Northern Brewer, both cell types are susceptible. Hpi: hours post inoculation.* ***D*** *– Micrograph of a leaf hair.* ***E*** *– A germinated fungal spore (white) on a resistant wild hop.* ***F*** *– The same interaction as E:"staining" of the defence responses (callose accumulation in the cell walls, white) indicates a hypersensitive response; cell-wall apposition is also visible at the point where the fungus is attempting penetration (arrow). Scale: the black bar = 25μm.*

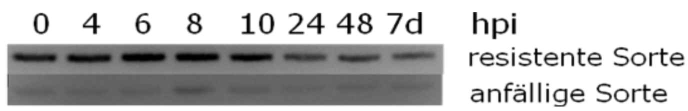


Fig. 4.5: Semi-quantitative PCR of a gene showing similarities with resistance genes of other plant types. In the resistant variety, this gene is "switched on", showing maximum activity between eight and ten hours post inoculation. In the susceptible variety, the gene shows practically no activity. Ubiquitin expression (not illustrated) was used as the internal control. Hpi: hours post inoculation, d: days.

4.3 Genome analysis

4.3.1 Genotyping of *Verticillium* pathotypes in the Hallertau – findings concerning *Verticillium*-infection risk assessment

Objective

Hop wilt, caused by the *Verticillium* fungus, has been responsible for massive crop failures in isolated regions of the Hallertau since 2005. For the first time ever, previously wilt-tolerant cultivars such as Northern Brewer were also affected, not only highly susceptible varieties such as Hallertauer Mittelfrüher. To assess the potential risk to the Hallertau, it is therefore important to investigate the race spectrum of this fungal pathogen. In the case of hop wilt, in particular, a distinction has always been made between mild and lethal strains. The latter have severely affected hop cultivation in Slovenia since 1995. In addition to genetic analyses for comparing known mild and lethal foreign references with the predominant German races, artificial *Verticillium* infection tests are being used to accurately determine the virulence of isolated *Verticillium* races. At the same time, special field trials are being conducted on leased hop yards seriously affected by wilt. The aim is to clarify whether crop husbandry measures, such as excessive nitrogen fertilisation or the spreading of inadequately decontaminated bine choppings, are causing the problem.

Method

To cultivate the *Verticillium* fungus, approximately 2 cm² bine sections from the collection of hop bines were prepared under sterile conditions, transferred onto solidified plum-agar medium in petri dishes, and incubated at 25 °C for two weeks in the dark. Once the *Verticillium* species had been clearly identified, single-spore mycelia were produced from every petri dish via dilution series. Optimum genetic differentiation and classification of the newly obtained *Verticillium* samples is only possible via these single-spore isolates. One-cm² pieces were cut out of the resultant single-spore mycelia and transferred to conical flasks containing liquid medium to allow further growth. Two weeks later, fungal-mycelium growth was sufficient to allow harvesting by means of a suction filter. The fungal material was freeze-dried, ground in a ball mill, and the DNA isolated according to the modified Doyle and Doyle protocol (1990) for subsequent PCR assays.

Results

To assess the potential risk to the Hallertau hop-growing region, it is important to clarify the extent to which the *Verticillium* races occurring in the region are of the mild or lethal form described in the literature. With the help of already published specific PCR primers and AFLP markers, evidence was furnished that the German *Verticillium* isolates investigated so far are not known lethal races introduced into German hop-growing regions from the United Kingdom or Slovenia (see Fig. 4.6).

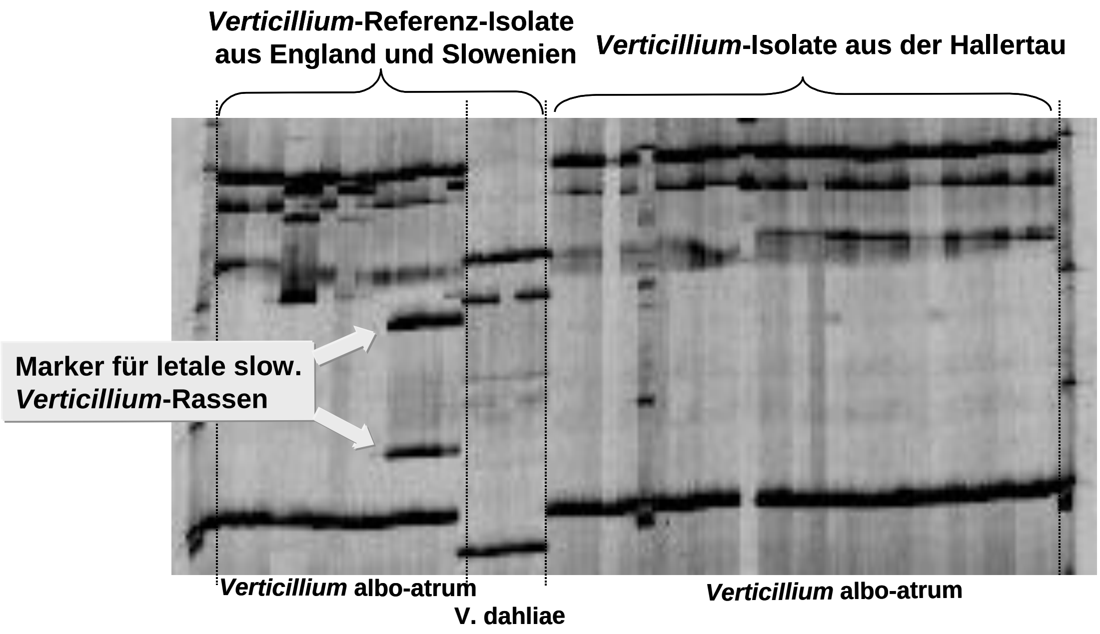


Fig. 4.6: AFLP patterns of various Verticillium races (Hallertau isolates compared with references)

Genotyping (= genetic differentiation) was subsequently commenced in order to identify genetic differences between the Hallertau *Verticillium* isolates and then test their virulence on the basis of these differences. Until recently, this work proved extremely difficult. Only minimal genetic differences were detected among the Hallertau *Verticillium* fungi, a finding explained by *Verticillium's* asexual life cycle. There is no genetic exchange during recombination events. New races are thus formed primarily by mutations in the fungal genome. This makes a finding obtained only recently during continued intensive AFLP analysis all the more serious: when screened with currently 10 AFLP primer combinations, 47 single-spore isolates of *Verticillium* were shown to contain specific DNA fragments found neither in the other isolates from the Hallertau growing region nor in the mild English isolates, but only in lethal English and lethal Slovenian isolates.

The virulence of the first Hallertau *Verticillium* isolates obtained was determined in an initial artificial *Verticillium* infection test already well established in Slovenia and used there routinely in breeding research. Besides the Slovenian reference isolates (mild and lethal), two Hallertau isolates from only slightly affected hop yards and two from seriously damaged hop yards were used in this test. In this infection test, these isolates and the references were used on the following hop cultivars: Celeia, Hallertauer Mittelfrüher, Hallertauer Tradition, Northern Brewer and Hallertauer Magnum. The cultivars were inoculated with the fungal isolates and the proportion of infected foliage measured (in %) after 30, 44 and 58 days. One noteworthy finding in this first test was that, on average, the levels of virulence of both the mild and the more aggressive Hallertau isolates lay somewhere between those of the mild and lethal Slovenian references. These results will be verified in a repetition test.

Outlook

Another focus of activity besides the current cultivation and genotyping of the *Verticillium* samples collected in summer, 2009 is the performance of further artificial *Verticillium* infection tests. This is the only way to accurately assess the extent to which the *Verticillium* race spectrum currently prevalent in the Hallertau region poses a risk to hop varieties under cultivation there. The plan is to monitor infected hop yards in order to determine the extent to which the *Verticillium* infection has already spread.

5 Hop cultivation and production techniques

LD Johann Portner, Dipl. Ing. agr.

5.1 N_{min} test in 2009

The N_{min} nitrogen fertiliser recommendation system is now in place and has become an integral part of fertiliser planning on hop farms. In 2009, 3338 hop yards in Bavaria were tested for their N_{min} levels, and the recommended amount of fertiliser calculated.

Table 5.1 lists the numbers of samples tested annually for N_{min} since 1983. N_{min} levels in Bavarian hop yards averaged 85kg/ha in 2009, around 10 kg/ha more than in 2008. Compared with the last 10 years, they were average.

As in every year, levels fluctuated considerably from farm to farm and, within farms, from hop yard to hop yard and variety to variety. Separate tests are therefore essential for determining the ideal amount of fertiliser needed.

Table 5.1: Number of N_{min} tests, average N_{min} levels and recommended amounts of fertiliser in hop yards in Bavarian hop-growing regions

Year	Number of samples	N_{min} (kg N/ha)	Fertiliser recommendation (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

Table 5.2 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 2009. It can be seen that N_{min} values for the Franconian hop-growing regions around Spalt and Hersbruck are higher than for the Hallertau districts. The nitrogen fertiliser recommendations for the targeted yields are correspondingly inverse.

Table 5.2: Number, average N_{min} levels and fertiliser recommendations for hop yards by administrative district and hop-growing region in Bavaria in 2009

District / Hop-growing region	Number of samples	N_{min} (kg N/ha)	Fertiliser recommendation (kg N/ha)
Hersbruck	56	114	113
Freising	326	88	145
Pfaffenhofen	1,127	84	150
Eichstätt	241	84	151
Kelheim	1,276	83	150
Landshut	224	78	148
Hallertau	**3,250**	**84**	**149**
Spalt (minus Kinding)	88	117	113
Bavaria	**3,338**	**85**	**148**

Table 5.3 lists N_{min} levels by variety and recommended fertiliser amount.

Table 5.3: Number, average N_{min} levels and fertiliser recommendation in 2009 for various hop varieties in Bavaria

Variety	Number of samples	N_{min} (kg N/ha)	Fertiliser recommendation (kg N/ha)
Brewers Gold	6	52	175
Herkules	374	79	166
Nugget	53	73	163
Hall. Magnum	667	74	158
Opal	9	69	148
Spalter Select	194	84	148
Hall. Taurus	286	85	148
Saphir	37	88	145
Hersbrucker Spät	161	87	144
Smaragd	7	86	142
Perle	632	88	142
Hall. Tradition	551	98	139
Northern Brewer	53	93	138
Hallertauer Mfr.	255	82	136
Hall. Merkur	10	112	127
Spalter	33	144	97
Other	10	66	147
Bavaria	**3,338**	**85**	**148**

5.2 Testing alternative training materials in 2009 (Bio-Cord paper string)

Objective

For many years, hop growers have been hoping to find an alternative training material to conventional iron wire. Use of a non-ferrous material would offer various benefits:

- Eco-friendly
- No metal spikes mixed with bine choppings being returned to the hop yard
- Less dependence on continuously increasing energy costs for steel
- No iron trainer-wire residues left on the barbed wire, thus increasing its service life
- Less wear on all cutting tools (harvesting machine, shredder etc.)
- Knots are easy to tie
- Degradable (suitable for fermentation of bine choppings in biogas plants).

Fig. 5.1: 300 strings compared with 500 wires

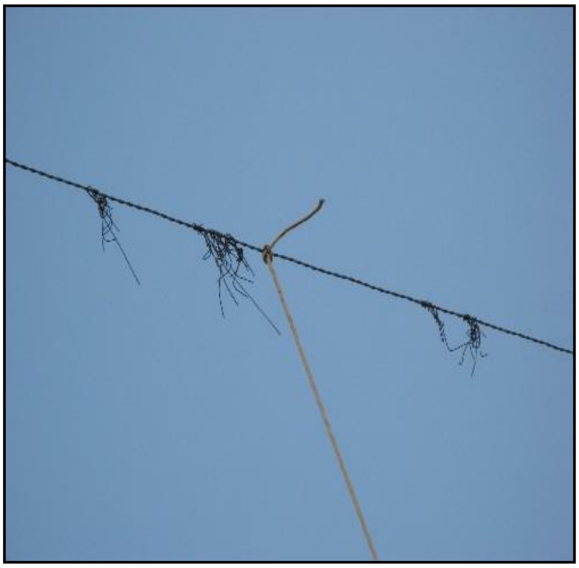


Fig. 5.2: Simple knots

Conducting the trial

Trial location: Rohrbach, light soil

Variety: Hallertauer Magnum

Material: Paper strings of three different gauges (4 mm, 5 mm and 6 mm) from the French company “textilose”. 100 strings of each thickness were used per row.

Stringing was carried out on April 2nd by two workers on the elevated platform and one tractor driver. The 3 different paper string gauges were suspended one beside the other. They were attached to the overhead barbed wire by means of a simple knot. A conventional 1.3 mm iron wire was hung for comparison. The wire and the paper strings were then embedded in the rootstock region by means of an insertion and anchoring device.

Observations and findings

- **Suspending the strings**

Time needed

It took 18 minutes to suspend 200 strings in two rows. The same team of field workers needed 15 minutes to suspend 200 wires. Taking a short practice period into account, it took 20 % longer to knot the strings than to hang the wires.

Additional observations

Advantages of paper string:

+ Lighter in weight
+ Clean material
+ Less risk of eye injuries

Disadvantages of paper string:

– The bulky pack of string has to be anchored to the elevated platform, sometimes with an expander, to prevent it from slipping.
– Tightening the knot on the barbed wire requires a great deal of strength, especially with the 5-mm and 6-mm string grades. Gloves are therefore essential to protect workers' hands from blisters and skin injuries.
– Strings that are already attached to the barbed wire and are hanging freely must not be run over by the tractor. Unlike the wire, they would be torn down.

- **Embedding the string**

Fig. 5.3: Freely suspended strings

Fig.5.4: Strings were embedded singly

Embedding the strings, especially in the centre of the rootstock region, requires more strength than is needed for wire. This is particularly true of the 5- and 6-mm grade strings. It is, moreover, impossible to embed 2 strings simultaneously because the strings are too thick for two of them to fit into the groove in the anchoring device.

It is important to embed the strings very soon after they have been suspended because, under windy conditions, they are apt to become entangled and be blown upwards.

Labour input

During the trial, which was conducted when there was no wind, an hourly embedding rate of 200 strings was achieved. This translates into 18 to 20 hours per hectare. Although the paper strings had to be embedded singly in the rootstock, the per-hectare rate for wire strings was no higher.

One disadvantage of paper training string compared to wire is that, once embedded, paper string cannot be tensioned again if it becomes loose.

- **Further observations during the growth period**

Within just two weeks of embedding the paper strings, micro-organisms had caused the first strings to rot in the soil-air transition zone.

Table 5.4: Number of rotted paper strings in the soil-air transition zone.

	Inspection dates		
String thickness	**22.04.**	**30.04.**	**08.05.**
4 mm	16	31	49
5 mm	14	27	41
6 mm	11	19	26

Fig. 5.5: Paper string that has rotted in the soil-air transition zone

By May 8th, 116 of the 300 training strings had already torn or rotted, allowing the wind to blow them to and fro and causing the bines to sag. As an emergency measure to prevent the whole crop from being lost, all the paper training strings were then pinned to the ground with wire pegs. This was problematic because the strings were very difficult to attach to the hooks on the pegs. Under windy conditions, further strings broke free from the pegs.

By harvesting time, the constant swaying of the sagging bines had caused several of them to fray at the base, break off and dry up. In many cases (46 bines), the plants had lost hold of the training string as a result of the continuous swaying. In consequence, some of them had slipped down several metres and had been partly prevented from forming cones. Throughout the growing season, the bines had to be regularly retrained, re-tied and re-attached to the overhead trellis so as to permit tractors to move between the rows for necessary cultivation and plant-protection work. Machine harvesting was made impossible by bines that had slipped down and were sagging.

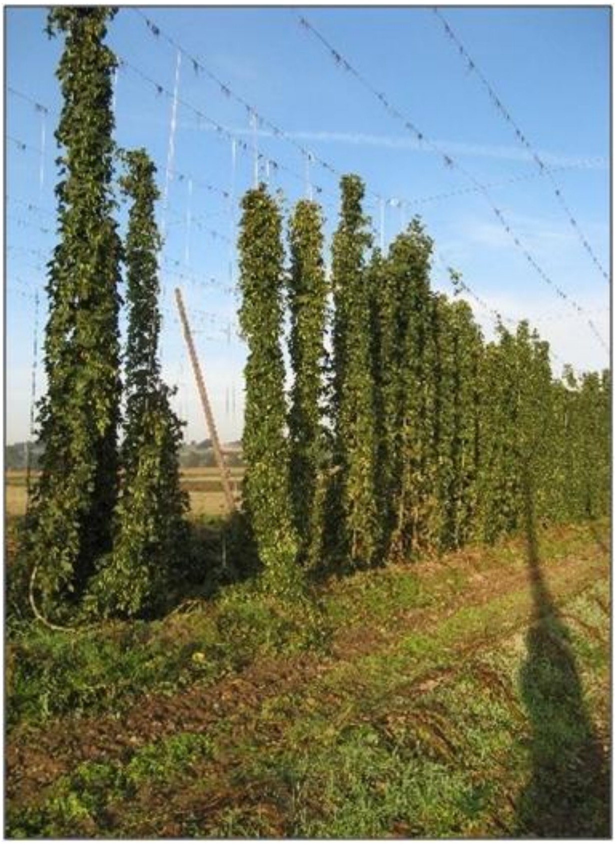


Fig. 5.6: Bines that have slipped down before the harvest

One positive aspect of these paper strings is their high tear strength. Not a single bine on any of the 3 string gauges (4, 5 or 6 mm) collapsed as a result of its weight.

Discussion and outlook

Securing the strings to the barbed wire takes a little longer than attaching iron wire. Embedding time is comparable. Even if the size of the packs makes paper string more difficult to handle, this disadvantage could be ignored in light of the advantages it has over wire.

On the other hand, the disadvantages of string as observed during the growth phase cannot be ignored. The need to secure the string in the ground a second time due to its rapid decomposition in the soil-air transition zone caused a lot of additional work. It was not possible to keep the strings adequately tensioned later on, either; as a result, wind-induced swaying repeatedly caused bines to sag, which ultimately made harvesting difficult and reduced yields by 9.4 %.

Continuing this trial would only appear to make sense if the training strings could be impregnated for 1 to 1.5 m at their lower ends with a substance that effectively prevents rotting in the soil-air transition zone for at least 4 months.

5.3 Spacing and bine-training trial with the Herkules cultivar and two or three bines per wire

Objective

Optimum within-row spacing and the ideal number of bines per training wire vary greatly from variety to variety and must be determined separately for each one. The time needed to train the bines increases with the number of bines per wire. So too, in combination with closer planting, does the potential risk of disease stemming from denser foliage. In this three-year trial, the influence of within-row spacing and the number of bines per training wire on yield, alpha-acid content in % and alpha-acid yield were investigated for the high-alpha cultivar Herkules.

Method

To investigate the influence of different amounts of growing space, a number of plots in a commercial hop yard in Wolnzach were planted in 2006 using close and wide within-row spacing. Rows were spaced 3.2 m apart. Within the rows, plant-to-plant spacing of 1.44 m or 1.62 m was selected, permitting the planting of 8 or 7 plants respectively between the poles. These figures translate into a per-wire growing space of 2.3 m² or 2.59 m², which, in turn, corresponds to 4348 or 3861 training wires per planted hectare. The trial plots were farmed conventionally, which included training 3 shoots up each wire. Project staff subsequently adjusted the numbers of bines/wire on the plots, which had been established for a three-year period, to suit trial purposes. From 2007-2009, bines were harvested from 20 wires per trial plot at the optimum harvesting time.

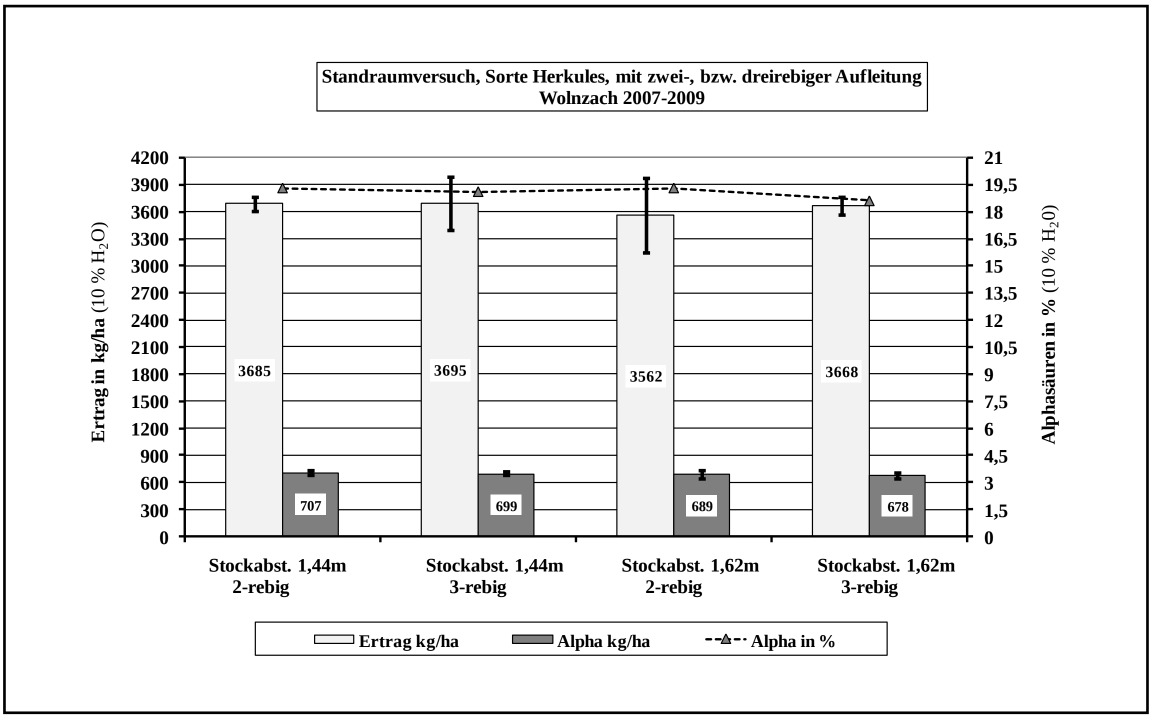


Fig. 5.7: Average yields in kg/ha dry hops, alpha-acid content in % and alpha-acid yields in kg/ha from 2007-2009

Results

The average kg/ha figures obtained for both dry-hop and alpha yields over the three years, all of which produced relatively heavy crops, showed no significant differences between the variants, although alpha-acid content was slightly lower in the plot with wide spacing and 3 bines per training wire. Neither did cone inspections for pests during the 3 years show any clear differences attributable to closer or wider spacing.

The Herkules cultivar proved highly adaptable with regard to spacing and light utilisation at this site. Bines with less dense foliage or with more growing space compensate for the lower number of bines/ha by producing more cones.

On the basis of the observations and findings from this trial, growers of Herkules are nevertheless recommended to train 3 bines up each wire. This is to ensure that, despite this cultivar's slightly poorer climbing ability, at least two bines will reach trellis level without excessive retraining work.

5.4 Increasing hop drying performance by optimising cone weight

Objective

Hop cones are harvested green, with a moisture content of 80 %, and have to be dried within a few hours to approximately 8-10 % moisture content. This is usually done in floor kilns, in which air heated to 65 °C flows through the hops on 3-4 floors, one above the other. Once the bottom layer of hops, on the discharge floor, has been completely dried and tipped out, the hop loads on each of the floors above are tipped one floor downwards. The top floor is then charged with a new load of cones.

The drying performance of floor kilns depends on the hop variety, drying surface area and drying temperature, depth of cone load, cone moisture content and stage of maturity, and speed of the drying air. In order to compare the drying performance of kilns on different farms or kilns fed different hop varieties, it is necessary to first define a uniform drying-performance unit. A suitable unit is kg dry hops/m² drying surface/h drying time.

The importance of correct air speed (in m/s) for drying performance was highlighted in the 2008 annual report. In practice, drying performance (in kg/m²/h drying time) is found to be highest in kilns where air speed can be raised to 0.4 m/s at the time of maximum moisture loss from the green hops on the top floor. Drying performance in kilns with limited blower capacity can only be increased by reducing the cone depth to a level which, at full blower output, allows an air speed of at least 0.3 m/s to be reached as quickly as possible following intake of a fresh load of cones.

Since the moisture content of green hops fluctuates greatly depending on the weather, cone weight (rather than cone depth) was used to calculate maximum drying performance.

Method

The top floor of a commercially operated kiln with a drying surface of 16 m^2 was charged with box-loads of green hops from the picking machine. In conventionally operated kilns, the top floor is charged with one box-load of cones at a time, i.e. kilns have hitherto been loaded on a cone-depth basis (30 cm). To determine the weight of the cone load, the corners of the box frames were fitted with load cells and the weight read off a digital display while the box was being filled. During the course of the trial, the cone weight for each fresh kiln intake was adjusted for the various hop varieties in such a manner that every time a kiln charge was emptied, the cones on the other floors could be tipped and the top floor immediately re-filled. Fixed parameters specific to the trial kiln included a blower output of 600 W/m² and a drying temperature of 65 °C.

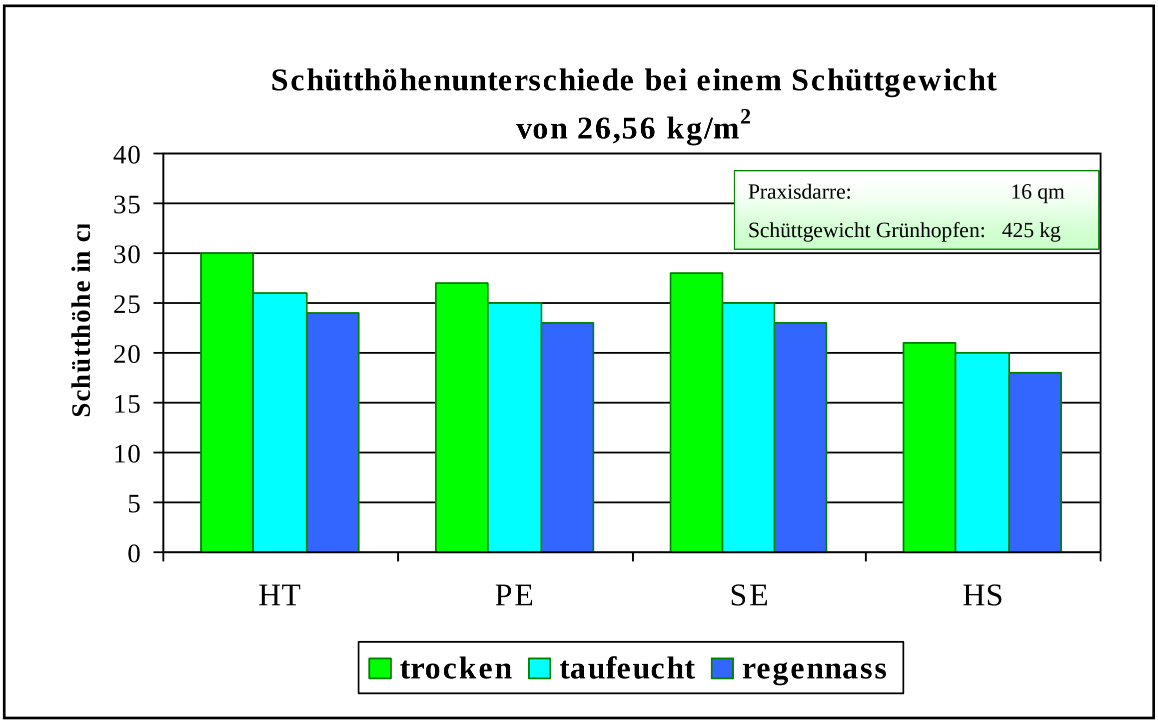


Fig. 5.8: Cone-depth differences as a function of variety and moisture content of the harvest

Results

Drying performance in the trial kiln was improved considerably by adjusting the cone weight so as to establish a constant loading and emptying rhythm. Irrespective of the hop variety, the best drying performance was obtained in this kiln by using fresh cone intakes of 425 kg. Reducing the green-hop intake to a lower level than before meant that the hops on the bottom floor could be emptied, and the top floor re-filled, on an almost hourly basis. The drying process was uninterrupted and the moisture extraction rate maintained at a maximum if this rhythm was adhered to. Drying performance (averaged for the different varieties) in the trial kiln, with its existing dimensions and blower capacity, was increased from a routine 5.4 kg to 6.9 $kg/m^2/h$. This is equivalent to a 27 % increase in performance. One interesting aspect for hop farmers is the connection between cone weight and cone depth (Fig. 5.8). Depending on the hop variety and weather conditions, cone depth varied strongly for a given cone weight. Accordingly, drying performance in kilns with limited blower capacity is best optimised, and external quality preserved, via cone weight.

The most important findings are that optimum drying performance can only be obtained via a constant filling and emptying rhythm and that optimum cone weight must be established for each individual kiln.

5.5 Hop-maintenance trial following the hail storm of May 26th, 2009

Initial situation

On May 26th, 2009 the southern part of the Hallertau region was badly damaged by hailstorm “Felix”. Hail and strong winds completely decimated 1,200 ha hops and seriously damaged another 2,800 ha. On the fringes of the 15-km wide path of the hailstorm, damage to shoot tips (known as “head damage”) was soon complete, but there were still some laterals and leaves left on the plants. The closer to the epicentre of the storm, the greater the damage to the hop plants. Some of them had been torn to shreds, leaving only the woody remains of the shoots on the training wires.

Depending on the variety, the hop plants had reached a height of 4 to 6 m by this time. The damaged and destroyed bines bled heavily and reacted by ceasing to grow for several weeks. Depending on the degree of destruction, new shoots emerged again from the undamaged section of the plants. Where leaves and laterals had been lost, they emerged from the leaf axils of bines that had largely survived. Where the bines had been totally decimated, new shoots emerged from dormant buds below the soil surface.

No previous experience had been obtained on the complete destruction of hop plants through hail at such an early stage of vegetation. As many new questions arose concerning the care of hops, a bine-training trial focusing on labour-related aspects was designed.

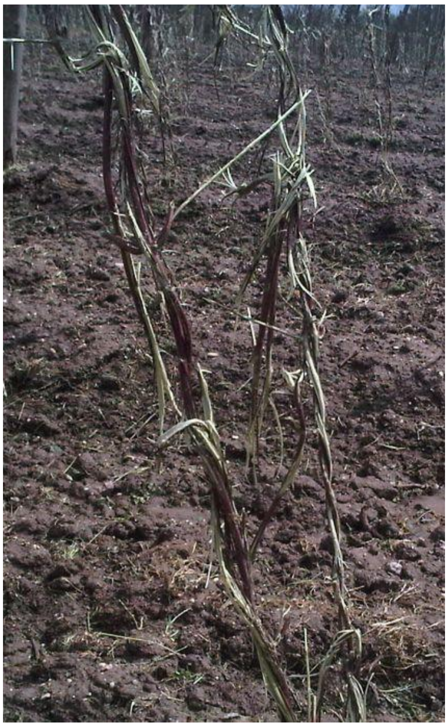


Fig. 5.9: Totally decimated hop bines

Trial set-up

Similar trials involving various degrees of bine treatment and training were conducted on Perle, Hallertauer Magnum and Herkules vines at three locations where there had been near-total hail damage. On June 17th (22 days after the hailstorm), bud break was still relatively poor in all varieties. Many plants could not yet be retrained onto the wires even after this long interval, the reason being the extremely wet and cold weather conditions during the period in question. Of the four varieties, Perle showed the best growth. Noteworthy here was the fact that the row had been only slightly hilled, or that the rootstock had been pruned close below the surface, making sprouting easier. Hallertauer Magnum bled most strongly and sprouting was also weakest in this cultivar. Some plants produced no new shoots and when uncovered were found to have no more eyes, a condition which ultimately caused a number of these plants to die completely. As it was the first year that Hercules had come up, the crown was still deep down and well covered with soil. The soil surface was also extremely muddy and had formed a crust, which meant that the hop shoots could only reach the surface through cracks in the soil.

To promote sprouting, the hop bines destroyed by hail were cut back to ground level with a carpet knife in half of the trial plots. The aim of this measure was to remove the plant's apical dominance, thus preventing the undesired formation of shoots from lateral buds on the largely destroyed bine and encouraging the plant to send up new shoots from the ground. The trial plots in which the bines were cut back have been labelled "AS". The label "N" was used to mark plots in which the old bines were not cut back, i.e. remained attached to the crown. The training of the new shoots was classified according to the labour input involved.

The most labour-intensive training procedure was "AL1", which involved first removing all the old shoots from the training wire in order to allow the new shoots to be twined closely around the wire. Sprouting varied greatly from plant to plant. An additional challenge was that lateral shoots from old bines had to be twined extremely carefully. Otherwise they broke off at the point of attachment. As is standard practice, 3 shoots were trained onto each wire. However, the shoots were very thin (like threads) and were difficult to attach to the wire.

With the AL2 procedure, only wires lacking any shoots had new shoots trained onto them. Surplus shoots were just wrapped around loosely. With procedure 3, labelled "N", the hops were left to climb by themselves. Training of Perle, which showed strong growth, was possible as of June 25th (after 30 days), and of Hallertauer Magnum and Herkules as of June 29th.

Results

- **Cutting back the destroyed hop bines**

The carpet knives became blunt after only 20 plants due to soil particles clinging to the shoots. To prevent cutting the wire, it was sometimes necessary to hold the shoots away from it. The effort (12h/ha) and the wear on the knives was immense.

The plants with the cut-back bines were still bleeding strongly after 10 days. On the plots where the bines were not cut back, the severe damage caused them to die completely anyway, so that hardly any difference was seen between the plots where the bines were cut back and those where they were not.

- **Training**

The following table shows the various labour inputs for the trial variants. The total labour input comprises the time required for cutting, training and re-training:

Table 5.5: Labour input in h/ha by trial procedure and hop variety

Pro-cedure	Cutting back	PE		HM		HS		**Ø all vari-eties**
		Train-ing	Re-training	Train-ing	Re-training	Train-ing	Re-training	
AS AL 1	12	105	21	80	16	65	16	**113**
AS AL 2	12	30	20	24	19	16	19	**55**
AS N	12	0	0	0	0	0	0	**12**
N AL 1	0	105	21	80	16	65	16	**101**
N AL 2	0	30	20	24	19	16	19	**43**
N N	0	0	0	0	0	0	0	**0**

- **Height**

To determine which measures promote optimum growth following hail, the height of the plants on the various plots was measured. Some plants had reached trellis level by July 30th, but the stands all displayed huge variations. Plant-to-plant differences were extreme even on plots where a lot of work had been done on re-training the stands completely. Weeds also remained a problem up to this time due to the unsettled weather conditions.

Table 5.6: Height in m by trial procedure and variety on July 30th, 2009

Procedure	PE	HM	HS	**Ø all varieties**
AS AL 1	2.40	1.90	2.90	**2.40**
AS AL 2	2.50	2.20	3.50	**2.70**
AS N	3.50	2.30	2.40	**2.70**
N AL 1	3.40	2.70	2.90	**3.00**
N AL 2	2.70	2.50	3.60	**2.90**
N N	2.60	2.60	3.40	**2.80**

The trial plots were assessed again on September 23rd. Besides measuring height, the shoots on the training wire were counted.

Table 5.7: Number of shoots and height in m by trial procedure and variety on September 23rd

Variant	PE		HM		HS		**Ø all varieties**	
	Shoots	Height	Shoots	Height	Shoots	Height	Shoots	Height
AS AL 1	2.8	3.30	1.6	2.10	1.60	3.90	**2.0**	**3.10**
AS AL 2	2.8	3.30	2.0	2.20	1.50	4.20	**2.1**	**3.20**
AS N	4.3	4.20	2.0	2.40	1.40	4.20	**2.6**	**3.60**
N AL 1	3.1	4.50	2.2	2.90	1.60	3.60	**2.3**	**3.70**
N AL 2	2.8	3.40	2.5	2.60	1.60	4.80	**2.3**	**3.60**
N N	4.1	3.50	2.7	2.40	1.40	4.30	**2.7**	**3.40**

Discussion

- **Cutting back**

Cutting back the remaining plant parts did not result in more vigorous new growth. A comparison of average heights reached by the end of July (Table 2) shows that they are lower on plots where the bines were cut back. Cutting back the bines resulted in the loss of even more sap, weakening the rootstock still further. This was still evident on the second assessment date (Table 3).

The number of shoots clinging to the wires was also found to be lower in the AS plots. On these plots the laterals from surviving bine material were missing, which mostly grow more vigorously than new shoots from the ground.

- **Training**

Looking at the N procedures only (bines not cut back), it is evident that growth was tallest on the N-AL 1 plots, followed by the A-AL 2 and N-N plots. If heights are compared in terms of labour input, (N-AL 1 = 101 h/ha, N-AL 2 = 43 h/ha and N-N = 0 h/ha), it becomes clear that the intensive efforts had very little effect on plant growth following hail damage. However, a minimum of maintenance was necessary because it enabled weak hop plants, in particular, to survive, which means that fewer replacements will be needed next year.

The mean labour input, denoted by AL 2, thus represents a compromise as far as maintenance is concerned. What is important is that remaining shoots are not cut back following hail damage. New shoots should merely be given a little help by wrapping them loosely around the wire or pressing them against it.

- **Other aspects**

The new shoots which the hail-damaged hop plants grew from the axils of the laterals and from the ground showed a surprisingly high degree of primary downy mildew infection (stunted, yellowish shoots known as “Bubiköpfe”). Inadequate control led to rapid spreading of the disease in the form of secondary infection on the leaves.

An additional problem was that the cool, damp weather, together with the high level of light exposure, promoted dense weed growth within the rows and in the tractor aisles. The damp conditions also accelerated fungal growth and made it difficult to control. As a result, pronounced migration of zoosporangia was observed in the downy mildew traps in Hirnkirchen as of early July, with levels remaining high until early August. The situation did not improve until the weed problem within the rows had been brought under control throughout the area hit by hail, making more intensive downy mildew control possible.

As of mid-August, pronounced PM infection was observed in the hail-damage area on hop plants that were still growing. The fact that the infection differed markedly in incidence and intensity from that in Hallertau hop gardens not damaged by hail is presumably attributable to the fact that the young, still-growing tissue displayed less age-related resistance than hops at the normal stage of development.

5.6 LfL projects within the Production and Quality Initiative

As part of a production and quality offensive on behalf of agriculture in Bavaria, the Bavarian State Research Centre for Agriculture has launched a programme to collect, record and evaluate representative yield and quality data for selected agricultural crops from 2009 to 2013. For the hops department of the Institute for Crop Science and Plant breeding, this work is being undertaken by its advisory service partner Hallertau Hop Producers' Ring. The aims of the hop projects are described briefly below, and the 2009 results summarized.

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

600 alpha-acid determinations in freshly harvested hop samples

Daily measurements of alpha content in freshly harvested hops provide insight into harvest maturities of the various hop cultivars, allowing recommendations to be made concerning optimum harvesting times.

Neutral Quality Assesment Procedure (NQF) results

Quality data collected within the framework of the NQF provide valuable information on the hop quality of the year in question and point to production-related errors or incorrect treatment of harvested hops. In 2009, for example, a high proportion of cones were found to be slightly decomposed. The LfL's hop consulting team tackled the problem immediately and looked for causes. The problems were pointed out to growers and corrective measures outlined at meetings held jointly with the Hop Producers' Ring.

Assessment of diseases and pests and classification into infection categories reveal cultivar-specific differences in resistance, indicate regional differences in infection levels and enable the effectiveness of plant protectives to be judged.

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

Accurate assessments of and investigations into aphid, spider-mite and virus infestations are necessary in order to provide advice and develop control strategies.

Aphid and spider-mite assessment:

The results have been included under Section 6.1!

Virus infestation:

Of 35 commercial hop gardens from which leaf samples were tested (ELISA) for viruses, 5 were free of viral disease. 28 hop gardens were infected either with hop mosaic virus (HMV) or, in 15 cases, apple mosaic virus (ApMV). 12 hop gardens were infected with both types of virus.

In another series of LfL tests, sample hop leaves from hop gardens with suspicious symptoms were tested for viruses and the results of the test compared with visible damage. This comparison was made in the hope that conclusions as to the type of virus might be drawn from the visible damage.

Of a total of 19 sampled hop gardens, only one stand was free of viral disease. 10 gardens were found to be infected with HMV, 15 with ApMV and 7 with both types of virus. Differentiation by variety produced the following picture:

ApMV was identified in 9 out of 10 samples of Spalter Select. By contrast, HMV was not identified in any of the samples. Some of the Perle and Hallertauer Tradition samples tested positive for ApMV, some for HMV and some for both viruses.

However, with none of the cultivars was it possible to draw conclusions as to the degree of infection with these viruses from the external appearance. Both viruses caused mosaic-, ring- or band-shaped paling of the leaves. Isolated plants with pronounced dwarfish growth and visible damage classed as severe were found to be free of any form of virus. By contrast, a few plants with a non-suspicious external appearance were shown to be very heavily infected with ApMV, HMV or both.

Infected Hallertauer Magnum plants were observed to form fewer laterals and show stunted growth. The appearance of their leaves, however, was less typical of a virus infection.

Besides dwarfish growth and reduced formation of laterals, other cultivars typically curled their leaves tightly. One striking aspect was the fact that most of the heavily infected Hallertau Tradition and Perle plants struggled and remained stunted in growth, whereas most of the affected Select plants, including those in which the virus was not only identified but also extremely visible, developed well after a few weeks of favourable weather conditions.

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

For this project, it is the task of the Hop Producers’ Ring to set up, service and operate Adcon weather stations at the 7 downy mildew forecasting locations in the hop-growing regions (5 in the Hallertau region, 1 in Spalt and 1 in Hersbruck). Weather-related data have to be evaluated daily and a downy mildew-outbreak probability index calculated. This index is needed at the LfL’s 3 scientific-test sites for comparing secondary-downy mildew control according to the previous early-warning model with control according to the Adcon weather model.

It was established in 2009 that the number of spray treatments based on the previous early-warning model was distinctly lower than for the Adcon model, although the possibility exists here that the selected preliminary control threshold was too low and needs reviewing. Assessments of leaf and cone infestation showed no differences between the control strategies.

5.7 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, 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 the Hop Producers' Ring.

The group's training and advisory activities in 2008 are summarized below:

5.7.1 Written information

- The 2009 "Green Pamphlet" on Hops – Cultivation, Varieties, Fertilisation, Plant Protection and Harvest – was updated jointly with the WG Plant Protection in Hop Growing following consultation with the advisory authorities of the German states of Baden-Württemberg, Thuringia, Saxony and Saxony-Anhalt. 2500 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.
- 38 of the 53 faxes sent in 2009 by the Hop Producers' Ring to 1002 recipients contained up-to-the-minute information from the work group on hop cultivation and spray warnings.
- Updated information was likewise made available at irregular intervals for the German Weather Service's weather data fax.
- 3338 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.
- Advice and specialist articles for hop-growers were published in 2 circulars issued by the Hop Producers' Ring and in 7 monthly issues of the magazine "Hopfen Rundschau".
- 598 field records (from 153 hop growers) on the 2009 hop harvest were evaluated with the "HSK" recording and evaluation program and returned to farmers in written form.

5.7.2 Internet and Intranet

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

5.7.3 Telephone advice and message services

- The downy mildew warning service, provided jointly by the WG Hop Cultivation/Production Techniques (Wolnzach) and the WG Plant Protection in Hop Growing (Hüll) and updated 75 times during the period from 12.05.2009 to 28.08.2009, was available via the answerphone (Tel. 08442/9257-60 and 61) or via the internet.
- 12 tips on hop growing, including up-to-date information on pests and diseases and on fertilising and soil-cultivation measures, were available via the answerphone in Wolnzach (Tel. 08442/957-401).
- Consultants from the WG Hop Cultivation/Production Techniques answered around 3,000 special questions by telephone or provided advice in one-to-one consultations, some of them on site.

5.7.4 Talks, conferences, guided tours, training sessions and meetings

- 7 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)
- 44 talks
- Equipment and poster exhibition on Open Day at the "House of Hops" in Wolnzach and at Agritechnica (posters)
- 25 guided tours through trial facilities for hop growers and the hop industry
- 6 conferences/workshops/seminars
- 5 trade events including note swapping with BayWa employees

5.7.5 Basic and advanced training

- Setting of 2 Master's examination topics and assessment of one work project for the examination
- 18 lessons for hop-cultivation students at the School of Agriculture in Pfaffenhofen
- 1-day course during the summer semester at the School of Agriculture in Pfaffenhofen
- Exam preparation and examination of agricultural trainees focusing on hop cultivation (2 districts)
- One "BiLa" seminar (educational programme for farming), in 4 evening sessions

6 Plant protection in hops

Ltd. LD Bernhard Engelhard, Dipl. Ing. agr.

6.1 Pests and diseases in hops

6.1.1 Aphids

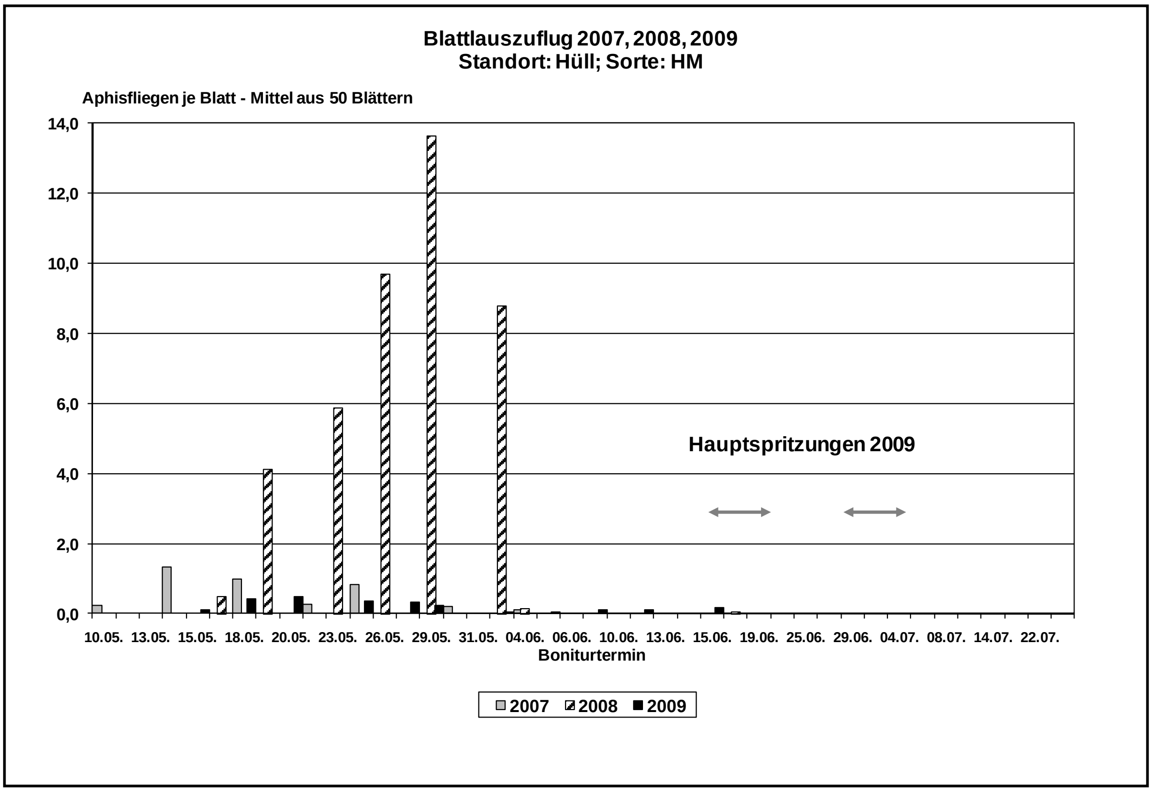


Fig. 6.1: Aphid migration

Migration began in mid-May and remained at a very low level throughout the season. Aphid monitoring performed by the Hop Producers' Ring on behalf of the LfL showed that the population increased only slowly until June 10th. In mid-June, the control threshold was reached for the first time in a number of hop yards.

Table 6.1: Aphid monitoring in 2009 across 30 locations

Date	No. of aphids per leaf			Remarks
	∅	min	max	
18.05.	0.83	0.0	2.78	
25.05.	3.47	0.4	10.00	
02.06.	4.59	0.1	17.00	Excluding hail locations
08.06.	14.00	0.9	47.00	
15.06.	34.10	0.6	205.00	
22.06.	93.60	0.0	415.00	Initial spraying
29.06.	140.10	0.0	905.00	
06.07.	2.20	0.0	32.70	After main sprayings

The surveys show how important it is to monitor individual hop yards.

At the time of the main sprayings, the conditions for successful control were very good: medium to high temperatures, soft leaves after prior rain, and no wind. Teppeki was used for the first time as the main product. A trial with additives did not result in additional improvements.

6.1.2 Common spider mite

The common spider mite was also monitored in the 30 hop gardens in the Hallertau region. The maximum average spider mite population, measured on 6th July, was only 1.8 per leaf; however, individual values ranged from 0.0 (even without treatment) to 38.7 mites, demonstrating the necessity of monitoring in all hop yards.

6.1.3 Downy mildew

The downy mildew warning service can only be used if primary infections are effectively controlled. In 2009, spray warnings drawing attention to the need for control measures were required until early July. Six downy mildew sprayings were necessary in 2009, even for tolerant cultivars.

Table 6.2: Age-dependent effect on dates and number of spray warnings for the cultivar groups

Datum	2009			2008			2007		
	tolerante	anfällige	späte	tolerante	anfällige	späte	tolerante	anfällige	späte
20.05.	x	x							
08./09.06		x						x	
18.06.				x	x				
26.06.					x				
29.06.	x	x							
05./06.07	x	x					x	x	
10.07.					x				
17.07.								x	
21.07.	x	x							
24.07.				x	x				
28.07.		x							
30./31.07					x		x	x	
05.08.	x	x		x	x				
12.-14.08	x	x			x		x	x	
21./22.08				x			x	x	
25.08.			x			x			
Summe	6 x	8 x	+ 1 x	4 x	7 x	+ 1 x	4 x	6 x	

6.2 Development of guidelines for assessing the severity of infection of dried hop cones by major hop diseases and pests

The effects of various, treatment-related levels of disease or pest infection on the yield and quality of harvested hops is frequently investigated in trial hop harvests.

For this purpose, the dried cones of all harvested varieties are assessed not only for yield, alpha-acid content and levels of other components, if any, but also for exact infection severity (Fig. 6.1).

Doldenbonitur 2009

Landwirt: NN | **Standort: NN**

Schlag: Berghopfen | **Sorte: HM**

Erntedatum: 09.09.2009 | **Bonitur auf: Blattlaus**

Code	Versuchs-glied	Wieder-holung	Dolden gesamt	gesunde Dolden	Anzahl kranker Dolden schwach	mittel	stark	gesamt	kranke Dolden [%] *)	gewogenes Mittel **)	Gewicht [g]	Volumen [ml]
LAN09/HM/01	P0	A	500	9	145	172	174	491	98,2	3,022	110,67	3000
LAN09/HM/02	P0	B	500	13	97	173	217	487	97,4	3,188	98,95	2600
LAN09/HM/03	P0	C	500	2	118	185	195	498	99,6	3,146	107,87	2700
LAN09/HM/04	P0	D	500	9	113	173	205	491	98,2	3,148	123,49	3500
	P0	**MW**							**98,35**	**3,126**	**110,25**	**2950**
	P0	**sd**							**0,79**	**0,062**	**8,787**	**350,0**
	P0	**V [%]**							**0,8**	**2,0**	**8,0**	**11,9**
LAN09/HM/05	P1	A	500	205	232	53	10	295	59,0	1,736	137,38	4100
LAN09/HM/06	P1	B	500	132	287	75	5	367	73,4	1,902	144,79	4500
LAN09/HM/07	P1	C	500	158	295	45	2	342	68,4	1,782	114,25	3600
LAN09/HM/08	P1	D	500	180	264	45	11	320	64,0	1,774	126,51	3600
	P1	**MW**							**66,20**	**1,799**	**130,73**	**3950**
	P1	**sd**							**5,32**	**0,062**	**11,525**	**377,5**
	P1	**V [%]**							**8,0**	**3,5**	**8,8**	**9,6**
LAN09/HM/09	P2	A	500	435	64	1	0	65	13,0	1,132	106,99	3200
LAN09/HM/10	P2	B	500	428	66	6	0	72	14,4	1,156	117,32	3600
LAN09/HM/11	P2	C	500	417	70	10	3	83	16,6	1,198	120,34	3700
LAN09/HM/12	P2	D	500	416	71	12	1	84	16,8	1,196	111,15	3400
	P2	**MW**							**15,20**	**1,171**	**113,95**	**3475**
	P2	**sd**							**1,58**	**0,028**	**5,207**	**192,0**
	P2	**V [%]**							**10,4**	**2,4**	**4,6**	**5,5**

*) Kranke Dolden : Dolden gesamt x 100

**) (gesunde Dolden + schwacher Befall x 2 + mittlerer Befall x 3 + starker Befall x 4) : Dolden gesamt

Fig. 6.2: Example of cone assessment from the 2009 trial harvest within the framework of the DBU aphid project (DBU = Deutsche Bundesstiftung Umwelt, a federal German foundation supporting environmental projects), in which three plots with different aphid treatments were compared (P0: untreated control, P1: one aphid treatment, P2: two aphid treatments).

Assignment of the relevant level of infection severity of the individual hop cones to four different classes - none, low, medium and significant - is performed by an experienced team of excellently trained employees in Hüll. Previously, no documented guidelines were available that defined four such severity classes for the most important diseases and pests, i.e. those most frequently subject to assessment. In order to remedy this situation, the four severity classes for downy mildew, PM, hop aphid and the common spider mite were precisely defined in writing, too, during the 2009 trial harvest. These definitions of the severity classes will serve as guidelines for assessment of dried hop cones in future.

6.2.1 Downy mildew *Pseudoperonospora humuli* (Miyabe & Takahashi) Wilson

Hop cones infected with downy mildew typically take on a brownish colour, which always starts at the cone petal base and runs along the petal veins in the direction of the apex.

Discolouration in the case of downy mildew infection thus differs clearly from the kind of brown discolouration at the distal ends of the cone petals caused, among other things, by wind gusts or animal pests. In addition, the discolouration of the cone petals as a result of downy mildew infection generally turns into a rich cocoa brown relatively quickly, which is also characteristic. The brown tone associated with botrytis infection, by contrast, is generally lighter.

Infection severity classes:

None: no discolouration indicating infection

Low: less than 5 % of entire surface of all cone petals discoloured

Medium: 5 % to a max. of 20 % of entire surface of all cone petals discoloured

High: more than 20 % of entire surface of all cone petals discoloured

6.2.2 Powdery mildew (*Podosphaera macularis* (Wallroth) U. Braun & Takamatsu)

A distinction between two phenotypically very different forms of PM infection must always be made when hop cones are assessed for the disease. During the normal course of the disease (typical mildew), the cones are severely impaired by the fungus while they are still developing. The cone petals turn a brownish colour and become crippled. If infection is severe, the cones remain vestigial and distorted, resembling small sausages in shape.

An atypical form of the disease that affects mature cones late in the season (late mildew) looks completely different and is much more difficult to address. Outwardly, the cones simply discolour to an extent that increases with the severity of infection. Usually, the actual infection with mycelia can only be seen if the cone petals are peeled back carefully.

Assignment to infection severity classes is the same for both forms of the disease and is based on the percentage of cone petals covered with mycelia.

Infection severity classes:

None: no mycelia on the cone petals

Low: <5 % of cone petals discoloured and bearing mycelial threads

Medium: 5 to 20 % of cone petals discoloured and bearing mycelial threads

High: >20 % of cone petals discoloured and bearing mycelial threads

6.2.3 Hop aphid *Phorodon humuli* (Schrank)

Aphid infestation of cones is usually assessed by the presence of whitish larvae skins that have been shed or of desiccated aphids on the cone. Dead aphids usually occur together with a conspicuous encrustation of sooty mould fungi of the Capnodiales order. The cone petals have to be peeled back for assessment purposes because the aphid remains are usually found hidden beneath them. Only in cases of high-severity infection is the sap-withdrawal damage caused by aphids on the cone immediately recognizable. It causes brownish discolouration of the cone petals.

Infection severity classes:

None: no larvae skins or desiccated aphids on the cone

Low: a maximum of seven larvae skins or desiccated aphids on the cone

Medium: eight to a maximum of 25 larvae skins or desiccated aphids on the cone

High:: from >25 larvae skins or desiccated aphids on the cone, right through to recognizable sap-withdrawal damage manifested as brownish discolourations and cone petals encrusted with honeydew

6.2.4 Common spider mite *Tetranychus urticae* Koch

Hop cones infected by spider mites are recognized by gradual paling of the cone petals. This paling is caused by the sap-withdrawal activity of the spider mites, which puncture the cells with their mouth parts in order to suck out the chloroplast-rich cell content. Low levels of infection initially cause this form of discolouration, which can become greyish, as increasing numbers of chloroplasts are lost. As infection becomes more severe and water loss via the punctured cells exceeds water uptake by the leaf, the cone petals slowly begin to dry out. The pale leaf discolouration turns to a coppery brown, a condition growers call “red hops”.

As spider mites profit greatly from high temperatures, even within a microclimate, cone damage is generally “two-sided”; the side of the cone originally exposed to the sun while the cone was attached to the plant will show distinctly more damage than the shaded side.

Infection severity classes:

None: no discolouration indicating damage by sap withdrawal

Low: slight sap-withdrawal damage not exceeding 10 % of the petal surface on each of one to three cone petals

Medium: sap-withdrawal damage not exceeding 30 % of the petal surface on each of four to ten cone petals

High: Individual cone petals with sap-withdrawal damage of >30 % of the petal surface in each case, or at least eleven cone petals showing general sap-withdrawal damage

6.3 Introduction of a forecasting model for powdery mildew

A logical connection between weather conditions and periods of PM infection was first established in 2003, following extremely severe PM infections in 1997 and 1999. This “preliminary forecasting model” has been under test in commercial hop yards since 2003, where plots treated in different ways are compared with untreated plots. 28 to 43 hop farms have participated in this trial every year. It has been the subject of four degree theses and a research project, during which, from 2007 to 2009, scientifically verified basic data on the biology and epidemiology of hop powdery mildew was collected (see previous annual reports). These research results and the findings based on the preliminary forecasting model were combined to produce a “weather-based disease forecast”.

6.3.1 2007 – 2009 comparison of the forecasting models

The preliminary PM forecasting model was based on relatively simple parameters. These were not modified during the course of the project. The new, weather-based disease forecasting model was adapted continuously during the project to take new findings into account.

The great advantage of this model is that continuous modification and improvement are possible, which will permit fine-tuning of the model during the next few years. Taking the latest findings concerning the biology and epidemiology of hop powdery mildew into account, the following spray warnings would have been necessary for the production of PM-free hops (preliminary model compared with weather-based model).

Table 6.3: Spray warnings in 2007

2007							**Spray warnings**
"Preliminary model"	A	09.05.	–	05.07.	10.07.	10.08.	4
	B	–	–	–	–	10.08.	1
"Weather-based model"	A	–	25.05.	–	29.07.	29.08.	3
	B	–	25.05.	–	–	–	1
2008							
"Preliminary model"	A	–	06.06.	–	13.07.	–	2
	B	–	–	–	14.07.	–	1
"Weather-based model"	A	22.05.	05.06.	–	13.07.	–	3
	B	22.05.	05.06.	–	13.07.	–	3
2009							
"Preliminary model"	A	14.05.	24.06.	08.07.	–	–	3
	B	15.05.	24.06.	–	–	–	2
"Weather-based model"	A	14.05.	–	08.07.	13.08.	–	3
	B	14.05.	–	–	–	–	1

A = susceptible cultivars infected as of 15.06
A = tolerant cultivars not infected as of 15.06

The following findings are of major importance for effective control of hop powdery mildew:

- Spraying in spring is especially important! Very good results can be obtained at low cost by spraying at the right time.
- Spray treatments not timed to coincide with infection periods have no effect because new leaves, flowers and cones are not protected.
- If weather conditions in July/August are favourable, even very low levels of disease can cause new infections that do great damage; e.g. the spray warning triggered on August 13th, 2009 by the "weather-based disease forecast" for slightly diseased susceptible cultivars was fully justified.
- If a hop stand is still 100 % free of PM pustules by the end of June, it will remain infection-free for the rest of the season.

Both forecasting models will be used for forecasting PM in 2010.

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 team (WG Hop Quality/Hop Analytics) performs all analytical studies required to support the experimental work of the other work groups.

The hop plant has three groups of components relevant to brewing: bitter compounds, essential oils and polyphenols. The bitter compounds consist of the alpha and beta acids, with alpha-acid content, which is a measure of the hop bittering potential, being the most important quality characteristic. The alpha-acids content is also becoming more and more important for hop prices, as illustrated by supplementary agreements to hop supply contracts and direct payment according to kg alpha-acids.

Beta acids do not play an important role in beer brewing. They do not dissolve easily in water and are largely lost during the brewing process. Their antimicrobial characteristics, however, make them interesting for alternative fields of use, including use as preservatives in the food industry or sugar and ethanol industries.

The second group of hop components, the essential oils, are responsible for hop scent and aroma. Their sedative properties can be exploited medicinally. A large number of drugs are thus already being produced on the basis of a combination of hops and valerian.

The third group of value-determining hop components are the polyphenols. They are regarded as substances boasting truly miraculous health-giving properties, with numerous publications attesting to this. In summary, it can be said that polyphenols function as anti-oxidants and can scavenge free radicals. Xanthohumol, in particular, has attracted a lot of publicity in recent years because of its significant anti-carcinogenic potential. The substance 8-prenylnaringenin, trace amounts of which are found in hops, is regarded as one of the most potent phyto-oestrogens and is responsible for the slightly oestrogenic effect of hops. The marketing of hops would benefit greatly from new fields of use outside of the brewing industry that exploit this wide variety of components. Alternative uses of hops are found primarily in the food industry, as well as in the fields of medicine and wellness.

7.2 Component optimisation as a breeding goal

7.2.1 Requirements of the brewing industry

Recent scientific findings make it absolutely necessary to revise the requirements of the brewing and hop industries regarding the composition of the hop components. These requirements were last presented in the form of papers and discussed by the brewing industry and hop-processing firms at an international symposium held in Wolnzach in May 2008 entitled “Hop Growing in 2020”.

All parties agreed that hop varieties with a maximum α-acid content that remains as constant as possible from year to year should be bred. A low cohumolone content has now become less important as a quality parameter. High-alpha varieties with a high cohumolone content are even in demand for downstream and beyond-brewing products.

With respect to the essential oils, there is now a growing move towards viewing the sensory aroma impression as an integral, synergetic quality. Some substances are perceived more strongly, others are blotted out. The correct ratio of the substances to one another is crucial. Key substances must be defined, however, so that aroma quality can also be characterised analytically. Myrcene tends to be regarded as indicative of an unpleasant, resinous aroma and linalool of a pleasant, flowery aroma. The goal is to breed aroma cultivars with various combinations of hop oils in order to guarantee product diversity. Key substances for hop aroma include linalool, humulene, caryophyllene and myrcene.

Polyphenols are partly responsible for the bitter taste imparted by hops (harmonious bitterness) and sometimes serve an additional functional purpose. The brewing industry would like to see hop growers cultivating hops with higher levels of low-molecular polyphenols, such as xanthohumol, prenylflavonoids and phenolic carboxylic acids.

7.2.2 Alternative uses

Although the brewing industry will remain the chief purchaser of hops in the future, hops can nevertheless be used for many other purposes thanks to the diversity of its components. Even in catalytic amounts (0.001-0.1 wt. %), the bitter substances have antimicrobial and preservative properties that become increasingly pronounced in the following order: 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 *helicobacter pylori*, a bacterium that triggers stomach cancer. This property can be exploited by utilizing the bitter substances in hops as natural biocides wherever bacteria need to be kept under control. The sugar and ethanol industries, for example, have already begun replacing formalin with β-acids in some cases. Other potential applications exploiting the antimicrobial activity of hop β-acids include their use as preservatives in the food industry, the sanitation of biogenic waste (sewage sludge, compost), removal of mould, improvement of the smell and hygiene of pet litter, control of allergens, and use as an antibiotic in animal food. In future, a considerable demand for hops can be expected for use in these fields of application. One of the breeding goals in Hüll is therefore to increase β-acid content. Currently, the record is about 20 %, and there is even a breeding line that produces only β- acids and no α-acids.

With a polyphenol content of up to 8 %, hops is very rich in this substance and therefore of great interest for the areas of health and wellness. Hops could be used in dietary supplements, functional foods and medicines. Work is being done on increasing the content of xanthohumol. A breeding line containing 1.7 % xanthohumol is already available. Other prenylated flavonoids, such as 8-prenylnaringenin, occur only in trace amounts in hops, but produce strong physiological effects. The flavonoid quercetin, contained in hops in concentrations of up to 0.2 %, has very strong anti-oxidant potential. This substance is also deemed extremely beneficial to health. Aroma hops generally have a higher polyphenol content than bitter hops.

If specific components are desired, the Hüll hop-breeding research team, together with the WG Hop Quality/Hop Analytics (IPZ 5d), can react at any time by selectively breeding for the required substances.

7.3 Development of analytical methods for hop polyphenols

As stated in 7.2 above, hop polyphenols are becoming more and more important for both the brewing industry and areas of alternative use. It is therefore essential that reliable, standardised analytical methods be developed for this substance group.

There are as yet no methods available for analysing hop polyphenols. For a number of years, work has been going on within the *Arbeitsgruppe für Hopfenanalytik (AHA)* to standardise methods for determining total polyphenols and total flavonoids. Table 7.1 shows the statistical data from the most recent ring test.

Table 7.1: Statistical data from ring test to determine total polyphenol and flavonoid contents

Sample	Mean	cvr	cvR	No. of laboratories
Pellet 1/Total polyphenols (with ascorbic acid)	4.739	1.41	10.75	7
Pellet 2/Total polyphenols (with ascorbic acid)	4.610	2.09	8.41	7
Pellet 3/Total polyphenols (with ascorbic acid)	2.689	1.00	10.94	7
Pellet 1/Total polyphenols (without ascorbic acid)	4.611	1.36	9.92	7
Pellet 2/Total polyphenols (without ascorbic acid)	4.637	1.57	8.61	7
Pellet 3/Total polyphenols (without ascorbic acid)	2.801	1.54	10.97	7
Pellet 1/Flavonoids (with ascorbic acid)	0.884	1.79	13.88	7
Pellet 2/Flavonoids (with ascorbic acid)	0.885	1.98	14.41	7
Pellet 3/Flavonoids (with ascorbic acid)	0.410	4.70	18.97	7
Pellet 1/Flavonoids (without ascorbic acid)	0.836	1.57	16.59	7
Pellet 2/Flavonoids (without ascorbic acid)	0.849	1.41	11.00	7
Pellet 3/Flavonoids (without ascorbic acid)	0.429	3.94	19.69	7

Mean values in %, cvr and cvR dimensionless

cvr stands for the variation coefficients (standard deviation/mean x 100) within the laboratories. cvR stands for the overall variation coefficient. The cvRs, in particular, are still relatively high, there being no differences between determinations with and without ascorbic acid (vitamin C).

These methods require improvement, above all with respect to sample preparation. Individual components such as quercetin and kaempferol are analysed by HPLC. This method has also been tested in a ring test.

Work has begun on developing methods for analysing the entire polyphenol spectrum. As of 2010, the Bavarian State Ministry of Agriculture and Forestry is funding a project entitled “Differentiating the world hop range with the help of total polyphenols”, which could be conducted within the framework of a degree or master thesis.

7.4 World hop range (2008 harvest)

This analysis is performed every year. The aim is to determine the quality- and variety-specific components of the available domestic and foreign hop varieties when these are grown under the conditions prevailing at Hüll. Table 7.2 shows the results for the 2008 harvest. It may be helpful in classifying unknown hop varieties. The oil analyses were performed by headspace gas chromatography. The individual oil components are quoted in relation to beta-caryophyllene.

Table. 7.2: World hop range, 2008

Variety	Myr-cene	2-M.-iso-butyrate	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendrene	Unde-canone	Humu-lene	Farne-sene	γ-Muu-rolene	ß-Seli-nene	α-Seli-nene	Cadi-nene	Seli-nadiene	Gera-niol	α-acids	ß-acids	ß/α	Cohu-mulone	Colu-pulone
Admiral	6276	1084	14	39	44	0	8	274	4	10	4	2	17	0	2	15.7	6.2	0.39	46.2	66.7
Agnus	4776	103	1	8	9	1	3	120	0	4	6	5	12	0	0	11.9	5.6	0.47	36.9	59.6
Ahil	5827	516	37	5	18	3	9	195	52	9	6	4	17	0	0	8.8	3.9	0.44	34.0	57.6
Alliance	1288	106	1	2	19	0	6	288	8	7	3	3	19	0	1	6.6	3.4	0.52	30.7	58.0
Alpharoma	1772	192	26	7	11	0	10	291	14	8	4	2	19	0	3	9.7	3.1	0.32	26.4	60.3
Apolon	7709	126	37	9	30	0	4	210	91	12	7	4	16	0	0	8.6	4.5	0.52	28.2	52.4
Aquila	3644	65	1	92	25	8	16	33	0	60	69	71	14	96	0	4.8	3.8	0.79	50.1	72.8
Aromat	2015	27	4	8	46	0	18	348	15	47	14	8	24	0	0	3.6	4.4	1.22	26.8	47.1
Atlas	3716	689	27	7	19	3	3	192	51	13	10	9	17	0	0	8.4	4.1	0.49	32.9	61.6
Aurora	8812	182	3	50	37	0	25	261	46	6	4	3	15	0	0	11.6	4.4	0.38	21.5	51.1
Backa	4113	764	6	27	33	0	8	260	18	13	4	2	17	0	0	9.2	5.9	0.64	42.4	65.3
Belgisch Spalter	2052	109	2	8	18	15	8	164	0	9	29	30	18	52	0	8.2	3.8	0.46	26.2	54.0
Blisk	3451	378	26	5	27	0	2	237	41	13	9	8	19	0	0	7.4	4.7	0.64	32.5	52.9
Boadicea	2492	80	1	15	4	2	3	109	14	4	5	5	14	0	0	7.4	4.8	0.65	22.2	48.9
Bobek	18594	308	13	172	65	0	19	245	58	10	8	7	13	0	0	8.1	6.6	0.81	26.0	50.4
Bor	5990	184	2	86	10	0	7	290	0	4	3	2	14	0	1	13.1	5.0	0.38	26.7	55.3
Bramling Cross (OT	3237	218	15	11	59	0	15	246	0	22	8	3	21	0	0	6.6	4.1	0.62	35.4	57.7
Braustern	3369	128	2	43	10	0	4	250	0	9	4	3	16	0	1	11.4	6.3	0.55	26.3	47.2
Brewers Gold	5232	214	10	29	13	0	3	169	0	4	8	8	12	0	0	8.3	5.0	0.60	41.0	66.9
Brewers Stand	23197	1070	59	70	59	19	19	53	0	32	76	74	116	112	0	9.5	4.3	0.45	24.6	52.2
Buket	4902	271	3	101	31	0	18	248	22	6	4	3	20	0	0	12.0	6.6	0.55	25.9	47.2
Bullion	3376	216	13	27	15	0	3	135	0	6	6	5	15	0	1	9.3	5.8	0.62	34.0	54.6
Cascade	4482	316	33	9	32	0	9	250	16	18	17	11	27	0	0	6.1	5.3	0.87	34.4	52.6
Chang bei 1	2286	14	4	3	35	0	14	248	16	13	22	22	19	27	0	4.0	4.7	1.18	32.7	47.2
Chang bei 2	1748	4	3	3	43	0	15	253	9	10	22	21	19	28	0	4.1	6.1	1.49	30.0	43.5
College Cluster	1017	176	14	9	8	0	4	128	0	5	6	6	10	0	0	7.5	2.8	0.37	26.4	56.4

Tabele 7.2 (cont.)

Variety	Myr-cene	2-M.-iso-butyrate	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendrene	Unde-canone	Humu-lene	Farne-sene	γ-Muu-rolene	ß-Seli-nene	α-Seli-nene	Cadi-nene	Seli-nadiene	Gera-niol	α-acids	ß-acids	ß/α	Cohu-mulone	Colu-pulone
Columbus	1929	214	17	5	11	0	3	163	0	10	19	16	47	15	1	13.5	5.6	0.41	28.2	51.6
Comet	1530	95	7	22	12	0	3	10	0	3	45	46	6	10	0	8.5	4.5	0.53	32.7	53.9
Crystal	952	13	4	5	22	24	15	225	0	15	40	39	21	56	0	2.8	6.0	2.14	15.8	35.8
Density	2093	185	8	7	50	0	12	268	0	18	7	3	17	0	0	7.7	4.5	0.58	33.2	57.8
Diva	6763	181	6	31	42	0	25	262	8	9	113	139	21	0	0	6.2	5.8	0.94	25.0	49.7
Dunav	3348	147	2	139	8	0	7	201	20	9	4	2	15	0	0	6.0	6.5	1.08	26.0	58.8
Early Choice	3170	102	1	31	7	0	4	219	0	7	48	51	15	0	0	2.9	1.8	0.62	36.3	56.0
Eastern Gold	2109	25	3	5	13	0	6	201	10	5	8	7	38	7	1	9.5	5.0	0.53	30.7	50.2
Eastwell Golding	2025	86	3	7	16	0	8	280	0	8	4	2	18	0	2	7.4	3.7	0.50	25.6	51.4
Emerald	1056	61	5	9	8	0	7	312	0	7	4	3	16	0	0	6.9	5.3	0.77	31.3	50.7
Eroica	4376	507	46	135	6	11	7	176	0	9	7	5	14	0	0	11.2	8.5	0.76	39.9	63.6
Estera	2053	133	1	4	20	0	7	286	18	14	3	2	17	0	0	5.0	3.7	0.74	28.3	50.8
First Gold	4641	566	6	13	25	3	12	266	10	6	121	153	22	0	2	10.9	4.9	0.45	27.5	55.1
Fuggle	2462	104	1	5	17	0	6	249	21	6	4	4	17	0	0	6.3	3.3	0.52	27.9	51.1
Galena	9892	521	32	349	6	7	8	163	0	5	11	12	13	0	0	12.7	9.0	0.71	38.9	64.2
Ging Dao Do Hua	1972	379	3	3	15	0	7	257	0	14	54	55	39	0	0	6.0	4.6	0.77	41.7	61.0
Glacier	1653	17	4	4	13	0	8	282	0	9	3	2	16	0	0	2.9	4.9	1.69	12.1	41.6
Golden Star	1851	607	2	3	16	0	7	271	0	17	49	49	41	0	0	5.7	3.9	0.68	42.7	63.8
Granit	3760	202	7	20	9	3	19	213	0	6	7	5	14	0	1	9.7	5.1	0.53	26.3	49.4
Green Bullet	1568	95	8	5	13	0	15	257	0	20	10	10	19	0	0	4.5	3.4	0.76	38.9	67.5
Hallertauer Gold	2083	139	23	6	30	0	7	300	0	10	5	5	20	0	0	7.6	5.5	0.72	23.9	46.5
Hallertauer Magnum	7760	184	29	28	10	2	5	288	0	5	3	2	14	0	0	18.7	6.6	0.35	28.3	56.5
Hallertauer Merkur	4968	224	17	8	20	3	5	277	0	9	4	3	15	0	1	17.4	6.3	0.36	21.8	45.2
Hallertauer Mfr.	466	95	2	2	30	0	8	338	0	15	7	4	28	0	1	3.0	4.8	1.60	19.3	40.4
Hallertauer Taurus	14958	200	17	28	41	0	9	253	0	12	57	72	16	0	0	18.9	5.5	0.29	21.9	47.5
Hallertauer Tradition	2376	111	7	5	27	0	9	300	0	6	3	2	17	0	0	7.6	4.2	0.55	24.2	50.0

Table 7.2 (cont.)

Variety	Myr-cene	2-M.-iso-butyrate	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendrene	Unde-canone	Humu-lene	Farne-sene	γ-Muu-rolene	ß-Seli-nene	α-Seli-nene	Cadi-nene	Seli-nadiene	Gera-niol	α-acids	ß-acids	ß/α	Cohu-mulone	Colu-pulone
Harmony	4091	61	3	14	27	2	11	263	14	10	68	72	20	0	0	8.0	7.0	0.88	20.1	40.7
Herald	6359	545	3	108	14	5	23	205	0	5	36	43	14	0	0	11.6	4.6	0.40	36.2	61.9
Herkules	9022	362	63	108	10	0	10	287	0	6	5	5	14	0	0	19.7	5.6	0.28	36.3	57.9
Hersbrucker Pure	6683	151	2	24	35	15	18	245	0	7	29	27	18	52	0	5.8	2.7	0.47	25.2	50.1
Hersbrucker Spät	3536	63	7	17	38	23	12	176	0	9	41	43	15	46	0	3.0	5.4	1.80	17.8	37.7
Horizon	6263	282	8	33	44	3	6	152	11	5	9	10	10	0	0	12.8	6.3	0.49	25.9	48.0
Hüller Anfang	581	113	6	1	21	0	7	319	0	18	6	4	24	0	1	1.8	3.2	1.78	21.1	37.9
Hüller Aroma	628	61	3	2	24	0	8	307	0	17	6	4	23	0	1	4.7	4.0	0.85	26.6	49.1
Hüller Bitter	5604	337	38	13	43	20	11	168	0	20	43	42	82	58	0	7.2	5.6	0.78	28.3	48.9
Hüller Fortschritt	858	43	8	2	28	0	9	314	0	18	5	3	21	0	0	4.3	4.7	1.09	26.3	45.6
Hüller Start	780	53	2	3	13	0	10	326	0	13	7	4	24	0	0	2.0	3.0	1.50	20.1	40.4
Jap. C 730	1417	6	13	37	13	0	9	129	36	12	9	8	11	0	0	4.8	3.1	0.65	36.9	59.1
Jap. C 827	1442	37	11	4	7	0	7	276	15	9	6	4	16	20	0	4.2	1.9	0.45	26.9	51.9
Jap. C 845	991	14	5	12	5	0	3	287	14	5	3	3	19	0	0	7.8	4.1	0.53	21.2	42.4
Jap. C 966	5424	38	24	23	14	4	4	215	113	12	40	42	15	0	0	4.0	2.3	0.58	39.9	57.3
Kirin 1	1648	535	6	5	17	0	9	256	0	23	59	57	48	0	0	4.7	3.5	0.74	43.2	61.3
Kirin 2	2084	598	2	4	15	0	7	257	0	12	58	60	43	0	0	5.4	4.0	0.74	41.5	60.6
Kitamidori	947	11	4	14	4	0	3	286	15	4	4	3	18	0	1	8.7	4.2	0.48	19.8	40.3
Kumir	2777	90	3	20	21	2	8	282	10	5	3	2	18	0	0	13.9	5.3	0.38	23.8	50.6
Late Cluster	34526	912	27	108	52	400	18	38	8	31	68	72	102	95	0	10.5	5.9	0.56	28.5	49.1
Lubelski	1780	7	3	5	32	0	16	327	19	26	8	4	22	0	0	3.9	4.9	1.26	21.3	43.1
Malling	2336	187	3	5	31	0	9	274	15	12	4	4	20	0	2	5.2	3.9	0.75	32.5	54.1
Marynka	6230	338	3	61	13	6	8	149	118	8	7	7	13	0	0	11.4	4.8	0.42	26.1	50.7
Mt. Hood	247	43	16	2	13	0	6	304	0	11	6	3	27	0	2	3.8	5.1	1.34	19.5	42.5
Neoplanta	1649	116	3	23	5	0	6	232	18	9	4	3	18	0	0	8.6	4.0	0.47	37.1	63.2
Neptun	4448	144	34	6	16	0	3	199	0	6	3	2	16	0	0	15.3	4.5	0.29	21.9	41.5

Table 7.2 (cont.)

Variety	Myr-cene	2-M.-iso-butyrate	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendrene	Unde-canone	Humu-lene	Farne-sene	γ-Muu-rolene	ß-Seli-nene	α-Seli-nene	Cadi-nene	Seli-nadiene	Gera-niol	α-acids	β-acids	β/α	Cohu-mulone	Colu-pulone
Northern Brewer	4574	125	2	55	8	0	5	241	0	4	3	2	15	0	0	10.3	4.4	0.43	25.5	50.2
Nugget	2273	72	2	17	11	2	4	180	0	3	9	10	11	0	1	11.5	4.5	0.39	28.0	55.2
NZ Hallertauer	4838	135	2	19	33	0	8	168	13	13	20	20	16	30	0	6.4	8.3	1.30	39.6	50.4
Olympic	3915	126	4	31	15	3	4	160	0	3	6	5	11	0	0	15.0	4.8	0.32	26.7	55.3
Omega	3892	393	16	15	22	0	6	277	0	10	60	66	16	0	2	8.5	4.4	0.52	28.7	55.6
Opal	3239	108	18	15	42	2	9	264	0	8	5	2	21	32	0	7.5	4.2	0.56	13.6	32.4
Orion	1270	127	4	6	18	0	6	229	0	6	4	3	19	0	0	8.7	6.1	0.70	30.7	50.1
Pacific Gem.	3802	403	19	21	18	0	11	281	0	8	3	2	17	0	2	10.1	6.6	0.65	40.2	66.7
PCU 280	2346	70	1	11	6	0	5	270	0	5	3	2	14	0	0	13.7	5.0	0.36	25.9	53.9
Perle	1923	129	1	25	7	0	5	264	0	10	4	3	16	0	0	8.3	4.5	0.54	31.9	57.9
Phoenix	1852	143	2	7	7	0	8	276	19	34	56	61	19	0	0	10.6	4.9	0.46	24.6	51.4
Pilgrim	10109	698	6	182	17	5	18	268	0	9	67	76	17	0	0	9.9	4.3	0.43	38.2	66.5
Pilot	14329	566	13	155	68	12	31	58	0	12	269	352	22	0	3	8.4	4.4	0.52	38.3	64.9
Pioneer	4706	477	2	95	16	4	22	231	0	6	59	75	18	0	0	9.2	4.2	0.46	33.3	60.5
Premiant	2600	59	3	9	19	2	9	281	8	11	4	3	17	0	1	12.9	4.8	0.37	24.8	49.9
Pride of Kent	2894	77	5	5	33	0	8	306	0	6	4	3	17	0	1	8.6	3.3	0.38	28.0	58.9
Pride of Ringwood	1160	18	1	2	6	0	7	12	0	6	81	84	16	0	0	7.7	6.0	0.78	33.4	53.6
Progress	23411	1221	62	84	67	35	18	36	0	34	77	78	126	123	0	9.5	4.2	0.45	24.6	52.3
Rubin	3775	191	46	19	13	0	6	247	0	6	56	59	20	0	2	14.0	4.6	0.33	30.8	53.4
Saazer	1957	2	2	5	25	0	14	305	22	8	4	2	19	0	0	3.6	4.2	1.17	21.4	39.7
Saphir	6406	74	3	37	35	5	25	200	0	6	17	17	13	22	0	4.9	7.5	1.53	12.0	46.0
Serebrianker	1683	58	2	6	30	0	6	165	0	13	45	43	22	0	0	0.9	3.2	3.56	17.9	40.5
Sirem	1540	5	4	7	46	0	25	323	20	34	7	2	27	0	0	4.0	4.3	1.08	27.1	46.1
Sladek	4520	112	3	25	21	0	8	276	13	4	3	3	15	0	0	13.3	4.8	0.36	25.5	53.7
Smaragd	5304	53	11	16	29	2	8	229	0	5	9	7	15	17	0	6.5	5.1	0.78	16.1	35.7
Sovereign	5036	137	3	15	27	0	8	262	17	7	82	108	18	0	0	5.4	2.7	0.50	25.2	49.2

Table 7.2 (cont.)

Variety	Myr-cene	2-M.-iso-butyrate	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendrene	Unde-canone	Humu-lene	Farne-sene	γ-Muu-rolene	ß-Seli-nene	α-Seli-nene	Cadi-nene	Seli-nadiene	Gera-niol	α-acids	ß-acids	ß/α	Cohu-mulone	Colu-pulone
Spalter	2683	2	2	6	28	0	11	295	35	7	4	2	19	0	0	3.4	4.1	1.21	24.4	42.8
Spalter Select	5943	120	25	13	94	20	18	209	39	18	49	50	20	62	0	6.3	4.7	0.75	26.4	51.8
Sterling	2778	132	3	21	14	2	4	177	0	3	6	7	11	0	1	12.0	4.4	0.37	27.5	55.3
Sticklebract	4530	308	26	17	15	0	20	210	30	12	46	50	14	0	5	8.0	5.5	0.69	39.7	67.4
Strisselspalter	3861	57	10	25	32	20	8	182	0	7	31	33	13	34	0	3.3	8.0	2.42	15.2	36.0
Super Alpha	2297	122	30	11	27	0	10	295	0	11	4	3	17	0	0	6.5	5.1	0.78	36.3	62.3
Talisman	3311	131	2	30	8	0	5	239	0	5	4	3	15	0	1	11.5	5.8	0.50	25.5	49.2
Tettnanger	1725	3	3	6	43	0	27	331	21	46	8	3	26	0	0	3.4	3.6	1.06	25.5	44.7
Toyomidori	2839	511	23	74	17	0	17	233	0	12	14	9	42	9	3	12.0	4.5	0.38	31.8	65.8
Ultra	449	64	7	2	17	0	5	312	0	6	9	8	21	0	1	4.6	4.5	0.98	30.1	46.6
Urozani	2998	9	1	4	70	0	11	243	30	26	30	29	19	35	0	2.7	5.8	2.15	24.5	43.0
USDA 21055	5587	497	3	232	9	0	3	127	50	6	17	19	14	0	1	11.1	3.8	0.34	35.4	69.4
Vojvodina	4142	178	2	31	11	0	7	237	10	5	4	2	16	0	2	9.0	4.3	0.48	28.9	57.0
WFG	2016	23	4	5	37	0	16	313	23	24	9	5	26	0	0	3.7	4.9	1.32	21.3	43.1
Willamette	3765	199	2	8	16	0	3	245	26	6	4	4	16	2	0	4.2	3.8	0.90	34.6	58.3
Wye Challenger	7900	538	7	49	33	0	13	251	7	8	48	56	16	0	0	6.2	5.2	0.84	24.7	48.7
Wye Northdown	2287	73	2	6	17	0	4	252	0	7	4	3	17	0	0	10.6	7.6	0.72	28.6	48.0
Wye Target	4121	444	7	17	47	4	17	176	0	19	11	9	37	10	0	11.8	5.4	0.46	34.9	62.2
Wye Viking	3239	109	7	33	14	0	13	216	54	13	40	42	17	0	0	7.7	5.1	0.66	24.8	48.8
Yeoman	3080	187	13	11	9	0	5	233	0	13	40	43	16	0	1	17.9	6.4	0.36	26.8	51.7
Zatecki	1947	123	2	9	20	0	7	279	12	12	6	4	17	0	0	5.9	4.1	0.69	28.4	49.6
Zenith	4148	157	2	19	28	2	8	270	0	6	86	96	20	0	0	10.1	4.0	0.40	24.6	50.9
Zeus	6228	122	12	14	9	0	3	146	0	9	11	10	34	11	0	14.5	5.9	0.41	36.2	58.1
Zitic	1969	2	1	11	10	4	10	298	6	8	4	3	16	0	1	7.8	5.9	0.76	29.4	49.5
Zlatan	1705	20	5	9	55	0	36	377	22	18	9	3	30	0	0	3.3	3.1	0.94	22.3	40.7

Essential oils = relative values, ß-caryophyllene = 100, α- and ß-acids in % air-dried hops, analoga in % of the α- and ß-acids

7.5 Wöllmer analysis of new Hüll breeding lines

The first step taken in an analysis according to the Wöllmer method is to measure the total ether-soluble resin content. This is then separated into the hexane-soluble soft-resin fraction and the hexane-insoluble hard-resin fraction. At the request of Prof. Dr. Narziss, Wöllmer analyses were performed on the new Hüll breeding lines (Table 7.3) because they provide information about the bittering quality.

Table. 7.3: Wöllmer analyses of the new Hüll breeding lines (2008 harvest)

Variety	Total resin	Conducto-meter reading	Soft resin	β-fraction	Hard resin	α-acids (HPLC)	β-acids (HPLC)	Xanthohumol (HPLC)
Opal	25.8	12.6	24.3	11.7	1.5	11.8	7.3	0.55
Saphir	20.7	4.9	16.8	11.9	3.9	4.0	7.1	0.45
Smaragd	20.1	8.0	17.3	9.3	2.8	7.5	6.5	0.41
Hall. Merkur	33.6	18.5	31.2	12.7	2.4	17.1	6.6	0.42
Herkules	32.2	19.2	29.4	10.2	2.8	17.6	5.6	0.85

All figures in % dry hops

At 3.9 %, the hard-resin content of the Saphir cultivar is especially high. This becomes even more apparent if the hard-resin content is compared with acid content (acids:hard resin = 1:0.80). Beer brewed using the Saphir cultivar has the highest hard-resin content. Hard resins are non-specific compounds that have not been fully analysed chemically but that contribute to bittering quality. The especially harmonious bitterness of beers brewed with Saphir may be due to these substances.

7.6 Nitrate in hops

Nitrates are salts derived from nitric acid and occur in all green plants. Plants take up the nitrogen needed for growth mainly in the form of nitrate (NO_3). Nitrates are formed in the soil as the result of mineralization of organic substances (e.g. humus decomposition) and breakdown of nitrogenous fertilisers. Nitrate levels in plants are dependent on various factors (Fig. 7.1).

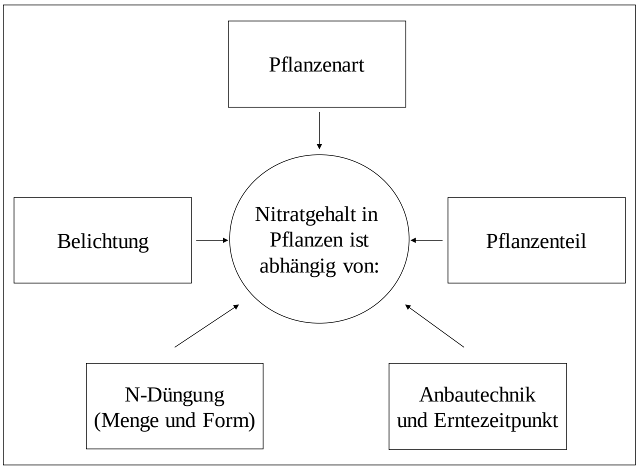


Fig.. 7.1: Nitrate levels in plants

In humans, nitrates can be reduced to nitrites. These react with secondary amines to form highly carcinogenic nitrosamines. Two thirds of nitrate uptake is via vegetables. The nitrate limit for lettuce is 0.3 % and for drinking water 50 mg/l. The nitrate content of foodstuffs is thus a quality criterion, too. The acceptable daily intake for adults is 3.65 mg NO_3/kg body weight. That corresponds to 292 mg per day for an adult weighing 80 kg. Nitrate tests are performed on hops at irregular intervals and the methods employed compared in ring tests. The aim is to keep nitrate levels in hops as low as possible. In Hüll, an HPLC technique is used to determine nitrate levels. To start with, a hop hot-water extract is prepared and analysed using an HPLC method. Over the last few years, an average nitrate content in hops of 0.89 % was measured, with a minimum of 0.36 % and a maximum of 1.55 %. Fig. 7.2 charts the distribution.

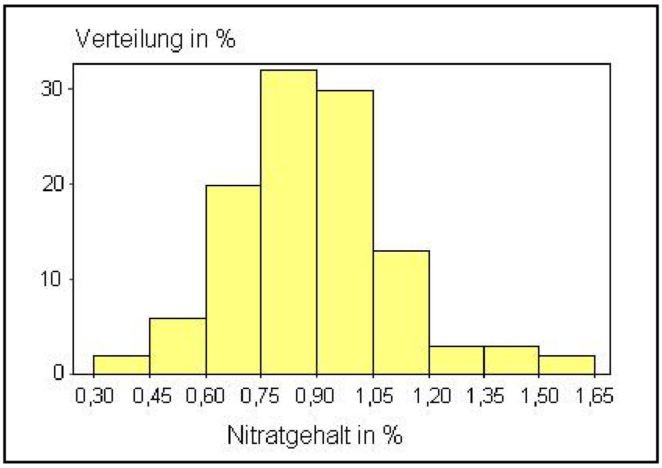


Fig. 7.2: Nitrate levels in hops

Light has been shown to have a considerable effect on nitrate levels. On sunny days, nitrate levels are lower than on rainy days, as light and warmth promote metabolic activity. At an average of 0.89 %, the nitrate content of hops is very high, the main reason probably being excessive nitrogenous fertilisation. Such fertilisation should always be preceded by an N_{min} analysis and then performed in accordance with the official fertilisation recommendations. As the hops contained in beer is very diluted, however, this high nitrate content is irrelevant. Nitrate levels in the brewing water are more important in this context.

7.7 Ring analyses of the 2009 crop

Since 2000, hop supply contracts have included a supplementary agreement concerning α-acid content. The contractually agreed price applies provided the α-acid content is within a defined range. If it is above or below this range, the price is marked up or down, respectively. The specification compiled by the *AHA* describes exactly how samples are to be treated (sample division and storage) and lays down which laboratories carry out post-analyses and what tolerance ranges are permissible for the analysis results. In 2009, the IPZ 5d team was once again responsible for organising the ring tests and evaluating them in order to verify the quality of the α-acid analyses.

The following laboratories took part in the 2009 ring tests:

- 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
- HVG Hallertau, Mainburg
- Agrolab GmbH, Oberhummel
- Thuringia State Research Centre for Agriculture (TLL)
- Hops Dept. of the Bavarian State Research Center for Agriculture (LfL), Hüll

In all, nine ring tests were conducted during the nine weeks from September 8th - November 6th 2009, as this was the period during which most of the hop lots were examined in the laboratories. Sample material was kindly provided by Mr. Hörmannsperger (Hallertau Hop Producers' Ring). 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 delivered to each of the laboratories. The laboratories then analysed one sample daily on each of the following weekdays. A week later, the results were sent back to Hüll and evaluated there. Altogether 36 samples were analysed in 2009. The evaluations were passed on to the individual laboratories as quickly as possible. In Fig. 7.3, a sample evaluation is presented as an ideal example of such a ring-test evaluation.

Nr. 9: HHE (22.09.2009)

Labor	KW		mittel	s	cvr		
						mean	3,97
1	3,93	3,94	3,94	0,007	0,2	sr	0,066
2	4,08	4,01	4,05	0,049	1,2	sL	0,074
3	4,05	4,01	4,03	0,028	0,7	sR	0,099
4	3,83	3,94	3,89	0,078	2,0	vkr	1,66
5	4,04	3,95	4,00	0,064	1,6	vkR	2,49
6	3,95	4,14	4,05	0,134	3,3	r	0,18
7	4,03	3,95	3,99	0,057	1,4	R	0,28
8	3,80	3,80	3,80	0,000	0,0	Min	3,80
						Max	4,14

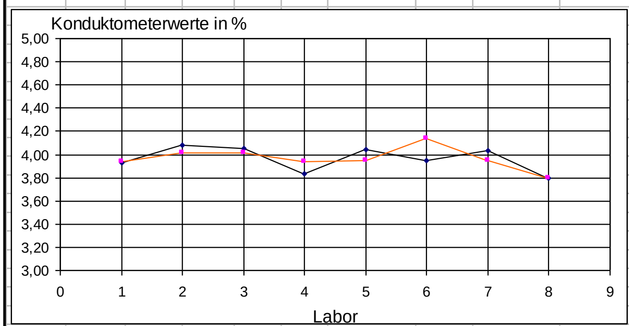


Fig.. 7.3: Evaluation of a ring analysis

The laboratory numbering (1-8) does not correspond to the above list. Grubb's test was performed according to ISO 5725 to detect any outliers among the laboratories. At a significance level of α = 0.05, five outliers were detected in 2009; none was detected at a significance level of α = 0,01. Table 7.4 shows the tolerance limits (critical difference values (CD), Schmidt, R., NATECO$_2$ Wolnzach) derived from the Analytica-EBC (EBC 7.4, conductometric titration) and the number of outliers in the years from 2000 to 2009.

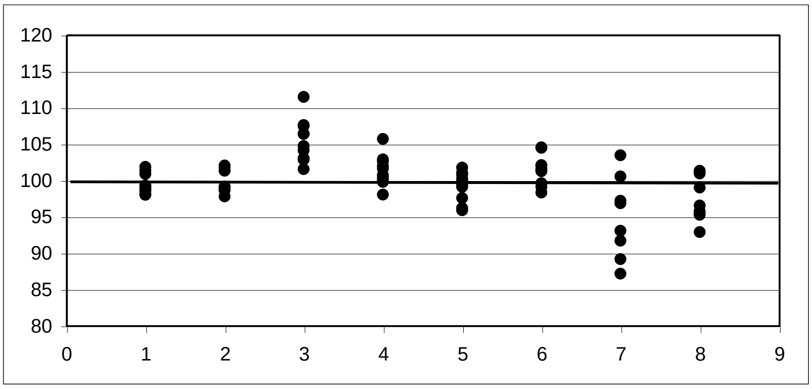
Table. 7.4: Tolerance limits set by EBC 7.4 and outliers in the years from 2000 to 2009

	Up to 6.2 % α-acids	6.3 % - 9.4 % α-acids	9.5 % - 11.3 % α-acids	From 11.4 % α-acids
Critical diff. CD	+/-0.3	+/-0.4	+/-0.5	+/-0.6
Tolerance range	0.6	0.8	1.0	1.2
Outliers				
in 2000	0	3	0	3
in 2001	2	1	0	2
in 2002	4	4	2	4
in 2003	1	1	1	0
in 2004	0	0	0	4
in 2005	1	0	1	3
in 2006	2	0	1	0
in 2007	1	0	0	0
in 2008	2	0	0	6
in 2009	3	2	0	4

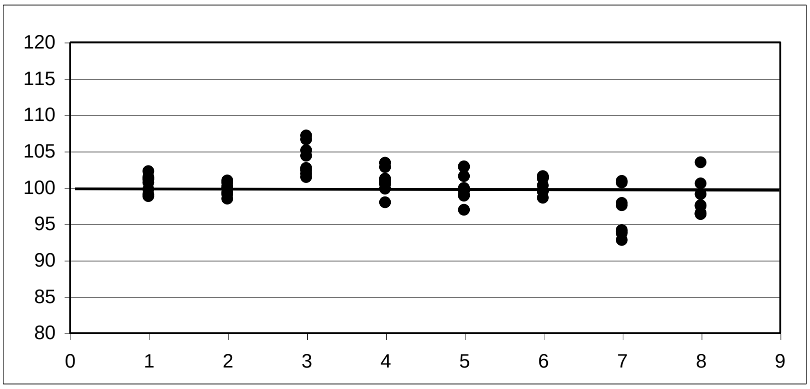
In 2009, a total of 9 results were outside the permissible tolerance range.

Fig. 7.4 shows all the analysis results for each laboratory as relative deviations from the mean (= 100 %), differentiated according to α-acid contents of <5 %, ≥ 5 % and <10 %, and also ≥ 10 %. The chart clearly reveals whether a laboratory is producing values that are too high or too low.

Proben mit α-Säurengehalten < 5 %



Proben mit α-Säurengehalten >= 5 % und < 10 %



Proben mit α-Säurengehalten >= 10 %

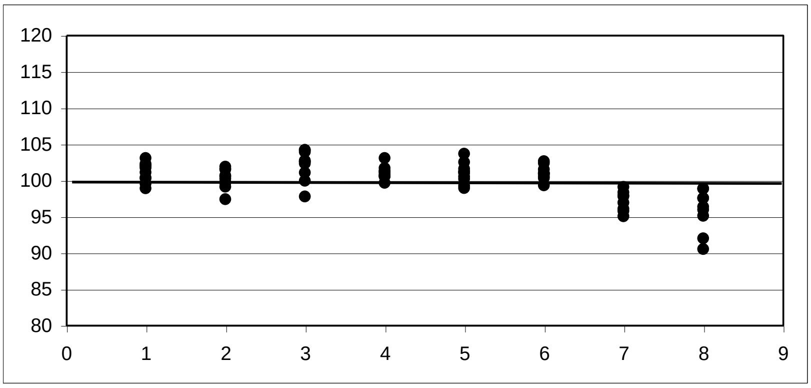


Fig. 7.4: Analysis results of the laboratories relative to the mean

For α-acid contents of < 5 % and also ≥ 5 % and <10 %, laboratory 3 is relatively high. For α-acid values of ≥10 %, laboratory 8 is too low. The Hüll laboratory is number 5.

7.8 Production of pure alpha acids and their ortho-phenylenediamine complexes for monitoring the stability of calibration extracts ICE 2 and ICE 3

The stability of ICE (International Calibration Extract) 2 is monitored twice a year within the *AHA.*

It is the task of the Hüll laboratory to produce α-acids that are as pure as possible (>98 %) to be used as standards for monitoring purposes. The ortho-phenylenediamine complex is first prepared from a CO_2 extract with a high acid content by reaction with ortho-phenylenediamine (Fig. 7.5).

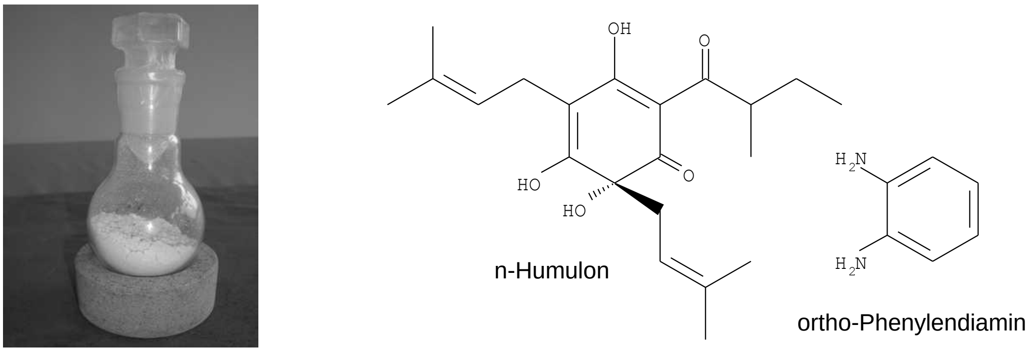


Fig. 7.5: ortho-phenylenediamine complex and its chemical structure

This complex can be purified by multiple recrystallization. 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. The most recent ICE 2 calibration did not reveal any significant degradation of the extract. Preparations for the introduction of the new ICE 3 calibration extract have been undertaken by the *AHA*, which is scheduled for autumn 2010.

7.9 Analyses for Work Group IPZ 3d "Medicinal and Spice Plants"

In 2009, analyses were performed on behalf of IPZ 3d for the first time. Initially, the goal was to design methods and establish them at the Hüll laboratory. Table 7.5 contains an overview of the results of these analyses.

Table 7.5: Analyses of medicinal and spice plants

Experimental parameters	No. of analyses	Mean	Min.- Max.
Salvia miltiorrhiza			
Cold-water extract	10	57.3	46.0 – 64.5
Hot-ethanol extract	10	7.4	6.0 – 11.7
Salvianolic acid B	10	5.8	3.8 –7.3
Tanshinone IIa	10	0.19	0.12 – 0.39
Saposhnikovia divaricata			
Hot-ethanol extract	10	22.6	20.9 – 25.0
Prim-O-glucosylcimifugin	10	0.23	0.20 – 0.26
5-O-methylvisamminoside	10	0.53	0.46 – 0.59
Paeonia lactiflora			
Paeoniflorin	10	3.51	2.60 – 4.11
Leonorus japonicus			
Hot-water extract	10	26.05	21.5 – 31.5
Flavonoids	10	0.64	0.26 – 1.44

All figures as a % of the plant material

As Prof. Dr. Bomme stated, the results correlate very well with previously obtained figures. It is planned to step up collaboration between IPZ 5d and IPZ 3d.

7.10 Tests for plant-protective residues in hops from the 2009 crop

The annual tests for plant-protective residues in hops, performed since the late 1980s, provide a very clear picture of the actual situation regarding the use of plant protectives. The 2009 crop, like those of the preceding years, was confirmed free of harmful residues. The high cost of the total analysis (approx. € 800 per sample) meant that the number of analyses in 2009 had to be limited once again to six samples. However, numerous additional analyses covering the same range of substances are commissioned by the hop-trading companies.

In 2009, 23 active substances were licensed for use in hops in Germany. Altogether, 109 different active plant-protective substances were analysed in this study. In addition to inspection for currently registered active substances, the hops are inspected and monitored for previously registered active substances and substances known to be used on other crops (e.g. grapes). The study thus covers all potentially relevant active substances.

The legally defined maximum permissible residue limits (MRL) are not toxicological limits! Definition is based on 1/100 of the acceptable daily intake. Field trials are performed in addition. If it is possible to adhere to an even lower value under best practices, this value is the maximum permissible limit for the relevant crop.

Holding time, i.e. the period between the last application of plant protective and harvesting, plays an important role with respect to minimizing residue levels. For example, the holding time for VERTIMEC, a commercial product used to control the common spider mite, is 28 days for hops but only 3 days for cucumbers and tomatoes! There is no risk to consumers even in the case of tomatoes with short pre-harvest intervals. With hops, the last advisable application under best agricultural practices is 4 weeks prior to harvesting; possible residues are minimized in this way.

7.10.1 Sample selection and analysis results

A total of around 100 hop samples representing all the important varieties grown in the Hallertau were supplied during the course of the 2009 weighing and certification season to the Hops Dept. of the Bavarian State Research Center for Agriculture (LfL) by the Hallertau Hop Producers' Ring. The samples were labelled only with the name of the variety and the bale number. The LfL was thus unaware of the names of the hop farms.

From these hop samples, the LfL selected **two** random samples for each of the six varieties listed in the table and made a mixed sample for each variety. The varieties selected for analysis include ones that are highly susceptible to pests and diseases (e.g. Hallertauer Magnum), less susceptible varieties (e.g. Hallertauer Tradition), late-maturing varieties (e.g. Hallertauer Taurus and Herkules) and varieties grown on large acreages (e.g. Hallertauer Magnum and Perle).

The analyses were performed for the first time by SOFIA GmbH, a Berlin laboratory which participates in ring analyses of hops for plant-protective residues.

Table 7.6: Tests for plant-protective residues – 2009 crop, registered and approved active substances (mg/kg = ppm)

Active substances listed by disease/pest	Maximum permissible level in ppm	R1/09 HS	R2/09 HT	R3/09 HM	R4/09 TU	R5/09 PE	R6/09 SR
1. Downy mildew							
Azoxystrobin	20	1.5	2.2	1.3	3.6	1.6	0.93
Cymoxanil	2	NQ	NQ	NQ	NQ	NQ	NQ
Dimethomorph	50	0.24	0.21	0.41	1.8	6.7	1.9
Folpet	150	0.047	NQ	1.7	0.56	NQ	NQ
Fosethyl	1,500	NQ	NQ	2.3	2.9	NQ	NQ
Copper compounds	1,000	270	4.6	149	152	58	189
Metalaxyl	10	0.034	0.007	0.012	0.048	0.013	0.015
2. Powdery mildew							
Myclobutanil	2	NQ	NQ	NQ	NQ	NQ	NQ
Quinoxyfen	0.5	NQ	NQ	NQ	NQ	NQ	NQ
Triadimenol	10	NQ	NQ	NQ	0.1	NQ	NQ
Trifloxystrobin	30	6.1	8.6	4.4	4.3	0.045	NQ
3. Aphids							
Flonicamid	2	NQ	NQ	NQ	NQ	NQ	NQ
Imidacloprid	10	NQ	NQ	NQ	NQ	NQ	NQ
Pymetrozin	15	NQ	NQ	NQ	NQ	NQ	NQ
4. Spider mites							
Abamectin	0.05	NQ	NQ	NQ	NQ	NQ	NQ
Hexythiazox	20	NQ	NQ	NQ	NQ	NQ	NQ
Spirodiclofen	30	NQ	NQ	NQ	NQ	NQ	NQ
5. Soil pests							
Lambda-Cyhalothrin	10	NQ	NQ	NQ	NQ	NQ	NQ
Methamidophos	0.02	NQ	NQ	NQ	NQ	NQ	NQ
6. Herbicides							
Bromoxynil	0.1	NQ	NQ	NQ	NQ	NQ	NQ
Cinidon-ethyl	0.1	NQ	NQ	NQ	NQ	NQ	NQ
Fluazifop-P-butyl	0.1	NQ	NQ	NQ	NQ	NQ	NQ
MCPA	0.1	NQ	NQ	NQ	NQ	NQ	NQ

NQ = not quantifiable
HS = Herkules
HT = Hallertauer Tradition
HM = Hallertauer Magnum
TU = Hallertauer Taurus
PE = Perle
SR = Saphir

In addition to the 23 registered active substances, the following 85 active substances from previously registered products or products previously or currently used on other crops were included in the analysis.

Additional active substances included in the analysis

Fungicides (26):

Boscalid	Fenpropimorph	Pyraclostrobin
Captafol	Fentin-acetat	Spinosad
Captan	Flusilazol	Spiroxamine
Chlorthalonil	Kresoxim-methyl	Tebuconazol
Dibrom	Malathion	Tolylfluanide
Dichlofluanid	Nitrothal-isopropyl	Triadimefon
Dithiocarbamate	Penconazol	Triforin
Fenarimol	Procymidon	Vinclozolin
Fenbutatin oxide	Propiconazol	

Insecticides/Acaricides (42):

3-Hydroxy-Carbofuran	Clothianidin	Fenpyroximate
Acephat	Cyfluthrin	Fenvalerat
Acetamiprid	Cyhexatin	Fipronil
Acrinathrin	Cypermethrin	Flucythrinate
Alphacypermethrin	Deltamethrin	Fluvalinate
Amitraz	Diazinon	Methidathion
Azocyclotin	Dichlorvos	Mevinphos
Bifenthrin	Dicofol	Omethoate
Bioresmethrin	Dicrotophos	Parathion methyl
Brompropylate	Dioxacarb	Permethrin
Carbofuran	Endosulfan	Pirimicarb
Carbosulfan	Ethiofencarb	Propargit
Chlorpyrifos-Ethyl	Etoxazol	Propoxur
Clofentezin	Fenpropathrin	Pyridaben

Herbicides (17):

2,4,5-T	Dichlorprop	MCPA
2,4-D	Diclofop	MCPP
2,4-DB	Diflufenzopyr	Metribuzin
Bentazone	Fluroxypyr	Monolinuron
Carfentrazon-ethyl	Haloxyfop	Trifluralin
Dicamba	Ioxynil	

The values in all of the analyses of the six hop samples were below the limit of quantification, which is currently 0.01 ppm to 0.5 ppm.

7.10.2 Assessment of the results

The pest burden in the 2009 season did not bring any unusual challenges, except for the pressure from primary and secondary downy mildew infections, which was higher than the long-term average. As growers were able to use a variety of registered active substances during the course of the season, residues were always much lower than the maximum permissible limits.

In the case of insecticides, acaricides and herbicides, no residues were found that exceeded the very low limits of quantification. Table 7.7 summarizes the residue situation for the 2009 crop.

Table 7.7: Residues in the 2009 hop crop

Active substance (trade name)	Incidence n = 6	ppm min-max.	MPL in ppm	MPL in ppm (US)	MPL in ppm (Japan)
Azoxystrobin (Ortiva)	6	0.93–3.6	20	20	20
Dimethomorph (Forum)	6	0.21–6.7	50	60	60
Folpet (Folpan WDG)	3	0.047–1.7	150	120	120
Fosethyl (Aliette)	2	2.3–2.9	1500	45	1440
Copper compounds	6	4.6–270	1000	ex.	ex.
Metalaxyl (Ridomil Gold Combi)	6	0.007–0.048	10+150	20+120	10+120
Triadimenol (Bayfidan)	1	0.10	10	-	5
Trifloxystrobin (Flint)	5	0.045–8.6	30	11	20

ex. = exempt

7.10.3 Resumé

In a year tending to experience below-average pest and disease pressure (with the exception of Downy mildew), the levels of plant-protective residues measured were also very low. The few residues of active substances detected were in concentrations that were a mere fraction of the maximum permissible levels. Most of the registered active substances and all of the non-registered active substances were found to have no residues at all. Negative effects of plant protectives on beer and consumers can accordingly be ruled out.

7.11 Monitoring of variety authenticity

The monitoring of variety authenticity on behalf of the German food control authorities is a mandatory duty of IPZ 5d.

Variety checks for the food control authorities

(District administrator's offices) 32

Complaints 0

8 Publications and specialist information

8.1 Summary of PR work

			Number
Practice-relevant information and scientific papers	45	Guided tours	72
LfL publications	3	Exhibitions and posters	8
Press releases	1	Basic and advanced training sessions	20
Radio and TV broadcasts	4	Final-year university projects	1
Conferences, trade events and seminars	14	Participation in work groups	17
Talks	78	Awards	2
Foreign guests	246		

8.2 Publications

8.2.1 Practice-relevant information and scientific papers

Author(s), title, journal, page

Engelhard, B., Schlagenhaufer, S. (2009): Prognosemodell als neue Entscheidungshilfe zur Bekämpfung des Echten Mehltaus (*Podosphaera macularis*) im Hopfen - Start in der Hallertau 2009. Hopfen-Rundschau 60: 77-82.

Engelhard, B., Schlagenhaufer, S. (2009): A forecasting model for the control of powdery mildew (*Podosphaera macularis*) in hops (*Humulus lupulus*) under climatic conditions in the Hallertau. Proceedings of the Scientific Commission, International Hop Growers` Convention, Leon, Spain, ISSN 1814-2192, 75-77.

Fuß, S., Portner, J. (2009): Hallertauer Mittelfrüher: Erst rechnen – dann entscheiden! Hopfen Rundschau 60 (3), 54-56.

Johnson, D.A., Engelhard, B., Gent, D.H. (2009): Downy Mildew. In: Mahaffee, W.F., Pethybridge, S.J., Gent, D.H. (eds), Compendium of Hop Diseases and Pests: 18-22. APS Press, St. Paul.

Lutz, A., Kneidl, J., Kammhuber, K., Seigner, E. (2009): Herkules – the new Huell High Alpha Variety. Proceedings of the Scientific Commission, International Hop Growers` Convention, Leon, Spain, ISSN 1814-2192, 21.

Lutz, A., Kneidl, J., Seigner, E., Kammhuber, K. (2009): The right time to harvest optimal yield and quality. Proceedings of the Scientific Commission, International Hop Growers` Convention, Leon, Spain, ISSN 1814-2192, 116.

Lutz, A., Seigner, E., Kneidl, J., Engelhard, B., Kammhuber, K. (2009): Erhaltungszüchtung der Sorte Hallertauer Tradition. Hopfenrundschau Nr. 11, November 2009, 294-295.

Lutz, A., Kammhuber, K., Kneidl, J., Petzina, C., Wyschkon, B. (2009): Bonitierung und Ergebnisse. Hopfenrundschau Nr. 12, Dezember 2009, 317-320.

Mahaffee, W., Engelhard, B., Gent, D.H., Grove, G.G. (2009): Powdery Mildew. In: Mahaffee, W.F., Pethybridge, S.J., Gent, D.H. (eds), Compendium of Hop Diseases and Pests: 25-31. APS Press, St. Paul.

Mahaffee, W., Engelhard, B. (2009): Gray Mold. In: Mahaffee, W.F., Pethybridge, S.J., Gent, D.H. (eds), Compendium of Hop Diseases and Pests: 24-25. APS Press, St. Paul.

Münsterer, J. (2009): Entwicklung und Erprobung einer neuartigen Messtechnik zur weiteren Optimierung der Trocknungsleistung. Hopfen Rundschau 60 (5), 110-112.

Niedermeier, E. (2009): Pflanzenstandsbericht. Hopfen Rundschau 60 (5), 113.

Niedermeier, E. (2009): Pflanzenstandsbericht. Hopfen Rundschau 60 (6), 150.

Niedermeier, E. (2009): Pflanzenstandsbericht. Hopfen Rundschau 60 (7), 179.

Niedermeier, E. (2009): Pflanzenstandsbericht. Hopfen Rundschau 60 (8), 204.

Niedermeier, E. (2009): Pflanzenstandsbericht. Hopfen Rundschau 60 (9), 237.

Niedermeier, E. (2009): Nach dem Sturm: Wie geht es weiter? Hopfenrundschau International 2009, 28-31.

Oberhollenzer, K., Seigner, E., Lutz, A., Eichmann, R., Hückelhoven, R. (2009): Powdery mildew on hops (*Humulus lupulus* L.): Histochemical studies and development of a transient transformation assay. Proceedings of the Scientific Commission, International Hop Growers` Convention, Leon, Spain, ISSN 1814-2192, 23-26.

Portner, J. (2009): Aktuelle Hopfenbauhinweise. Hopfenbau-Ringfax Nr. 6; 7; 9; 10; 12; 13; 14; 15; 17; 18; 19; 20; 21; 22; 23; 24; 25; 26; 27; 28; 29; 30; 32; 33; 35; 36; 37; 38; 39; 40; 41; 42; 43; 44; 45; 48; 49; 52.

Portner, J. (2009): Erste N_{min}-Ergebnisse in Hopfen und anderen Ackerkulturen; Empfehlungen zur Stickstoffdüngung 2009! Hopfen Rundschau 60 (3), 57.

Portner, J. (2009): Gezielte Stickstoffdüngung des Hopfens nach DSN (N_{min}). Hopfen Rundschau 60 (3), 58.

Portner, J. (2009): Nährstoffvergleich bis 31. März erstellen! Hopfen Rundschau 60 (3), 59.

Portner, J., Brummer, A. (2009): N_{min}-Untersuchung 2009. Hopfen Rundschau 60 (5), 110.

Portner, J. (2009): Peronosporabekämpfung – Planen Sie Ihren Mitteleinsatz. Hopfen Rundschau 60 (6), 150-151.

Portner, J. (2009): Kostenfreie Rücknahme von Pflanzenschutzverpackungen PAMIRA 2009. Hopfen Rundschau 60 (8), 186.

Portner, J. (2009): Näherungsmethode zur Ermittlung der Effizienz der Trocknungsleistung von Hordendarren bei Hopfen. Hopfen Rundschau 60 (8), 202-203.

Portner, J. (2009): Rebenhäcksel bald möglichst ausbringen! Hopfen Rundschau 60 (8), 204.

Portner, J. (2009): Verbrennung nicht beernteter Hopfenreben im Hagelgebiet. Hopfen Rundschau 60 (9), 237.

Portner, J. (2009): Fachkritik zur Moosburger Hopfenschau 2009. Hopfen Rundschau 60 (10), 254-258.

Portner, J. (2009): Aktuelles zum Pflanzenschutz. Hopfenring-Information v. 04.08.2009, 1.

Portner, J. (2009): Haus des Hopfens. Hopfenrundschau International 2009, 65-66.

Portner, J. (2009): Hinweise für Hopfenpflanzer zu Schlagkarteiauswertung, Fortbildungsveranstaltungen und KuLaP-Förderung. Hopfenring-Information v. 27.10.2009, 1-2.

Schlagenhaufer, S., Engelhard, B., Wolf, P.F.J. (2009): Sporenverteilung des Echten Mehltaus im Hopfen ausgehend von Infektionsherden und Abhängigkeit vom Vegetationsstadium. Gesunde Pflanzen 61: 31-37.

Seefelder, S., Seigner, E., Niedermeier, E., Radišek, S., Javornik, B. (2009): Genotyping of Verticillium pathotypes in the Hallertau: Basic findings to assess the risk of Verticillium infections. Proceedings of the Scientific Commission, International Hop Growers` Convention, Leon, Spain, ISSN 1814-2192, 72-74.

Seefelder, S., Seidenberger, R, Lutz, A., Seigner, E. (2009): Development of Molecular Markers Linked to Powdery Mildew Resistance Genes in Hop (*Humulus lupulus* L.) to Support Breeding for Resistance. Proceedings 32rd EBC Congress, Hamburg, 10.-14.05.2009.

Seefelder, S., Seigner, E., Niedermeier, E., Radišek, S., Javornik, B. (2009): Wilting disease in the Hallertauer hop region- Molecular characterisation of various Verticillium strains. Proceedings of the 10th International Verticillium Symposium, Corfu Island, Greece.

Seigner, E., Lutz, A., Oberhollenzer, K., Seidenberger, R., Seefelder, S., Felsenstein, F. (2009): Breeding of Hop Varieties for the Future. II International Humulus Symposium, ISHS, Acta Horticulturae 848, 49-57.

Seigner, E. (2009): Herbert Ehrmaier, Hopfenzüchter. In: Biographisches Lexikon zur Geschichte der Pflanzenzüchtung. Ergänzungsband (4. Folge). Gerhard Röbbelen (Hrsg.), 21-22.

Weihrauch, F. (2009): Damson-hop aphid. In: Mahaffee, W.F., Pethybridge, S.J., Gent, D.H. (eds), Compendium of Hop Diseases and Pests: 60-62. APS Press, St. Paul.

Weihrauch, F. (2009): Hop flea-beetle. In: Mahaffee, W.F., Pethybridge, S.J., Gent, D.H. (eds), Compendium of Hop Diseases and Pests: 63-64. APS Press, St. Paul.

Weihrauch, F. (2009): First steps towards a revised control threshold for the Damson-hop aphid Phorodon humuli. Proceedings of the Scientific Commission of the International Hop Growers´ Convention, León, Spain, 21-25 June 2009: 82-85.

Weihrauch, F. (2009): Die Bibliographie des Arbeitskreises „Neuropteren", Version 2.0. DGaaE-Nachrichten 23: 83.

Weihrauch, F., Fisher, G.C. (2009): Rosy rustic moth. In: Mahaffee, W.F., Pethybridge, S.J., Gent, D.H. (eds), Compendium of Hop Diseases and Pests: 66-67. APS Press, St. Paul.

Weihrauch, F., Gruppe, A. (2009): Die Neuropterida des Dürnbucher Forstes: Auf der Suche nach Myrmeleon bore in Bayern. DGaaE-Nachrichten 23: 84-85.

Weihrauch, F., Baumgartner, A., Felsl, M., Lutz, A. (2009): Aphid Tolerance of Different Hop Genotypes: First Attempts to Develop a Simple Biotest for Hop Breeding by the Use of Phorodon humuli. II International Humulus Symposium, ISHS, Acta Horticulturae 848: 125-129.

8.2.2 LfL publications

Name	Work group	LfL publications	Title
Engelhard, B., et al.	IPZ 5	LfL flyer	Hopfenkrankheiten, Schädlinge, Nichtparasitäre Schadbilder (Hop diseases, pests, visible non-parasitic damage)
Lutz, A., Kneidl, J., Seigner, E., Kammhuber, K.	IPZ 5c and 5d	LfL Information	Hopfenqualität – Ernte zum richtigen Zeitpunkt (Hop quality – ideal harvesting time)
Portner, J.	IPZ 5a	"Grünes Heft" (Green Leaflet)	Hopfen 2009 (Hops 2009)

8.2.3 Press releases

Autor(s) / Work group	Title
Portner, J., IPZ 5a	Hallertauer Modell zum ressourcenschonenden Grundwasserschutz (Hallertau model for resource-saving groundwater protection)

8.2.4 Radio and TV broadcasts

Name /WG	Date of broadcast	Topic	Title of programme	Station
Engelhard, B., IPZ 5b	02.09.09	Forecasting model for hop powdery mildew	teleschau	IN-TV
Engelhard, B., IPZ 5b	11.09.09	Plant protection in hops	Abendschau	B3

Name /WG	Date of broadcast	Topic	Title of programme	Station
Portner, J., IPZ 5a	02.09.09	Interview on the situation in the hail-damaged area		Radio Ingolstadt
Portner, J., IPZ 5a	17.09.09	Interview on the hop show in Moosburg		Regional TV Landshut

8.3 Conferences, talks, guided tours and exhibitions

8.3.1 Conferences, trade events and seminars

Organised by	Date / Venue	Topic	Participants
Engelhard, B., Wick, Dr. M. (JKI)	04.-05.02.09	Internat. conference on the harmonisation and licensing of plant protectives	IPZ, Julius Kühn Institute (JKI), hop growers' and hop traders' associations, plant protection companies, colleagues from European institutes
Bioland	11.02.09	Organic hop production	Hop growers, IPZ 5a, IPZ 5b
Fed. Ministry of Food, Agric. + Consumer Protection (BMELV)	17.02.09	Technical discussion on plant protection	Hop growers' and hop traders' associations, plant protection companies, federal authorities, IPZ 5b
Portner, J.	02.03.09 Hüll	"Grünes Heft" meeting	Colleagues from hop research institutes in Germany
Schätzl, J., Portner, J.	19.05.09; 03.06.09; 16.06.09; 30.06.09; 28.07.09 Various venues	Information pooling	BayWa employees
Schätzl, J.	20.05.09; 03.06.09; 17.06.09; 01.07.09; 15.07.09; 29.07.09 Various venues	Experience sharing and training	Ring consultants and Ring experts
IPZ 5 - Seigner, E., Engelhard, B.; J.A. Magadan, S.A. Española de Fomento del Lúpulo	21.-25.06.09, León, Spain	Congress of the Scientific Commission of the International Hop Growers' Convention (IHGC)	Hop scientists and experts from the hop and brewing industries, 51 participants
Münsterer, J.	08.07.09 Wolnzach	Irrigation workshop	12 hop growers
Portner, J.; Fuß, S.	31.08.09 Osseltshausen	Instructive hop-harvest tour in the area hit by hail	120 hop growers
Association of German Hop Growers (VdH)	02.09.09	Plant protection conference	Federal authorities, plant protection companies, hop growers' and hop traders' associations

Organised by	Date / Venue	Topic	Participants
Portner, J.	15.09.09 Moosburg	Hop judging at the Moosburg hop show	20 members of the panel of judges
Bayern Innovativ, IPZ 5	30.09.09	Hop Research Centre in Hüll – supporting programme for the cooperation forum	Scientists, companies from the food, pharmaceutical and cosmetics industries
Portner, J.	06.11.09 Wolnzach	Implementing the Water Framework Directive in hop production	Colleagues from the LfL, the national offices for food, agric. and forestry (ÄELF); water consultants and Hallertau Hop Growers' Association (HVH)
Portner, J.	14.12.09 Hüll	Application methods for hop plant protectives	Colleagues from LfL (IPZ 5, IPS) and the Stuttgart branch of the LTZ (agric. technology centre)

8.3.2 Talks

AG	Name	Topic / Title	Organiser / Attended by	Date / Venue
IPZ 5	Engelhard, B.	Climate change in the Hallertau region, too?	Hop syndicate	20.08.09 Niederlauterb.
IPZ 5	Niedermeier, E., Portner, J., Lutz, A., Seigner, E.	Hop growing in the Hallertau	"Hopfenrundfahrt", guided bus tour 170 participants	02.09.09 Au
IPZ 5	Portner, J., Seigner, E.	Report of the IHGC's Scientific Commission in Leon (Spain)	52nd IHGC congress / 150 intern. guests	04.08.2009 Straßbourg (F)
IPZ 5a	Fuß, S.	Sensor technology in hop production	15 hop growers	11.02.2009 Plankstetten monastery
IPZ 5a	Fuß, S.	Requirements concerning plant-protective use and equipment technology	LfL and ÄELF / 205 hop growers	12.-17.02.2009 4 venues
IPZ 5a	Fuß, S.	Office organisation for hop growers	20/30 hop growers	29.10/12.11 Wolnzach
IPZ 5a	Münsterer, J.	Energy saving in hop drying	Niederlauterbach hop syndicate / 50 hop growers	04.03.2009 Niederlauter-bach
IPZ 5a	Münsterer, J.	Irrigation trials in hop growing	LfL / 30 participants of the "Agroklima" project	09.03.2009 Freising
IPZ 5a	Münsterer, J.	Hop-card-index evaluation	Hop Producers' Ring (HPR) and LfL / 40 hop growers	18.03.2009 Niederlauter-bach
IPZ 5a	Münsterer, J.	Hop-card-index evaluation	HPR and LfL / 25 hop growers	19.03.2009 Wolnzach
IPZ 5a	Münsterer, J.	Hop-card-index training	8 hop growers	28.05.2009 Wolnzach
IPZ 5a	Münsterer, J.	Energy-saving potential in hop drying	HPR, ISO-certified farms / 18 hop growers	06.08.2009 Niederlauter-bach

AG	Name	Topic / Title	Organiser / Attended by	Date / Venue
IPZ 5a	Münsterer, J.	Irrigation trials in 2009	LfL / 14 participants of the “Agroklima” project	26.10.2009 Wolnzach
IPZ 5a	Münsterer, J.	New findings in hop drying	HPR, ISO-certified farms / 70 hop growers	08.12.2009 Aiglsbach
IPZ 5a	Niedermeier, E.	Latest update on plant protection	Hop syndicate 28 participants	20.05.2009 Niederlauterb.
IPZ 5a	Niedermeier, E.	Measures to take after hail damage	HVH approx. 280 partic.	29.05.2009 Mainburg
IPZ 5a	Portner, J.	Fermentation of bine choppings – returning fermentation residues to hop gardens	Young hop growers’ association 280 hop growers	12.01.2009 Niederlauter-bach
IPZ 5a	Portner, J.	Evaluation of drying performance and energy consumption	IPZ 5a / 10 hop growers (workshop)	13.01.2009 Haunsbach
IPZ 5a	Portner, J.	Requirements concerning plant-protective use and equipment technology	BayWa 20 employees	02.02.2009 Mainburg
IPZ 5a	Portner, J.	Requirements concerning plant-protective use and equipment technology	Beiselen GmbH 15 participants from rural trading firms	06.02.2009 Mainburg
IPZ 5a	Portner, J.	Requirements concerning plant-protective use and equipment technology	LfL and ÄELF 320 hop growers	09.-17.02.2009 5 venues
IPZ 5a	Portner, J.	Evaluating hop production costs	IPZ 5a 10 hop growers (workshop)	18.02.2009 Haunsbach
IPZ 5a	Portner, J.	Correct fertilisation in hop growing	Upper Austrian Chamber of Agriculture, 35 participants	19.02.2009 Neudorf bei Haslach a.d. Mühl (Austria)
IPZ 5a	Portner, J.	Ways to reduce nitrate leaching in hop growing	Kehlheim district administrator’s office 80 invited guests	23.03.2009 Ratzenhofen
IPZ 5a	Portner, J.	Status of the work on hop irrigation – crucial for ensuring reliable supplies	Society of Hop Research (GfH) / 30 members of the tech. sci. committee (TWA)	31.03.2009 Wolnzach
IPZ 5a	Portner, J.	Training in forecasting, latest update on plant protection	Office for food, agric. and forestry (AELF), Roth / 60 hop growers	27.05.2009 Spalt
IPZ 5a	Portner, J.	Latest update on plant protection	HPR and LfL 35 hop growers	08.07.2009 Lobsing
IPZ 5a	Portner, J.	Development of fully automated wire-stringing equipment for hop growing	52nd IHGC congress / 150 intern. guests	03.08.2009 Straßburg (France)
IPZ 5a	Portner, J.	Current situation and harvesting date for Hallertauer Mittelfrüher	HPR 80 participants	11.08.2009 Landersdorf

AG	Name	Topic / Title	Organiser / Attended by	Date / Venue
IPZ 5a	Portner, J.	Current situation and harvesting date for Hallertauer Mittelfrüher	HPR 40 participants	12.08.2009 Unterpindhart
IPZ 5a	Portner, J.	Current situation and harvesting dates	Young hop growers' association / 80 participants	13.08.2009 Niederlauterb.
IPZ 5a	Portner, J.	Expert hop review (2009)	Town of Moosburg 150 guests	17.09.2009 Moosburg
IPZ 5a	Portner, J.	The "House of Hops" and the importance of hop production	LfL, Instit. f. Agric. Ecology, Organic Farming + Soil Prot. (IAB) 1a / 20 colleagues + guests	26.10.2009 Wolnzach
IPZ 5a	Portner, J.	Costs involved in hop production	HVG hop producer group / Diageo brewery	03.12.2009 Wolnzach
IPZ 5a	Schätzl, J.	Review of plant-protective situation, update on downy mildew (PS) situation in 2009, downy mildew forcasting service	HPR and LfL 25 hop growers	19.03.2009 Wolnzach
IPZ 5a	Schätzl, J.	Total harvest failure in 2009 due to hail? Measures needed to regenerate the stands!	Bavarian Farmers' Assoc. (BBV) / HVH 90 hop growers	10.06.2009 Osseltshausen
IPZ 5a	Schätzl, J.	Tasks of the LfL, organisation of the hop industry	LfL / 44 AELF (Erding) employees	24.06.2009 Wolnzach
IPZ 5a	Schätzl, J.	Downy mildew warning service for hop growers	LfL / 8 food inspectors	23.07.2009 Wolnzach
IPZ 5a	Schätzl, J.	Ring consultant training – 2009 in review	HPR 11 Ring consultants	07.12.2009 Wolnzach
IPZ 5b	Engelhard, B.	Permanent problems in hop growing – wireworms, alfafa weevils and flea beetles	VdH	02.09.09 Au
IPZ 5b	Engelhard, B. Schlagenhaufer, S.	The latest findings on PM biology and infection	BayWa	02.02.09 Mainburg
IPZ 5b	Engelhard, B. Schlagenhaufer, S.	The latest findings on PM biology and infection	Beiselen/BSL	06.02.09 Mainburg
IPZ 5b	Engelhard, B. Schlagenhaufer, S.	The latest findings on PM biology and infection	IPZ 5/ÄLF	09.-17.02.09 9 venues
IPZ 5b	Engelhard, B. Schlagenhaufer, S.	A forecasting model for the control of powdery mildew (Podosphaera macularis) in hops (Humulus lupulus) under climatic conditions in the Hallertau	IHGC, Scientific Commission / 43 participants	23.06.09 León (Spain)
IPZ 5b	Schwarz, J.	Current situation regarding reductions in copper by means of new copper formulations	Bioland, hops workshop / 26 participants	11.02.09 Plankstetten
IPZ 5b	Schwarz, J.	Development of integrated methods of plant protection against the Lucerne weevil *(Otiorhynchus ligustici)* in hops	3rd coordination meeting of the Fed. Agency for Agric. and Food (BLE) / 31 participants	02.12.09 Bad Kreuznach

AG	Name	Topic / Title	Organiser / Attended by	Date / Venue
IPZ 5b	Schwarz, J. Weihrauch, F. Engelhard, B.	The registration situation in 2009 for hop plant protectives	BayWa	02.02.09 Mainburg
IPZ 5b	Schwarz, J. Weihrauch, F. Engelhard, B.	The registration situation in 2009 for hop plant protectives	Beiselen/BSL	06.02.09 Mainburg
IPZ 5b	Schwarz, J. Weihrauch, F. Engelhard, B.	The registration situation in 2009 for hop plant protectives	IPZ 5/ÄLF	09.-17.02.09 9 Orte
IPZ 5b	Weihrauch, F.	Where did the aphids disappear to in 2008? Presentation of an in-progress research project on aphid control	Bioland, hops workshop / 26 participants	11.02.09 Plankstetten
IPZ 5b	Weihrauch, F.	Neuropterida in Dürnbuch forest: in search of Myrmeleon bore in Bavaria	"Neuroptera" workshop, German Soc. for General and Applied Entomology (DgaaE) / 15 participants	25.04.09 Schwanberg, Rödelsee
IPZ 5b	Weihrauch, F.	Bibliography of the "Neuroptera" workshop, version 2.0	"Neuroptera" workshop, DgaaE / 15 participants	25.04.09 Schwanberg, Rödelsee
IPZ 5b	Weihrauch, F.	First steps towards a revised control threshold for the damson-hop aphid Phorodon humuli	IHGC, Scientific Commission /43 participants	23.06.09 León (Spain)
IPZ 5b	Weihrauch, F. Engelhard, B.	Will there still be a sufficient range of registered plant protectives in future?	ÄLF Abensberg, Landshut /approx. 140 participants	28.01.09 Elsendorf
IPZ 5c	Lutz, A.	Criteria for high-quality hops	Preparatory meeting – PR tour for Microbreweries (USA) by the Assoc. of German Hop Growers / 6 participants	24.03.09 Mainburg
IPZ 5c	Lutz, A.	The influence of the harvesting date on internal and external hop quality, as illustrated by the 2008 harvest	Tech. scientific committee of the GfH / 35 participants	31.03.09 Wolnzach
IPZ 5c	Lutz, A.	Hop quality – harvesting at the right time	Spalt Raw Material Day / 100 participants	20.10.09 Spalt
IPZ 5c	Lutz, A.	Hop breeding – cone assessment	"Alt-Weihenstephaner Brauerbund"/ approx. 25 participants	03.11.09 Freising
IPZ 5c	Lutz, A.	Herkules – a curse or a blessing?	Elbe-Saale hop growers' autumn conference / 45 participantsTN	25.11.09 Leipzig
IPZ 5c	Lutz, A.	Hop quality – harvesting at the right time	15th workshop for ISO-certified hop farmers / 55 partic.	08.12.09 Aiglsbach

AG	Name	Topic / Title	Organiser / Attended by	Date / Venue
IPZ 5c	Oberhollenzer, K.	Powdery Mildew on Hops (*Humulus lupulus L.*): histochemical studies and development of a transient transformation assay	IHGC, Scientific Commission / 43 participants	22.06.09 Leon, Spanien
IPZ 5c	Oberhollenzer, K.	Powdery Mildew on Hops *(Humulus lupulus L.*): histochemical studies and development of a transient transformation assay	Doctoral-student seminar, Centre of Life and Food Sciences (WZW) at Munich Tech. Univ. (Prof. Hückelhoven), 25 participants	30.11.2009 Freising
IPZ 5c	Oberhollenzer, K.	Hop powdery mildew (*Humulus lupulus L.)*: microscopic investigations and identification of "resistance genes"	Meeting of the HVG Supervisory Board / 25 participants	10.12.2009 Wolnzach
IPZ 5c	Seefelder, S.	Are there new *Verticillium* races (hop wilt) in the Hallertau region?	Tech. scientific committee of the GfH / 35 participants	31.03.09 Wolnzach
IPZ 5c	Seefelder, S.	Development of molecular markers linked to powdery mildew resistance genes in hops to support breeding for resistance	Congress of the European Brewery Convention (EBC) / approx. 650 partic.	11.05.09 Hamburg
IPZ 5c	Seefelder, S.	Association mapping – a new tool for advanced hop breeding	European Hop Research Council, 5 TN	11.05.09 Hamburg
IPZ 5c	Seefelder, S.	Genotyping of *Verticillium* pathotypes in the Hallertau - basic findings to assess the risk of Verticillium infections	IHGC, Scientific Commission / 43 participants	23.06.09 Leon, Spain
IPZ 5c	Seefelder, S.	Genotyping of hop *Verticillium* in Germany – fundamentals of risk assessment	HVG Supervisory Board / approx. 25 participants	12.10.09 Wolnzach
IPZ 5c	Seefelder, S.	Genotyping of hop *Verticillium* in Germany – fundamentals of risk assessment	15th workshop for ISO-certified hop farmers / 55 particip.	08.12.09 Aiglsbach
IPZ 5c	Seigner, E.	Hop research in Hüll – research and expertise for the brewing and hop industries	Fraunhofer Institute for Process Engineering and Packaging, Freising / 8 participants	18.02.09 Freising
IPZ 5c	Seigner, E.	Herkules – the new Hüll high alpha variety	IHGC, Scientific Commission / 43 participants	22.06.09 Leon, Spain
IPZ 5c	Seigner, E.	The right time to harvest optimal yield and quality;	IHGC, Scientific Commission	24.06.09 Leon, Spain
IPZ 5c	Seigner, E.	Conference of the Scientific Commission, IHGC, in Spain	Hops dept. briefing / 45 participants	08.07.09 Hüll
IPZ 5c	Seigner, E.	PM isolates and their use in breeding PM-resistant hops	Wissenschaftl. Station für Brauerei in Munich, approx. 70 participants	29.06.09 Munich
IPZ 5c	Seigner, E.	Hop stunt viroid infections – monitoring of HSVd in Germany	Advisory Board meeting, GfH / 22 participants	16.09.09 Munich

AG	Name	Topic / Title	Organiser / Attended by	Date / Venue
IPZ 5c	Seigner, E.	Hop stunt viroid monitoring in Germany	HVG Supervisory Board meeting	10.12.2009 Wolnzach
IPZ 5d	Kammhuber, K.	The importance of hop components in beer brewing and for health	Fraunhofer Institute, Freising / 8 partic.	18.02.09 Freising
IPZ 5d	Kammhuber, K.	Initial experiences with the UHPLC system	Techn. scientific committee of the GfH / 35 participants	31.3.09 Wolnzach

8.3.3 Guided tours

(WG = work group)

WG	Name	Date	Topic/Title	Gast institution	No of partic.
IPZ 5	Engelhard, B.	04.05.09	Hop research	GF Doemens	1
IPZ 5	Engelhard, B. Kammhuber, K. Schwarz, J.	13.05.09	Hop research, hop production	Primary school teachers Pfaffenhofen district	12
IPZ 5	Engelhard, B.	20.05.09	Hop research, hop production	Augsburg grammar school, Grade 11	60
IPZ 5	Engelhard, B. Seigner, E.	04.06.09	Hüll Hop Research Center	Prof. Becker, Dr. Krottenthaler, Dr. Gastl, Munich Tech. Univ., Chair of Brewing and Beverage Technology	3
IPZ 5	Engelhard, B.	15.06.09	Hop research, hop production	Pfaffenhofen administrators	30
IPZ 5	Engelhard, B.	17.06.09	Hop research, hop production	Munich Tech. Univ., Instit. of Organic Farming	17
IPZ 5	Engelhard, B. Kammhuber, K.	14.07.09	Hop research	LfL's PR coordination group	12
IPZ 5	Engelhard, B.	16.07.09	Organisation of hop research	Bayern Innovativ	7
IPZ 5	Engelhard, B. Kammhuber, K.	20.07.09	Hop research	AB-InBev	4
IPZ 5	Engelhard, B.	21.07.09	Hop production for the world market	Traunstein grammar school	32
IPZ 5	Engelhard, B. Seigner, E. Kammhuber, K. Lutz, A.	21.07.09	Hop research for the brewing industry	Brewing technology students at the Tech. Univ. of Munich, Dr. habil. Krottenthaler	28
IPZ 5	Engelhard, B.	24.07.09	Hop production for the world market	Wolnzach grammar school	26
IPZ 5	Engelhard, B. Fuß, S. Weihrauch, F.	07.08.09	Tour of trial plantings	Assoc. of graduates from Landshut agricultural college	15
IPZ 5	Engelhard, B. Schätzl, J. Weihrauch, F.	13.08.09	Tour of trial plantings	Assoc. of graduates Freising and Moosburg agricultural colleges, hop growers from the Freising district	39
IPZ 5	Engelhard, B. Portner, J. Weihrauch, F.	14.08.09	Tour of trial plantings	Assoc. of graduates from Kelheim agricultural college	40
IPZ 5	Engelhard, B.	28.08.09	Tour of the Hop Research Centre	Hop weeks	45
IPZ 5	Engelhard, B. Schlagenhaufer, S	02.09.09	PM forecasting	Hop weeks	170
IPZ 5	Portner, J. Niedermeier, E. Lutz, A. Seigner, E.	02.09.09	Guided bus tour of trial plantings	Guests of the Freising district and of the hop growers' association	150

WG	Name	Date	Topic/Title	Gast institution	No of partic.
IPZ 5	Engelhard, B. Kammhuber, K. Lutz, A.	04.09.09	Hop breeding and analytics	Aarhus Univ. (DK)	4
IPZ 5	Engelhard, B. Kammhuber, K.	10.09.09	Hüll Hop Research Centre	Institute for Fisheries (LfL)	4
IPZ 5	Engelhard, B.	15.09.09	Hop cultivation and research	Stähler	25
IPZ 5	Engelhard, B. Kammhuber, K. Seigner, E.	17.09.09	Hop research in Hüll/Wolnzach	Dr. Gabler, Bavarian State Ministry for Food, Agric. and Forestry (StMELF)	1
IPZ 5	Engelhard, B. Kammhuber, K. Lutz, A. Seigner, E.	18.09.09	Hop research at Hüll	SAB-Miller-Coors managers, HVG	35
IPZ 5	Seigner, E.	20.09.09	Hop research at Hüll	AB-Inbev, Dr. Buholzer	45
IPZ 5	Engelhard, B. Kammhuber, K. Lutz, A.	21.09.09	Hop research for the brewing industry	Head of the Research Dept. at Schincariol brewery (BRA)	1
IPZ 5	Seigner, E.	27.09.09	Hop research at Hüll	AB-Inbev, Dr. Buholzer	48
IPZ 5	Doleschel, P. Engelhard, B. Kammhuber, K. Seigner, E.	30.09.09	Hüll Hop Research Centre	Bayern Innovativ, participants of the “Functional plant components”	65
IPZ 5	Engelhard, B.	01.10.09	Hüll Hop Research Centre	Head of the Hops Dept. Baden-Württemberg Ministry of Nutrition and Rural Areas	1
IPZ 5	Engelhard, B., Lutz, A.	05.10.09	Hop research at Hüll	AB-Inbev, Russian delegation	21
IPZ 5	Engelhard, B.	07.10.09	Hüll Hop Research Centre	Deputy District Administrator Rothmeier (Pfaffenhofen district)	1
IPZ 5	Engelhard, B. Kammhuber, K. Lutz, A. Seigner, E.,	03.12.09	Hop research at Hüll	DIAGEO managers, Guiness brewery, Ireland; HVG, Hop Growers’ Association	20
IPZ 5a	Schätzl, J.	20.05.09	Latest update on plant protection and fertilisation	Hop growers from Au and Abens	16
IPZ 5a	Portner, J.	26.05.09	House of Hops	students from the Kloppenburg School of Agriculture	23
IPZ 5a	Niedermeier, E.	01.07.09	*Verticillium* wilt: field-crop inspection, causes, countermeasures	High-quality hop syndicate, Niederlauternach	32
IPZ 5a	Niedermeier, E.	06.07.09	Farmland walkthrough: current crop production and plant-protection measures	HPR in Eichelberg	37

WG	Name	Date	Topic/Title	Gast institution	No of partic.
IPZ 5a	Münsterer, J.	10.07.09	Current situation regarding diseases and pests; recommendations	HPR	35
IPZ 5a	Fuß, S.	13.07.09	Current situation regarding diseases and pests; recommendations	Hop growers, Herrenau and vicinity	24
IPZ 5a	Fuß, S.	13.07.09	Current situation regarding diseases and pests; recommendations	Hop growers, Straßberg and vicinity	15
IPZ 5a	Schätzl, J.	13.07.09	Current situation regarding diseases and pests; recommendations	Hop growers, Margaretenthann and vicinity	14
IPZ 5a	Schätzl, J.	14.07.09	Current plant-protection situation and crop inspections	Hersbruck hop growers in Iggensbach	15
IPZ 5a	Schätzl, J.	16.07.09	Current plant-protection situation and crop inspections	Hop growers, buyers and traders, Osseltshausen	68
IPZ 5a	Niedermeier, E.	17.07.09	Farmland walkthrough: current crop production and plant-protection measures	HPR in Kirchdorf	4
IPZ 5a	Schätzl, J.	17.07.09	Current situation regarding diseases and pests	Hop growers and traders in Spalt	40
IPZ 5a	Münsterer, J.	22.07.09	An insight into hop research	District Administrator's office, Freising	9
IPZ 5a	Schätzl, J.	22.07.09	Latest update on plant protection in hop yards hit by hail	LfL, HPR and hop growers in the community of Au, in Hirnkirchen	14
IPZ 5a	Niedermeier, E.	29.07.09	Farmland walk-through: current crop production and plant-protection measures	Representatives of the Geisenfeld Bavarian Farmers' Association; venue: Ilmendorf	41
IPZ 5a	Niedermeier, E.	04.08.09	Current situation regarding diseases and pests; recommendations	Hop growers from Wolnzach	18
IPZ 5a	Niedermeier, E.	05.08.09	Current situation regarding diseases and pests; recommendations	Hop growers from Eschelbach	11
IPZ 5a	Fuß, S.	13.08.09	Tour of trial plantings	Young Hop Growers' Association	80
IPZ 5a	Portner, J.	20.08.09	Hop tour	Hop syndicate guests	55
IPZ 5a	Münsterer, J.	03.09.09	Hop irrigation trials	Water Authority Munich/Freising	35

WG	Name	Date	Topic/Title	Gast institution	No of partic.
IPZ 5b	Schwarz, J.	30.07.09	Current experimental findings in organic hop production	Bioland hop workshop, summer excursion	20
IPZ 5b	Weihrauch, F.	30.07.09	Spider mite control in hops	Stähler and Nichino (JP)	4
IPZ 5b	Weihrauch, F.	05.08.09	Organic hop production	Žatec Hop Research Institute (CZ)	3
IPZ 5c	Lutz, A.	16.03.09	Hüll Hop Research Centre – focus on breeding	Mr. Seidl from HVG, Mr. Taichi Maruhashi from Suntory	2
IPZ 5c	Lutz, A.	28.04.09	Growth of hops on low trellis systems	Prague Univ., Prof, Rybka, hop growers and dealers in agricultural machinery, Czech. Republic	8
IPZ 5c	Lutz, A.	20.05.09	Growth of hops on low trellis systems	Zatec Hop Research Institute, Czech. Republic	6
IPZ 5c	Seigner, E.	03.06.09	Hüll Hop Research Centre	Delegation from the Ukraine	7
IPZ 5c	Seigner, E.	04.06.09	Hop research at Hüll	Ms. Pockrandt, translator of the Annual Report	2
IPZ 5c	Seefelder, S.	19.06.09	Hop genome analysis	Local CSU association, Rottenburg a.d. Laaber	15
IPZ 5c	Lutz, A.	31.07.09	Hüll Hop Research Centre – focus on breeding	Agricultural students, Pfaffenhofen	8
IPZ 5c	Lutz, A.	06.08.09	Hüll Hop Research Centre – hop varieties, low trellis systems	Nuffield, Australien; Barth	2
IPZ 5c	Lutz, A.	17.08.09	Hop quality, cultivars, harvesting times	HPR	35
IPZ 5c	Lutz, A.	19.08.09	Hop quality, hop breeding, low-trellis hops	Growers – GfH members	18
IPZ 5c	Lutz, A.	25.08.09	Hop cultivars and breeding lines	Joh. Barth & Sohn	4
IPZ 5c	Seigner, E.	25.08.09	Hüll Hop Research Center – hop cultivars and quality	Kirin Brewery, Mitsubishi, Japan; Dr. Pichlmaier, HVG	7
IPZ 5c	Seigner, E.	26.08.09	Hüll Hop Research Centre – hop quality	AB-InBev, Ms. Vanthuyne, Dr. Buholzer	2
IPZ 5c	Lutz, A.	27.08.09	Hop varieties and breeding lines	Bauer (Tea), Mr. Krafka	1
IPZ 5c	Seigner, E.	27.08.09	Hüll Hop Research Centre	Eventconcepts and AB-InBev, Dr. Buholzer	3
IPZ 5c	Seigner, E.	15.09.09	Hop research at Hüll – brewing quality	Master brewers from AB-InBev, Dr. Buholzer	12
IPZ 5c	Lutz, A.	17.09.09	Hop assessment, harvesting time and hop quality	Agricultural committee of the German Association of Brewers	25

WG	Name	Date	Topic/Title	Gast institution	No of partic.
IPZ 5d	Kammhuber, K.	22.07.09	Hop analytics	Employees from District Administrators' offices (food inspectors)	8

8.3.4 Exhibitions and posters

(WG = work group)

Name of Exhibition	Exhibition objects/projects and poster topics	Organiser	Duration of exhibit	WG
Open Day – 50 years House of Hops	– Downy mildew warning service (objects and posters) – Diseases, pests and beneficial organisms in hops (objects and posters) – Sensor-controlled individual plant treatment (equipment and poster) – Drying and conditioning (poster) – Irrigation (model and poster) – Low-trellis system (model) – Automated wire-stringing equipment (model, presentation and poster) – Modified spray equip. (prototype)	LfL, HVG, HPR, Hallertau hop growers' assoc.	21.06.2009	IPZ 5a
Agritechnica	Automated wire-stringing equipment in hop production (poster)		10.11.-14.11.09	IPZ 5a + ILT
Hop tour	Development of an innovative forecasting model for the control of powdery mildew in hops	VdH, Freising district	02.09.09	IPZ 5b
Functional plant components	– The diversity of components in the Hüll cultivars, breeding lines and wild hops – Breeding permits adaptation of the hop components to different requirements	Bayern Innovativ	01.10.09	IPZ 5c
10th Intern. *Verticillium* Symposium	Wilting disease in the Hallertauer hop region - Molecular characterisation of various *Verticillium* strains	Agricultural Univer-sity of Athens, Greece	16-20.11.09 Corfu, Greece	IPZ 5c
Congress of the Scientific Commission of the Int. Hop Growers Conven-tion (IHGC)	– Herkules - the new Hüll high alpha cultivar – The right time to harvest optimal yield and quality	Scientific Commission, León, Spain	21.06.-25.06.09	IPZ 5c and IPZ5d
Functional plant components	– Hop components – The hop plant is not only indispensable for beer brewing but is also a medicinal plant	Bayern Innovativ	01.10.09	IPZ 5d
Open Day in Freising	– Hop components – The hop plant is not only indispensable for beer brewing but is also a medicinal plant – Marker-assisted differentiation of *Verticillium* pathotypes – Development of molecular markers for powdery-mildew resistance – Genetic relatives of the Hüll hop collection – Advantages of genome analysis in hop breeding	LfL	28.06.09	IPZ 5d IPZ 5c

8.4 Basic and advanced training

(Organised /carried out)

Name, work group	Topic	Participants
Portner, J., IPZ 5a	Downy mildew	7 1st semester students of the Pfaffenhofen School of Agriculture
Portner, J., IPZ 5a	Botrytis and powdery mildew	7 1st semester students of the Pfaffenhofen School of Agriculture
Portner, J., IPZ 5a	Hop wilt	7 1st semester students of the Pfaffenhofen School of Agriculture
Portner, J., IPZ 5a	Other diseases, viruses and viroids	7 1st semester students of the Pfaffenhofen School of Agriculture
Portner, J., IPZ 5a	Less serious pests, alfafa weevil, hop aphid	7 1st semester students of the Pfaffenhofen School of Agriculture
Portner, J., IPZ 5a	Common spider mite	7 1st semester students of the Pfaffenhofen School of Agriculture
Portner, J., IPZ 5a	Irrigation	9 1st- and 3rd-semester students of the Pfaffenhofen School of Agriculture
Portner, J., IPZ 5a	Hop drying	13 3rd semester students of the Pfaffenhofen School of Agriculture
Portner, J., IPZ 5a	Conditioning, low-trellis systems	13 3rd semester sudents of the Pfaffenhofen School of Agriculture
Portner, J., IPZ 5a	Supervision and evaluation of hop-growing work projects for the Masters examination	1 Master-diploma candidate
Portner, J., IPZ 5a	Cultivation, fertilisation, plant protection and marketing of hops (4 evenings)	14 participants in the “BiLa” educational programme
Schätzl, J., IPZ 5a	Diseases and pests, current plant protection methods, warning service	7 2nd semester students of the Pfaffenhofen School of Agriculture
Schätzl, J., IPZ 5a	Final professional-farming examination (hop production) in Thalhausen	Exam. candidates (majoring in hop growing) from the Freising dsitrict
Schätzl, J., Fuß, S., Münsterer, J., alle IPZ 5a	Final professional-farming examination (hop production) in Attenhofen	Exam. candidates from the Kehlheim and Freising districts
Oberhollenzer, K. ,IPZ 5c	Hop biotechnology	F. Daniel, biology student at Munich Technical University (Weihenstephan)
Oberhollenzer, K., IPZ 5c	Hop biotechnolgy	J. Rossbauer, bio-engineering student at the Munich University of Applied Sciences

Name, work group	Topic	Participants
Seefelder, S., IPZ 5c	Genome analysis in hops, medicinal and spice plants and in fodder grasses	J. Tank, agricultural-technician trainee in Landsberg
Seefelder, S., IPZ 5c	*Verticillium* in hops	A. de Roy, biotechnology student
Seefelder, S., IPZ 5c	Hop genome analysis	Beverly A. Joseph, information pooliong
Seefelder, S., IPZ 5c	Hop genome analysis	Carolyn Püschel, biology-lab technician trainee

8.5 Final-year university projects

Projects completed in 2009

AG	Name	Topic/title of final-year university project	Zeitraum	LfL supervisors / Cooperation
IPZ 5c	Bergmaier, Michael	The yield structure of different hop cultivars	Aug. 2007 - Oct. 2009	A. Lutz, B. Engelhard / Weihenstephan Univ. of Applied Sciences: Prof. Dr. Ebertseder

8.6 Participation in work groups, memberships

Name	Memberships
Fuß, S.	• Member of the professional-farmer examination committee at the Landshut advanced agricultural training centre
Kammhuber, K.	• Member of the Analysis Committee of the European Brewery Convention (Hops Sub-Committee) • Member of the *AHA*
Münsterer, J.	• Member of the professional-farmer examination committee at the Landshut advanced agricultural training centre • Member of the assessment committee for hop-production investments within the investment subsidy scheme for individual farms (EIF) at the Landshut office for food, agriculture and forestry (AELF)
Portner, J.	• Member of the Expert Committee on the Approval Procedure for Plant Protection Equipment, responsible for advising the JKI's Application Techniques Division on the assessment of inspected plant protection equipment • Member (deputy) of the master-farmer examination committee in eastern Upper Bavaria
Schätzl, J.	• Member of the professional-farmer examination committee at the Landshut advanced agricultural training centre • Member of the professional-farmer examination committee at the Erding/Freising advanced agricultural training centre
Seefelder, S.	• Member of the LfL's PR coordination group
Seigner, E.	• Chairman (since June 2009) and secretary of the Scientific Commission of the International Hop Growers' Convention • Member of the Editorial Board of "Hop Bulletin", Institute of Hop Research and Brewing, Žalec, Slovenia
Weihrauch, F.	• Secretary on the executive board of the Society of German-Speaking Odonatologists • Editor of the magazine "Libellula" • Neuroptera work group of the German Society of General and Applied Entomology (DgaaE) – responsible for the bibliography • Expert on macrozoobenthos at the Bavarian Academy for Nature Conservation and Landscape Management (ANL) • Member of the Bavarian Environmental Protection Agency's working groups on red-listed grasshoppers and dragonflies in Bavaria

8.7 Awards and commendations

8.7.1 Anniversaries

Anton Lutz, IPZ 5c, 25 years' service, October 1st, 2009

Elisabeth Seigner, IPZ 5c, 25 years' service, November 1st, 2009

9 Current research projects financed by third parties

WG Project leader	Project	Dura-tion	Sponsor	Cooperation
IPZ 5a J. Portner	Automatic hop-yield recording and mapping	2008-2011	Erzeugergemeinschaft Hopfen HVG	Rottmeier, Erding; geo-konzept, Adelschlag A. Widmann, Hüll
IPZ 5a J. Portner	Response of important aroma and bitter varieties to reduced trellis height (6 m) and testing of new plant-protective application techniques	2008-2010	Erzeugergemeinschaft Hopfen HVG	5 hop growers; Mitterer, Terlan (I)
IPZ 5a J. Portner	Development of fully automated wire-stringing equipment for hop-growing	2008-2010	BLE (Federal Agency for Agriculture and Food)	ILT, Freising; Soller GmbH, Geisenfeld
IPZ 5a J. Portner	Experimental work on the statics of hop trellis systems	2009-2010	Erzeugergemeinschaft Hopfen HVG	Bauplanungs- u. Ingenieurbüro S. Breitner, Wolnzach
IPZ 5b B. Engelhard	Development of an innovative forecasting model for the control of hop powdery mildew (*Podosphaera macularis*)	2007-2009	BLE (Federal Agency for Agriculture and Food); Erzeugergemeinschaft Hopfen HVG	Christian-Albrecht-Universität, Kiel; Hopfenring Hallertau; GfH (Society of Hop Research); 8 hop farms
IPZ 5b B. Engelhard	Development of integrated methods of plant protection against the Lucerne weevil (*Otiorhynchus ligustici*) in hops	2008-2010	BLE (Federal Agency for Agriculture and Food)	Curculio-Institut e.V., Hanover; hop farms; joint project coordinated by JKI;
IPZ 5b/IPZ 5c B. Engelhard	Long-term optimization of aphid (*Phorodon humuli*) control in hops (*Humulus lupulus*) by means of control thresholds and breeding of aphid-tolerant hop cultivars	2008-2011	DBU (Deutsche Bundesstiftung Umwelt)	Hop farms
IPZ 5b/IPZ 5c B. Engelhard	Testing the suitability of a streptomycetes strain for controlling *Verticillium* hop wilt	2009	Erzeugergemeinschaft Hopfen HVG	JKI - Darmstadt
IPZ 5b/IPZ 5c/ IPZ 5d B. Engelhard	Identification of compounds involved in the attraction and resistance of hop to the damson-hop aphid – preliminary investigations in 2009	2010-2011	Erzeugergemeinschaft Hopfen HVG	Plant Research International B .V., Wageningen, NL
IPZ 5c E. Seigner A. Lutz	Breeding of resistant hops particularly suited for growth on low-trellis systems	2007-2010	BLE (Federal Agency for Agriculture and Food), GfH	Hop growers J. Schrag and M. Mauermeier; GfH
IPZ 5c E. Seigner A. Lutz S. Seefelder	Powdery mildew isolates and their use in breeding PM-resistant hops	2006-2010	Wissenschaftliche Station für Brauerei in München e.V.	EpiLogic

WG Project leader	Project	Dura- tion	Sponsor	Cooperation
IPZ 5c S. Seefelder E. Seigner	Development of molecular markers linked to powdery mildew resistance genes in hops	2004-2009	Europ. Hop Research Council (EHRC)	EpiLogic
IPZ 5c S. Seefelder E. Seigner	Genotyping of *Verticillium* pathotypes in the Hallertau – basic findings concerning *Verticillium*-infection risk assessment	2008-2010	Erzeugergemeinschaft Hopfen HVG	Mr. Niedermeier IPZ 5a; Dr. Radisek, Slovenian Institute of Hop Research and Brewing
IPZ 5c E. Seigner	Gene transfer in economically relevant hop varieties to improve fungal resistance and use of transgenic hop cells as a resistance testing system in the lab.	2008-2011	Erzeugergemeinschaft Hopfen HVG	Prof. Hückelhoven, WZW; Dr. Müller, IPZ 1c; Dr. Reichmann, IPZ 3b; EpiLogic
IPZ 5c E. Seigner A. Lutz IPS 2c L. Seigner	Monitoring for Hop stunt viroid in Germany	2008-2009	Erzeugergemeinschaft Hopfen HVG	Dr. K. Eastwell, Washington State University Prosser, USA

10 Main research areas

WG	Project	Duration	Cooperation
5a	Specialist advice on hop production techniques and business management	Ongoing	
5a	Production-related and economic evaluation of hop card indices	Ongoing	
5a	Compilation and updating of advisory-service documentation	Ongoing	
5a	Evaluation of downy mildew forcasting models and preparation of information for the warning service	Ongoing	
5a	Optimisation of plant-protective application methods and equipment; 2009: Spray-coating measurements with various blower models Spray-coating measurements with an innovative sprayer	Ongoing	
5a	Trials to investigate irrigation control in hop growing	2005-2011	Mosler; German weather service (DWD); IAB
5a	Optimizing drying performance and ways to save energy in hop drying	2006-2009	
5a	Spacing and bine-training trial with the Herkules cultivar	2006-2009	
5a	Fungicide treatment with and without strobilurins	2007-2009	
5a	Automation of drying and conditioning	2007-2010	ATEF
5a	Nitrogen enrichment trial to compare broadcast and banded fertiliser	2007-2011	
5a	Development of fully automated wire-stringing equipment for hop-growing	2008-2010	Institute for Agricultural Engineering and Animal Husbandry; Soller
5a	Continuous hop-yield recording and mapping	2008-2009	Rottmeier
5a	Response of various hop cultivars to reduced trellis height (6 m) and testing of new plant-protective application techniques	2008-2010	Mitterer
5a	Leaf fertilisation with Pentakeep	2008-2010	
5a	Testing of the Adcon weather model for the downy mildew warning service	2008-2013	Hop Producers’ Ring
5a	Testing of alternative training materials	2009	textilose
5a	Experimental work on the statics of hop trellis systems	2009-2010	Planungs- und Ingenieurbüro Breitner
5a	Positioning of drip hose in hop irrigation	2009-2011	

WG	Project	Duration	Cooperation
5a	Hallertau model for resource-saving hop cultivation	2010-2014	Bavarian State Institute of Forestry (LWF); Bavarian Environment Agency (LfU); Ecozept
5b	Testing of plant-protectives for their efficacy against various harmful organisms and their compatibility in hops as a prerequisite for registration and authorisation of these products for hop growing – offical pesticide testing according to EPPO and GEP guidelines; 2008: 126 trial variants with 48 products at 29 locations	Ongoing	Plant protection companies; hop growers
5b	Phytosanitary measures for the re-establishment of hop yards on areas previously used for hops – 2 trial variants	2009 - 2010	2 hop growers
5b	Soil-pest control	2005 -	Hop growers
5b	Switching to the program PIAF for reporting on field trials involving official pesticide testing	2008 - 2009	proplant Münster
5b	EU-wide harmonisation of trial procedures for plant-protective products in hops	2005 -	Institutes in FR, CR, SI, UK, PL
5b	Trials aimed at reducing the amount of copper used in the control of downy mildew	2006 -	Spiess-Urania
5b	Testing of additives to improve the efficacy of insecticides	2009 - 2010	1 hop grower
5b	Plant protection according to the warning service and control thresholds in two varieties being grown in a commercial hop yard ; a cost and labour comparison with conventional methods	2009 - 2013	1 hop grower
5c	Breeding of high-quality, disease-resistant aroma and bitter varieties	Ongoing	EpiLogic, Dr. F. Felsenstein, Freising
5c	Testing of wild hops as a new genetic resource for breeding powdery-mildew-resistant cultivars	Since 1999	EpiLogic, Dr. F. Felsenstein, Freising
5c	Breeding of high-quality aroma and bitter varieties containing optimised hop components	Ongoing	IPZ 5d
5c	Performance potential of the new high-alpha Herkules cultivar	2000-2009	IPZ 5d
5c	Promoting quality through use of molecular techniques to differentiate between hop varieties	Ongoing	IPZ 5d; propagation establishments; hop trading businesses
5c	Virus studies in the major hop varieties and breeding lines	Ongoing	IPZ 5b
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	*AHA* storage trial (SR, OL, SD compared with HM and SE)	2009	*AHA*
5d	Development of analysis methods for hop polyphenols (total polyphenols, flavonoids and individual substances such as quercetin and kaempferol based on HPLC)	2007-offen	*AHA*
5d	Production of pure alpha acids and their ortho-phenylenediamine complexes for calibrating and monitoring the stability of calibration extracts ICE 2 and ICE 3	Ongoing	*AHA*
5d	Ring tests for the checking and standardising of important analytical parameters within the *AHA* laboratories (e.g. linalool, nitrate, HSI)	Ongoing	*AHA*

WG	Project	Duration	Cooperation
5d	Development of an NIRS calibration model for alpha-acid content based on HPLC data	2000-open-ended	
5d	Organisation and evaluation of ring analyses for alpha-acid determination and for the hop supply contracts	2000-open-ended	*AHA*
5d	Variety checks for the food control authorities	Ongoing	District administrators' offices (food control)
5d	Introduction and establishment of UHPLC in hop analytics	2008-open-ended	

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 2009 (WG = Work Group)

IPZ 5

Coordinator: Ltd. LD Engelhard Bernhard

Dandl Maximilian
Felsl Maria
Hertwig Alexandra
Hock Elfriede
Krenauer Birgit
Maier Margret
Mauermeier Michael
Pflügl Ursula
Presl Irmgard
Suchostawski Christa
Waldinger Josef
Weiher Johann

IPZ 5a

WG Hop Cultivation/Production Techniques

LD Portner Johann

Fischer Elke
Fuß Stefan, LOI
Münsterer Jakob, LA
Niedermeier Erich, LA
Schätzl Johann, LAR

IPZ 5b

WG Plant Protection in Hop Growing

Ltd. LD Engelhard Bernhard

Eicheldinger Renate, LOI (parental leave)
Ehrenstraßer Olga, LTA
Lachermeier Ute, B.Sc.
Meyr Georg, LHS
Schlagenhaufer Stefan, Dipl.-Biol. (Univ.)
Schwarz Johannes, Dipl.-Ing. (FH)
Dr. rer. nat. Weihrauch Florian

IPZ 5c

WG Hop Breeding Research

RD Dr. Seigner Elisabeth

Bogenrieder Anton, Agr.-Techn.
Forster Brigitte, CTA
Hager Petra, CTA (parental leave)
Haugg Brigitte, LTA
Kneidl Jutta, LTA
Lutz Anton, LAR
Mayer Veronika, CL
Dipl.-Biol. (Univ.) Oberhollenzer Kathrin
Petosic Sabrina, CL
Püschel Caroly, BL (as of 03.07.2009)
ORR Dr. Seefelder Stefan
Ziegltrum Ursula

IPZ 5d

WG Hop Quality/Hop Analytics

ORR Dr. Kammhuber Klaus

Neuhof-Buckl Evi, CL
Sperr Birgit, CL (as of 01.02.2009)
Petzina Cornelia, Dipl.-Ing. agr. (Univ.)
Weihrauch Silvia, CTA (parental leave)
Wyschkon Birgit, CTA