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Gesellschaft für Hopfenforschung e.V.

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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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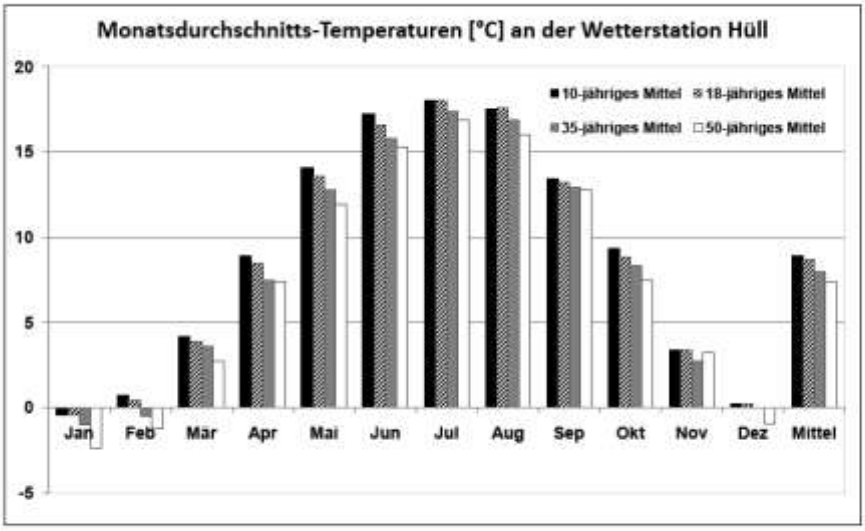
Research Promotes Competitiveness

Executives in the hops industry see hops research as a resource, comparable with financial assets or available plant protectives for pest control. The scientists and staff of the Hops Dept. at the Bavarian State Research Centre for Agriculture (LfL) naturally find such appreciation on the part of our clients, for whom our research efforts are basically intended, very gratifying. However, it also entails a commitment! A commitment to assess both current situations and future trends correctly and to respond to them rapidly in our research (e.g. by including major new components in the planning of new hybrids).



Nearly every week, reports on climate change and its impact on agriculture are published in the technical press. Climate change is an example of an issue demanding a response and of the nature such a response may take. That a climate change is taking place is no longer disputed. Proof has been available for at least 20 years in the recordings of the Hop Research Centre in Hüll. The rise in annual mean temperature from 7.4 °C (1927 – 1976) to 8.7 °C (1991 – 2008) is indicative of a serious change. There are few sites in Bavaria at which continuous weather recordings have been documented for as long as in Hüll. Thanks to a dedicated staff.

The emerging change has so far had the following impact on the scope of our research objectives:

- Inclusion of a new breeding goal: varieties that withstand weather extremes and show little fluctuation in alpha-acid content and yield
- Adjustment of pest control-action thresholds to a longer growing season, more hot days and record temperature highs
- Investigations into water-saving irrigation systems and implementation of cultivation methods requiring less water
- The influence of lower, and hence much more stable, trellis systems on yield (e.g. 6 m instead of 7 m high)
- Intensification of our research on low trellis systems (up to 3 m in height)

We take this opportunity to assure the hop and brewing industries that we will remain in tune with the latest developments and provide products that satisfy current demands.

Dr. Schmitt
Vice-Chairman of the Managing Committee
of the Society of Hop Research

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

Contents

Page

1 Research projects and main research areas of the Hops Dept.

1.1 Current research projects

Powdery mildew isolates and leaf resistance test in the laboratory as a basis for breeding powdery mildew resistant hops

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, *(Bavarian State Research Centre for Agriculture)* Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtung *(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:	RDin Dr. E. Seigner, LAR A. Lutz, ORR 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 - 30.04.2010

Objective

Disease-resistant hop cultivars are of critical importance to growers and brewers alike. By implementing innovative selection and assay methods in the greenhouse and the lab when testing for PM resistance in breeding lines, wild hops and cultivars, we are able to substantially improve resistance breeding.

Results

Currently, 11 different single-spore isolates of *Podosphaera macularis* (formerly called *Sphaerotheca humuli*), the fungus that causes powdery mildew in hops, are available as inoculation material for breeding PM-resistant cultivars. These 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 June 2008:

- To assess the resistance properties of some 144,000 seedlings from 99 crosses, 68 wild hops, 385 breeding lines and one foreign variety in the greenhouse and the laboratory leaf test;
- To obtain reliable resistance data on 360 seedlings from 4 mapping populations in order to develop molecular markers for various PM resistance genes;
- In 8 gene expression analyses following inoculation with special PM isolates; it is assumed that contact with the fungus induces certain genes that are directly involved in PM resistance. The aim is to identify molecular markers for these genes.

These cDNA-AFLP markers, as they are known, are considerably more reliable and informative for resistance selection purposes than the conventional AFLP-based molecular markers used in the past.

- To assess the virulence of PM populations in the Hallertau region of Bavaria and around the globe, and thus evaluate the efficacy of known resistances. It has been established, for instance, that resistance in the Hüll cultivar "Hallertauer Merkur" is still fully effective, whereas in the cultivar "Herkules" it has already been broken down in certain regions.
- To characterize PM/hop interaction on and under the leaf surface, using various virulent and avirulent PM isolates. The aim is to obtain closer insight into the various resistance responses found in Hüll varieties and breeding stock. Such knowledge is essential if various resistance mechanisms with mutually complementary effects are to be combined successfully in future varieties.

Breeding of dwarf hops for low trellis systems

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, *(Bavarian State Research Centre for Agriculture)*
	Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtung und AG Hopfenqualität/Hopfenanlytik *(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 Institute for Food and Agriculture)*
	Erzeugergemeinschaft Hopfen HVG e.G. *(Hop Producer Association HVG)*
Project managers:	RDin Dr. E. Seigner, LAR A. Lutz
Project staff:	LAR A. Lutz, LTA J. Kneidl; A. Bogenrieder,
	ORR Dr. K. Kammhuber, C. Petzina, B. Wyschkon, S. Weihrauch, E. Neuhof-Buckl (all from IPZ 5d)
Cooperation:	Gesellschaft für Hopfenforschung; *(Society for 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 producing 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 drift thus reduced.

Results

In 2007, altogether 17 crosses (6 aromatic and 11 bitter types) were conducted with the aim of breeding hops "suitable for growing on low trellis systems". Preliminary selection of seedlings from these crosses for PM resistance began in March. Of the 9,000 seedlings that emerged, about 25 % proved to be PM-resistant. The most promising 678 seedlings were planted out in the vegetation hall at the end of April. In the autumn, following further selection, 482 female seedlings were planted out in the Hüll breeding yard and 46 male seedlings in the Freising breeding yard. In May, an AFLP marker was used to determine the sex of the remaining seedlings with good growth characteristics. It was thus possible to select a further 203 female seedlings and plant them out as early as the beginning of June.

From among 33 seedlings from nine crosses with the potential to produce dwarf progeny, five 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 five were found to be promising candidates for growing on 3-metre trellises. Once confirmed virus-free, they will be propagated in spring so that small-plot, low-trellis trials can commence in 2009.

In July, a further 19 crosses (7 aroma- and 12 bitter-type) were carried out as part of the research project. Seeds were obtained from all the crosses in autumn.

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

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, *(Bavarian Sate Research Centre for Agriculture),* Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtung *(Institute for Crop Science and Plant Breeding, WG Hop Breeding Research)*
Financed by:	Erzeugergemeinschaft Hopfen HVG e.G. *(Hop Producer Association HVG)*
Project manager:	RDin Dr. E. Seigner
Project staff:	K. Oberhollenzer, S. Nadler (until 15.09.2008), B. Forster (as from 17.11.2008) LAR A. Lutz
Cooperation:	Prof. Dr. R. Hückelhoven, Munich Technical University, Centre of Life and Food Sciences Weihenstephan, Chair of Phytopathology Dr. F. Felsenstein, EpiLogic GmbH Agrarbiologische Forschung und Beratung, Freising Dr. M. Müller, IPZ 1c
Duration:	01.04.2008 - 31.03.2011

Objective

The aim of this new research project is to microscopically investigate the interaction between hop and hop powdery mildew (PM) in susceptible and resistant varieties. The results allow studying the spatio-temporal development of the fungus on the hop leaf surface. A further aim is the functional characterization of PM-defence-related genes by way of transient gene transfer at cell level (transient assay).

Methods

- Inoculation of hop leaves with PM isolates, currently provided by EpiLogic
- Various staining techniques for the PM fungus and detection of hop-cell defence responses
- Microscopic investigation with fluorescence and confocal laser microscopes (Prof. Hückelhoven, Munich Technical University)
- Transient transformation of individual epidermal cells of hop leaves using a particle gun

Results

Various staining techniques have been established to permit microscopic investigation of hop – hop PM interaction. Detection methods for hop cell defence responses have also been established.

In addition, the transient assay principle has been shown to be a suitable method of characterising gene function during hop – hop PM interaction. Various parameters still need to be modified here in order to permit statistically reliable evaluation.

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

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, *(Bavarian State Research Centre for Agriculture),* Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtung *(Institute for Crop Science and Plant Breeding, WG Hop Breeding Research)*
Financed by:	EHRC (European Hop Research Council - Carlsberg Breweries, Heineken, InBev, Hopfenveredelung St. Johann, Hallertauer Hopfenveredelungsgesellschaft/Hopsteiner)
Project managers:	ORR Dr. S. Seefelder; RDin Dr. E. Seigner
Project staff:	R. Seidenberger (until 30.04.2008), V. Mayer, S. Petosic, LTA J. Kneidl ORR Dr. S. Seefelder, LAR A. Lutz, RDin Dr. E. Seigner
Cooperation:	Dr. F. Felsenstein, EpiLogic GmbH Agrarbiologische Forschung und Beratung, Freising
Duration:	01.12.2004 - 30.04.2009

Objective

To develop molecular selection markers for the resistance genes of two wild hops with good powdery mildew resistance.

Results

- AFLP-based investigations have led to identification of two AFLP markers closely linked with the resistance gene of wild hop WH18.
  The markers are 2.2 cM from the resistance locus. In addition, the PM resistance of a Japanese hop has been characterized by an AFLP marker with a map location that coincides directly with the resistance locus.

- Within the context of cDNA-AFLP expression analysis, identification of molecular markers for active resistance genes in wild hop WH18 was commenced. The analyses were continued in 2008, building on the differential expression work conducted on genes which, in the case of PM-resistant hops but not of susceptible hops, are activated by contact with powdery mildew.
  This initially involved screening for cDNA-AFLP fragments which, in resistant hop plants only, occur 4 – 24 hours after contact with the PM fungus and are possibly involved directly in the defence response or in pathogen identification.
- So far, 365 primer combinations have been used, with which thousands of gene sequences (known as TDFs = Transcript-Derived Fragments) that are activated after PM contact have been found.
- 130 fragments, which may constitute part of the resistance reaction by virtue of their expression kinetics, have been cloned and examined for homologies with known resistance genes in other crop plants (BLAST search).
- The exact sequences of 111 promising TDFs (= DNA fragments) with very similar sequences to other resistance genes have been determined.
- Endeavours are currently underway to screen the entire DNA of the PM-resistant wild hop for these regions (sequences) activated by fungal contact and involved in the resistance response, and to simultaneously verify them.

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

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, *(Bavarian State Research Centre for Agriculture),* Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtung und AG Hopfenbau/Produktionstechnik (*Institute for Crop Science and Plant Breeding, WG Hop Breeding Research and WG Hop Cultivation/Production Techniques)*
Financed by:	Erzeugergemeinschaft Hopfen HVG e.G *(Hop Producer Association HVG)*
Project managers:	ORR Dr. S. Seefelder; RDin Dr. E. Seigner
Project staff:	S. Petosic, LA E. Niedermeier, ORR Dr. S. Seefelder,
Cooperation:	Dr. S. Radisek, Slovenian Institute of Hop Research and Brewing, Slovenia IPZ 5a (WG Hop Cultivation/Production Techniques)
Duration:	01.03.2008 - 28.02.2010

Objective

Hop wilt, caused by the *Verticillium* fungus, has been responsible for considerable yield reductions in some parts 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.

What needs to be clarified is whether agronomic factors, such as excessive mineral fertilisation or the spreading of fresh bine material directly after harvesting, are responsible for the current *Verticillium* problem, whether lethal *Verticillium* strains from England or Slovenia have already appeared in the Hallertau growing region, or whether new, highly virulent races have developed here. In order to clarify the issue, the plan is to take samples from infected hop bines, to cultivate the *Verticillium* fungus and to subject it to genetic differentiation.

An *in-planta* test will also be devised; when breeding material is exchanged or hop-bine cuttings (setts) propagated, this test will provide reliable information on the presence of *Verticillium* in the plants before the wilt symptoms appear. It will also obviate the need for tedious fungus cultivation.

Results

- Sampling of altogether 123 diseased and 28 phenotypically healthy bines from some 30 locations
- Molecular *in-planta* detection of *Verticillium albo-atrum* in wilt-diseased hop bines
- Cultivation of *Verticillium* in solid and liquid media
- Harvesting of fungal mycelia from the liquid media and subsequent DNA extraction in preparation for the PCR assays
- Microscopic and in some cases molecular determination of the species *Verticillium albo-atrum* in all the diseased and phenotypically healthy hop bines.

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

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, *(Bavarian State Research Centre for Agriculture),*
	Institut für Pflanzenbau und Pflanzenzüchtung, AG Pflanzenschutz *(Institute for Crop Science and Plant Breeding, WG Plant Protection)*
Financed by:	Bundesanstalt für Landwirtschaft und Ernährung (BLE) *(Federal Institute for Food and Agriculture)*
	Erzeugergemeinschaft Hopfen HVG e.G. *(Hop Producer Association HVG)*
Project manager:	LLD Bernhard Engelhard
Project staff:	Dipl.-Ing. S. Schlagenhaufer
Duration:	01.05.2007 - 31.12.2009

Objective

To obtain 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

- Cleistothecia and mycelia are known to be possible overwintering forms. Generally, cleistothecia are described as being initiators of the primary infection. In various experiments, however, it proved impossible to obtain a new infection with ascospores from viable cleistothecia. Possibly, only widespread occurrence of mildew, as in 1997, 1999, 2001 and 2002, can answer the question of whether ascospores are responsible for initial infection. Evidence of primary infection initiated by mycelia on hop plants that had not been pruned and on wild hops has been obtained in hop yards during the project.
- In small climatic chambers constructed specially for the purpose, 56 weather variants were investigated for their effects on incubation time and degree of infection. It was found that temperature, the difference in temperature between day and night, and the light intensity have the strongest influence.
- In 2008, the scientifically obtained basic data was used for the first time to produce a "weather-based disease forecast", and control thresholds were determined for susceptible and tolerant varieties. The thresholds were checked at eleven locations. Powdery mildew infection occurred at one location only, on the Hallertau Taurus variety.
  The two sprayings carried out in line with the disease forecast were fully effective in controlling the disease. The new "weather-based disease forecast" correlates very closely with the experimentally obtained "preliminary forecasting model".
- Outlook: the plan is to incorporate the existing findings in a practical guideline entitled "Powdery Mildew Forecasting" as early as 2009.

Long-term optimisation 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 Centre for Agriculture,* Institut für Pflanzenbau und Pflanzenzüchtung, AG Pflanzenschutz *(Institute for Crop Science and Plant Breeding, WG Plant Protection)*
Financed by:	Deutsche Bundesstiftung Umwelt (DBU)
Project manager:	LLD Bernhard Engelhard
Cooperation:	Hop growers
Project staff:	Dr. Florian Weihrauch
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 Hop Department plans to make better use in future of genetic aphid-resistance resources, and to incorporate them 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 (58 in 2008) 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 a single 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 infestation on the cones from the time of their formation until harvesting, a modified Berlese funnel was constructed. This was extremely convenient and efficient. With the help of a light source, aphids and other arthropods can be driven out of freshly harvested, still-green hop cones and thus the intensity of the infestation accurately determined. During the second part of the project, use was made of the "aphid cage", familiar from tests for aphid resistance to insecticides.

Initial results

The widespread aphid outbreaks in 2008 made for good experimental conditions (see 6.1). Despite pronounced aphid colonization early on, not even the untreated plots had reduced yields.

Only in the case of five out of 58 plots did compensation have to be paid for quality shortcomings (appearance).

The aphid-resistance tests on the various cultivars did not indicate any reliable trend.

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

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, *(Bavarian State Research Centre for Agriculture,* Institut für Pflanzenbau und Pflanzenzüchtung, AG Pflanzenschutz *(Institute for Crop Science and Plant Breeding, WG Plant Protection)*
Financed by:	Bundesanstalt für Landwirtschaft und Ernährung (BLE) *(Federal Institute for Food and Agriculture)*
Project manager:	LLD Bernhard Engelhard
Cooperation:	Part of the integrated project "Erarbeitung von integrierten Pflanzenschutzverfahren gegen Bodenschädlinge" *(Development of integrated methods of plant protection against soil pests)*
Project staff:	Ute Lachermeier, Dipl. Ing. (FH) Johannes Schwarz
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 *Otiorhynchus* species actually occurring as pests in German hop-growing areas.

Results

Soil traps were distributed in the following German hop-growing regions in order to catch *Otiorhynchus* species for identification purposes: Hallertau 4, Elbe-Saale 2, Spalt 1, Tettnang 1. Six catch periods from April to August were used in order to pinpoint when the pests occur.

Dr. Peter Sprick from the Curculio Institute in Hanover is identifying the species. This work has not yet been concluded.

To test the EPN, four trial plots were set up at each of three locations in the Hallertau. The species *Steinernema carpocapsae* and *Heterorhabditis bacteriophora* were used for the test.

Since the efficacy of the method for the hop plants can only be directly determined at the end of the experiment, clover sods (15 x 15 cm clods of earth planted with clover) were worked into the plots in April.

Red clover is described as being a very good bait plant for beetle larvae. Due to experimental problems, no usable results have been obtained to date.

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

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, *(Bavarian State Research Centre for Agriculture,* Institut für Pflanzenbau und Pflanzenzüchtung, AG Hopfenbau/Produktionstechnik *(Institute for Crop Science and Plant Breeding, WG Hop Cultivation/Production Techniques)*
Financed by:	Bundesanstalt für Landwirtschaft und Ernährung (BLE) *(Federal Institute for Food and Agriculture)*
Project manager:	LD J. Portner
Project staff:	Dr. G. Fröhlich, ILT
Cooperation:	Soller, Geisenfeld
Duration:	01.01.2008 - 31.01.2010

Objective

To automate the stringing of training wire, which is currently performed manually. To this end, a German 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 will be no need for workers (often seasonal workers) on the hop platform, or "crow's nest", the risk of accidents will be reduced and the job will be less dependent on weather conditions.

Results

Hydraulics and mechatronics specialists from the LfL's Institute for Agricultural Engineering and Animal Husbandry are already testing existing Soller assemblies for their functional efficiency and potential problems during automated operation. The plan is to construct an improved prototype in 2009 once problems have been ironed out, and to test it in practice.

Automatic hop-yield recording and mapping

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, *(Bavarian State Research Centre for Agriculture,* Institut für Pflanzenbau und Pflanzenzüchtung, AG Hopfenbau/Produktionstechnik *(Institute for Crop Science and Plant Breeding, WG Hop Cultivation/Production Techniques)*
Financed by:	Erzeugergemeinschaft Hopfen HVG e.G. *(Hop Producer Association HVG)*
Project manager:	LD J. Portner
Project staff:	LD J. Portner
Cooperation:	Rottmeier, Erding A. Widmann, Hüll
Duration:	01.01.2008 - 31.12.2009

Objective

To develop and test a continuous yield-measuring system on the cone conveyor belt. The recorded yield data could be processed (with software yet to be developed) and charted in the form of a coloured yield map based on a 10 x 10 m grid. Conceivable application fields would include advisory services relating to the detection of problems caused by viral attack, soil differences and micronutrient deficiency, and optimisation of fertilisation and plant-protection measures.

Measuring yields in test hop stands is an easy way of showing the influence of different production techniques. The yield maps will 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 dates and durations, crop volumes, etc.

Results

The Rottmeier engineering agency installed an RFID (radio frequency identification) transponder system and a bine counter on the intake arm of the plucking machine at a commercial hop farm. A belt weigher was installed between the cone delivery conveyor and the conveyor to the green-hop silo in order to continuously monitor the yield.

During the hop harvest, the weigher supplied continuous yield data that 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 to the plucking 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 weighed yield within the row was calculated by means of the bine counter.

Difficulties have arisen due to variations in the moisture content of the hop cones (dew – rain – dry weather), with excess moisture clinging to the cones, gumming up the weighting belt and falsifying weight measurements. If it is not possible to eliminate these errors, it will be necessary to switch to another method of yield measurement.

If the tests are successful and provide plausible data, the plan is then to develop software for processing the yield data and charting it in the form of yield maps.

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, *(Bavarian State Research Centre for Agriculture,* Institut für Pflanzenbau und Pflanzenzüchtung, AG Hopfenbau/Produktionstechnik *(Institute for Crop Science and Plant Breeding, WG Hop Cultivation/Production Techniques)*
Financed by:	Erzeugergemeinschaft Hopfen HVG e.G. *(Hop Producer Association HVG)*
Project manager:	LD J. Portner
Project staff:	LOI S. Fuß LA E. Niedermeier
Cooperation:	Mitterer, Terlan
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 established 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: Hallertauer, Mittelfrüher, Perle und Hallertauer Tradition, and on the following bitter varieties: Hallertauer Magnum, Hallertauer Taurus und 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

By the end of the first year of the trial, initial responses (growth and yield) to the lower trellis height by the various cultivars had been observed. The results must be confirmed over the next two years before any definitive statements can be made.

No results are available as yet for the innovative sprayer, as these tests are not scheduled to begin until 2009.

1.2 Main research areas

1.2.1 Main research area: hop breeding

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

Project managers: LAR A. Lutz, RDin Dr. E. Seigner
Project staff: LAR A. Lutz, LTA J. Kneidl, IPZ 5c team
Cooperation: ORR Dr. K. Kammhuber, IPZ 5d team

Objective

The main focus of the Hüll breeding activities is on developing high-quality, environmentally sound varieties adapted to the needs of the market. Selective crosses have been made during the last few years in order to optimise components. Within this context, changes in the brewing industry's requirements must be catered to and, in addition, possible alternative uses for hops explored.

On account of their bacteriostatic and antimicrobial effects, bitter acids and particularly beta acids are used as harmless, environmentally compatible preservatives, for example in the food and ethanol industries. In addition, the hop plant is of interest to the pharmaceutical/medical sector because of its health-promoting components, such as xanthohumol and bitter acids. Current crosses are aimed at considerably enriching these substances in future cultivars that might find use be used in the pharmaceutical industry.

Measures and results

During 2008, seven specific crosses were carried out with parents characterized by promising components. The plan is to select seedlings with considerably increased beta-acid and xanthohumol contents from the descendants.

Crossing parents	Alpha-acid content	Beta-acid content	Alpha-+ beta-acid content	Xanthohumol
2003/067/002	9.5 – 13.0	10.0 – 14.2	20 – 26	0.6 – 0.8
2003/067/005	12.0 – 16.5	9.0 – 12.2	21 – 25.5	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 – 23.6	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, UHPLC and GC

Performance potential of the new high-alpha Herkules cultivar

Project managers: RDin Dr. E. Seigner, LAR A. Lutz
Project staff: LAR A. Lutz, LTA J. Kneidl, Team von IPZ 5c
Cooperation: ORR Dr. K. Kammhuber, IPZ 5d team;
Erzeugergemeinschaft Hopfen HVG e.G.
(Hop Producer Association HVG)

Objective

Over the past 9 years, the new Herkules cultivar has been compared with Hallertauer Magnum und Hallertauer Taurus, the other two high-alpha Hüll cultivars, in so-called "Stammes- and Hauptprüfungen" (field trials with less or more advanced selections, with several replications) conducted at the two breeding yards in Hüll and Rohrbach and in "Anbauprüfungen" (trials with highly promising selections on experimental farms). It has thus been possible to reliably estimate the potential of the new cultivar in respect of yield, alpha-acid content and alpha-acid yield at various locations and under weather conditions that varied from year to year.

Methods

- Yield determination in the trial plots (in kg /ha)
- Alpha-acid determination by HPLC (High Performance Liquid Chromatography)
- Alpha-acid yield as the product of alpha-acid content (kg α acids/kg hops) and yield (kg/ha)

Results

Compared with Hallertauer Magnum and Hallertauer Taurus, the first two high-alpha Hüll cultivars, Herkules demonstrated a clear-to-very-clear breeding edge in all performance characteristics.

The following table summarizes the mean values – based on all production trials from 2000 to 2008 – 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.

	Mean values 2000 - 2008		
	Hall. Magnum	**Hall. Taurus**	**Herkules**
Yield (kg/ha)	2,475	2,147	**3,258**
α-acid content (%)	13.8	16.2	**16.3**
α-acid yield (kg α acids / ha)	341	348	**531**

The data confirm the fact that, with the new Herkules cultivar, a high-performance, robust, high-alpha variety characterized by very high yields and alpha-acid content has been made available to growers. It will guarantee a reliable supply of premium-quality hops – now and in the future.

Investigation of hop stunt viroid (HSVd) in hops

Project managers:	RDin Dr. L. Seigner, Institut für Pflanzenschutz, IPS 2c
	RDin Dr. E. Seigner, LAR A. Lutz (both from IPZ 5c)
Project staff:	M. Kappen, C. Huber, M. Kistler, D. Köhler (all from IPS 2c)
Cooperation:	Dr. K. Eastwell, Washington State University, USA

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 also 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 detection process using HSVd-specific primers (Eastwell und Nelson 2007) and an additional mRNA-based internal positive control has been established under the direction of Dr. L. Seigner in the LfL's pathogen diagnostic lab.

Results

In the spring of 2008, 55 hop samples of various origins, including the USA, were investigated by RT-PCR (reverse transcription-polymerase chain reaction) using primers from Eastwell und Nelson (2007). HSVd-RNA was not detected in any of the samples, which is why the hops were rated as HSVd-free.

However, the danger of HSVd infections in Germany can certainly not be ruled out completely on the basis of these limited results from the Hallertau, and HSVd monitoring will therefore be continued in 2009. Testing of some 250 hop samples is envisaged.

We hope that these investigations will make it possible to rule out HSVd infections in the breeding yards in Hüll, Rohrbach and Freising, in the Society for Hop Research's propagation facilities, and in field crops in the Hallertau, Elbe-Saale and Tettnang hop-growing regions.

References

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., M. Kappen, C. Huber, M. Kistler, D. Köhler (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.

1.2.2 Main research area: hop cultivation/production techniques

Trials to investigate irrigation control in hop growing

Project manager: LD J. Portner
Project staff: LA J. Münsterer

Three irrigation trials are being conducted to determine how much water is needed in order to obtain an optimum hop yield and when it is needed. Each of the trials, one in Hüll, one in Ilmendorf and one in Lurz, involve a number of experimental variants and stages. In these trials, conventional irrigation-control systems are compared with computer-aided water-supply models and methods of measuring soil moisture.

Leaf fertilisation with Nutri-Phite Magnum S

Project staff: LA E. Niedermeier
Duration: 2006 - 2008

Nutri-Phite Magnum S is a liquid NPK fertiliser for leaf application and is intended to increase the vitality and resistance of the hop plant. The harvest was measured in terms of yield and alpha-acid content. The results of the 3-year trial are described in detail under Section 5 of the Annual Report.

Fertilisation trial to investigate potassium fixation

Project manager: LD J. Portner
Project staff: LA E. Niedermeier
Duration: 2006 - 2009

The fertilisation trial to rectify potassium depletion due to fixation was begun on a suspect area in 2006. Plots are being fertilised with 300 kg K_2O/ha and 600 kg K_2O/ha and compared for several years with unfertilised plots. The influence of chlorinated potassium fertilisers and fertilisers low in chlorine, both with and without magnesium, is also being investigated. To date, the test results indicate that potassium fertilisation has a positive influence on yield. Information as to the preferred form of potassium fertiliser cannot be provided yet on account of fluctuations in the test results. For this reason, the trial will be continued for another year.

Determining the optimum harvest time for the Herkules cultivar

Project staff: LD J. Portner, LAR A. Lutz
Duration: 2006 - 2009

To determine the optimum harvest-time in the Hallertau for the high-alpha variety Herkules, 20 trained bines were harvested in each case from a field crop at intervals of 3-4 days. The procedure was repeated four times (over a period of four years). The bines were harvested on 5 harvesting dates and were evaluated for yield, alpha-acid content, aroma and external quality (picking quality, colour and sheen, cone development and defects). Initial results indicate that, in normal years, the Herkules cultivar is ready for harvesting as from mid-September. The stable external quality and relatively constant alpha-acid content point to a wide harvesting window.

Optimising drying performance and ways to save energy in hop drying

Project staff: LA J. Münsterer

Drying performance can be maximised and energy input minimised by optimising the air-speed in floor kilns. As spot air-speed measurements are not meaningful due to non-uniform drying, measuring techniques are being developed and tested with which the mean air speed across the drying surface can be calculated and controlled as required at any one time.

Spacing and bine-training trial with the Herkules cultivar

Project manager: LD J. Portner
Project staff: LA 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 the 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 as the number of bines per wire rises and so does the pressure of disease stemming from the dense foliage. From an economic point of view, however, maximum yield and alpha-acid content remain crucial.

To clarify these questions, 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. The trend emerging from the results to date is that closer planting produces a higher yield and that training 2 bines per wire is preferable to 3 bines per wire. A final assessment will be made after the next harvest.

Fungicide treatment with and without strobilurins

Project staff: LAR J. Schätzl
LOI S. Fuß
Duration: 2007 - 2009

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" is indeed visible. To substantiate the results, two peronospora treatments (one with a strobilurin preparation and one with a comparative 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.

Nitrogen enrichment trial to compare broadcast and banded fertiliser

Project manager: LD J. Portner
Project staff: LA E. Niedermeier
Duration: 2007 - 2011

Earlier trials in the Hallertau and in Thuringia prove that if fertiliser is banded rather than broadcast, the same yield can be achieved with up to a third less fertiliser. In addition to beneficial environmental effects, there are advantages for 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 by using banded fertiliser.

Leaf fertilisation with Pentakeep

Project manager: LD J. Portner
Project staff: LA E. Niedermeier
Duration: 2008 - 2010

In addition to various primary nutrients and micronutrients, Pentakeep leaf fertiliser contains 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 hop yards. It is applied by spraying (the control plot remains unsprayed) according to 2 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 peronospora early-warning service

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

To forecast the probability of a peronospora 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 favourable for the pest, a regional spray warning is issued, which varies according to variety.

In other hop-growing regions (Elbe-Saale, Czech Republic), the early-warning forecast is based purely on weather models and the infection potential ignored. The 5-year trial is intended to determine the extent to which the time-consuming and labour-intensive counting of zoosporangia at the peronospora 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 Main research areas: hop quality and analytics

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

Project manager:	ORR Dr. K. Kammhuber
Project staff:	CL E. Neuhof-Buckl, CTA S. Weihrauch, CTA B. Wyschkon, Dipl. Ing. Agr. C. Petzina, ORR Dr. K. Kammhuber
Cooperation:	IPZ 5a team (WG for Hop Cultivation/Production Techniques), IPZ 5b team (WG Plant Protection in Hop Growing), IPZ 5c team (Work Group for Hop Breeding Research)
Duration:	Long-term task

Hops are grown for their components. Component analysis is therefore essential to successful hop breeding.

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

Development of an NIRS calibration model for alpha-acid content based on HPLC data

Project manager:	ORR Dr. K. Kammhuber
Cooperation:	Dr. M. Biendl, Hallertauer Hopfenveredelungsgesellschaft mbH
	J. Betzenbichler, Hallertauer Hopfenveredelungsgesellschaft mbH
	R. Schmidt, NATECO2 GmbH & Co. KG, St. Johann
	U. Weiss, Hopfenveredelung St. Johann GmbH & Co. KG, St. Johann
Project staff:	CL E. Neuhof-Buckl, CTA B. Wyschkon, Dipl. Ing. Agr. C. Petzina, ORR Dr. K. Kammhuber
Duration:	September 2000 to August 2008

An HPLC-data-based NIRS calibration equation was 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.

Every year, the existing calibration equation was expanded and improved by the addition of new data sets. It was decided within the *Arbeitsgruppe für Hopfenanalytik (AHA)* (the Hallertau work group in which the four laboratories involved work together) that this method would be suitable for routine use and as an analytical method for hop supply contracts if it was at least as accurate as conductometric titration according to EBC 7.4.

However, as no further improvement was possible, it was decided to discontinue development of a joint calibration equation. For the 2008 harvest, a joint calibration equation was established once again. At the Hüll laboratory, the NIRS method remains in use. It is undoubtedly suitable as a screening method for hop breeding.

Development of analysis methods for hop polyphenols

Project manager:	ORR Dr. K. Kammhuber
Cooperation:	Arbeitsgruppe für Hopfenanalytik (AHA)
Project staff:	CL E. Neuhof-Buckl, ORR Dr. K. Kammhuber
Duration:	2007 to (open-ended)

Primarily on account of their health-promoting properties, polyphenols are becoming increasingly important with regard to alternative uses of hops. It is therefore important to have suitable analysis methods available.

To date, however, no officially standardized analysis methods exist. In 2007, the *Arbeitsgruppe für Hopfenanalytik* conducted initial ring tests for total polyphenol and flavonoid contents in hops.

The variation coefficients for total polyphenol are still relatively high, and work is being done to improve them. Determination of total flavonoid content already works remarkably well. In an initial ring test, an HPLC method was tested on quercetin and kaempferol. The results obtained were comparable.

Introduction and establishment of UHPLC in hop analytics

Project manager:	ORR Dr. K. Kammhuber
Project staff:	CTA B. Wyschkon, Dipl. Ing. Agr. C. Petzina, ORR 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. Analytical run times are much shorter, without any loss in resolution.

The UHPLC 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 Hull laboratory is equipped with the latest state of the art, putting it in a stronger position to attract research projects. One of the project proposals would be to differentiate among the global range of hop varieties on the basis of low-molecular polyphenols.

1.2.4 Plant Protection in Hop-Growing

Testing of plant protectives for licenses and approvals, and for the 2008 advisory-service documentation

Project manager: LLD Bernhard Engelhard
Project staff: Johannes Schwarz, Georg Meyr

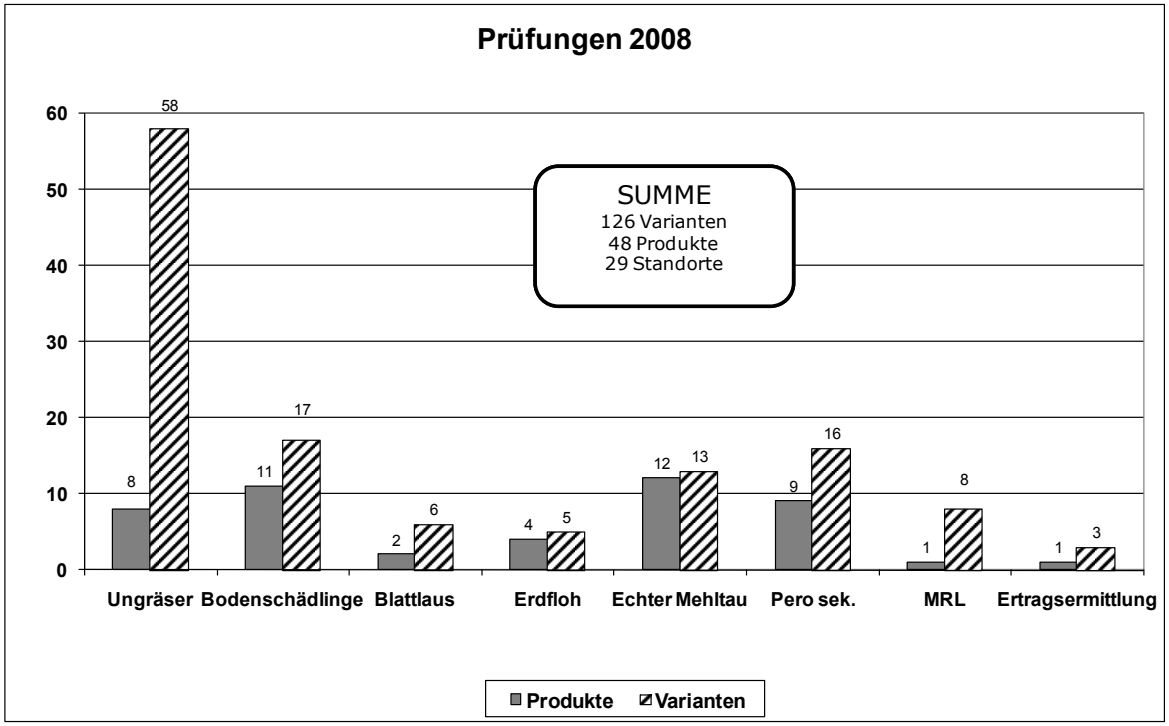


Fig. 1.1: Tests

A new focus of activity was the testing of herbicides to combat annual bluegrass (Poa annua) and millet species during the vegetation period and after harvesting. In addition to competing for water and nutrients, dense growth hampers soil cultivation measures. Another new project is the testing of insecticides against flea beetles in spring and following cone formation.

2 Weather conditions in 2008 – summer temperatures in February and warmer-than-average conditions throughout the year

LLD Bernhard Engelhard, Dipl. Ing. agr.

As in the previous year, the winter of 2007/2008 was again much too warm and devoid of snow. The ground was frozen only during the first half of January – to a depth of 20 cm.

The weather tempted a number of hop-growers to begin rootstock pruning as early as February 23rd. With temperatures peaking at 20 °C on February 24th, this was not altogether surprising. The phenological start of the vegetation cycle was on March 15th.

March and April were wet and relatively cold. This inclement weather hampered

- completion of trellis work
- soil sampling to test for nitrogen
- soil preparation – rootstock pruning and "crowning"

These conditions had the following disease- and pest-related impacts:

- Very widespread primary peronospora infection, which led repeatedly to re-infection until mid-June
- Very little occurrence of alfafa weevil (no location was found where infection was sufficient for a trial)
- Serious wireworm infection
- Delayed spider-mite infection

The planting and tending of root cuttings was particularly difficult.

The first half of May was warm and dry; as from May 17th, however, there followed another period of heavy, continuous rain. This, combined with the late blackberry winter around May 20th, halted growth. What was surprising under these conditions was the pronounced, concentrated migration of aphids as from May 13th; migration peaked at the end of May.

June and July were characterized by showers and thunderstorms, with occasional heavy rain. Good growth conditions caused Hallertauer Magnum and Hallertauer Mittelfrüher to commence flower-setting on June 20th.

Rainfall in the Hallertau was sufficient at all times, even though there was a lot less rain in the northern areas (Abensberg, Jura) than in central parts. In the Spalt hop-growing region, the rain came just in time; in Hersbruck, water shortage led to crop failure.

In the Hallertau, weather conditions favourable to hops (rain and pleasantly warm) led to a bumper harvest. Well-above-average alpha-acid content was measured for the early-maturing varieties (up to 7 % for Perle) as early as August 14th. The high-alpha varieties, too, soon followed in their wake, so that altogether a record crop was harvested in respect of alpha-acid yield. There were no disease- or pest-related problems.

A storm to the east of Hüll in the Hallertau destroyed around 20 ha of hop gardens on August 7th.

2.1 Weather data (monthly means or monthly totals) for 2008 compared with 10- and 50-year means

Month		Temp. 2 m above ground Mean (°C)	Min.∅ (°C)	Max.∅ (°C)	Relative humid. (%)	Precipi-tation (mm)	Days with prec. >0.2 mm	Sun-shine (h)
January	2008	2.2	-1.3	6.4	88.8	50.3	9.0	90.4
∅	10-yr.	-0.6	-4.0	3.1	88.4	50.6	12.4	73.9
	50-yr.	-2.4	-5.1	1.0	85.7	51.7	13.7	44.5
February	2008	2.7	-2.5	9.3	84.7	39.2	12.0	174.3
∅	10-yr.	0.6	-4.0	5.5	85.0	40.0	12.0	96.2
	50-yr.	-1.2	-5.1	2.9	82.8	48.4	12.8	68.7
March	2008	4.3	-0.1	9.1	82.8	84.0	16.0	126
∅	10-yr.	4.2	-0.8	9.8	80.1	68.3	12.9	149.4
	50-yr.	2.7	-2.3	8.2	78.8	43.5	11.3	134.4
April	2008	8.4	3.0	14.5	83.5	118.1	21.0	148.1
∅	10-yr.	8.9	2.9	15.2	73.6	56.3	11.3	190.3
	50-yr.	7.4	1.8	13.3	75.9	55.9	12.4	165.0
May	2008	15.0	8.5	22.0	74.1	50.1	11.0	249.1
∅	10-yr.	14.0	7.7	20.3	72.9	93.3	12.7	221.5
	50-yr.	11.9	5.7	17.8	75.1	86.1	14.0	207.4
June	2008	17.6	11.4	24.0	74.8	110.6	18.0	201.5
∅	10-yr.	17.1	10.4	23.7	72.9	89.8	13.5	250.2
	50-yr.	15.3	8.9	21.2	75.6	106.1	14.2	220.0
July	2008	17.7	11.6	24.8	76.4	129.5	18.0	226.6
∅	10-yr.	17.9	11.9	24.5	75.9	96.9	16.2	228.3
	50-yr.	16.9	10.6	23.1	76.3	108.4	13.9	240.3
August	2008	17.5	11.4	24.7	77.7	92.9	14.0	224.1
∅	10-yr.	17.4	11.4	24.3	78.1	88.3	12.3	209.7
	50-yr.	16.0	10.2	22.5	79.4	94.9	13.3	218.4
September	2008	11.9	6.9	17.8	83.0	55.6	15.0	125.6
∅	10-yr.	13.5	8.1	19.9	83.2	76.9	12.2	165.3
	50-yr.	12.8	7.4	19.4	81.5	65.9	11.4	174.5
October	2008	8.5	4.0	14.2	86.8	57.8	11.0	107.4
∅	10-yr.	9.3	5.0	14.7	87.6	68.9	12.8	114.5
	50-yr.	7.5	2.8	13.0	84.8	60.0	10.4	112.9
November	2008	4.0	0.4	8.6	86.8	44.9	10	77.5
∅	10-yr.	3.2	-0.1	6.7	92.1	67.3	13.1	61.6
	50-yr.	3.2	-0.2	6.4	87.5	58.8	12.6	42.8
December	2008	0.6	-1.8	3.5	87.0	51.2	15.0	71.6
∅	10-yr.	0.1	-2.9	3.3	91.1	45.4	13.4	62.2
	50-yr.	-0.9	-4.4	1.6	88.1	49.1	13.3	34.3
2008		9.2	4.3	14.9	82.2	884.2	170.0	1822.2
10-year mean		8.8	3.8	14.3	81.7	841.8	154.8	1823.0
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 1998 through 2007.

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			

Table 3.2: Hop acreages, 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 - 2008 to 2007				Increase + / Decrease - 2008 to 2007			
	2007	2008	ha	%	2007	2008	Farms	%	2007	2008
Hallertau	14 754	15 678	+ 923	+ 6.3	1 222	1 213	- 9	- 0.7	12.07	12.92
Spalt	384	382	- 2	- 0.5	84	81	- 3	- 3.6	4.57	4.72
Tettnang	1 193	1 233	+ 40	+ 3.3	174	172	- 2	- 1.1	6.86	7.17
Baden, Bitburg and Rhine. Pal.	19	19	± 0	± 0	2	2	± 0	± 0	9.50	9.50
Elbe-Saale	1 321	1 383	+ 63	+ 4.7	29	29	± 0	± 0	45.55	47.69
Germany	**17 671**	**18 695**	**+ 1024**	**+ 5.8**	**1 511**	**1 497**	**- 14**	**- 0.9**	**11.70**	**12.49**

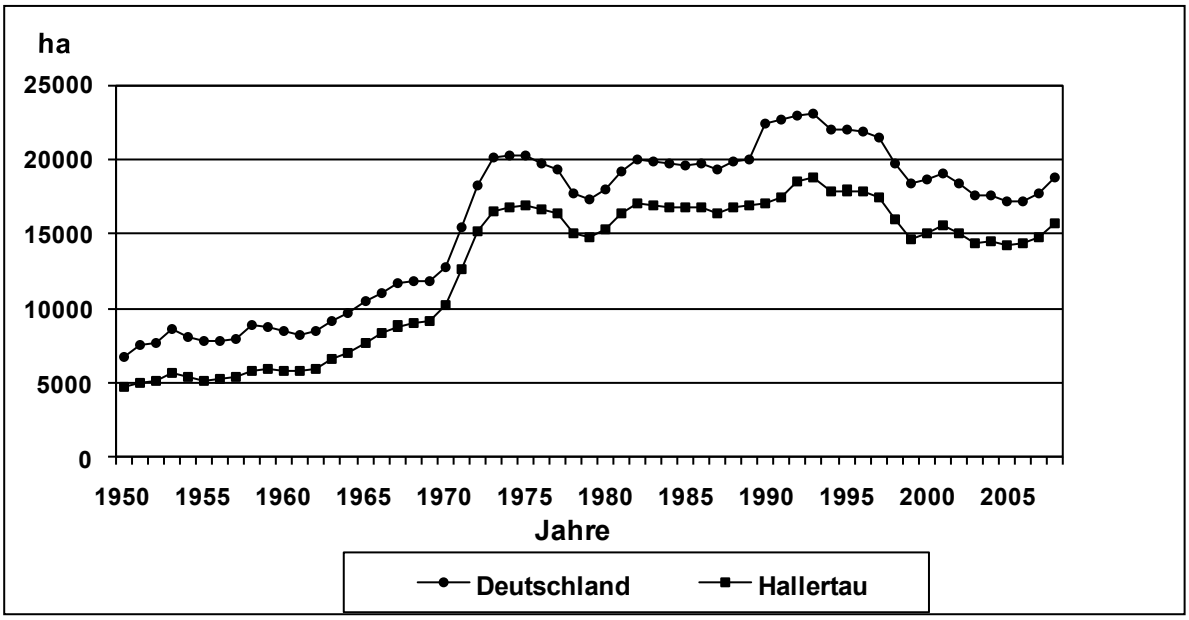


Fig. 3.1: Hop acreages in Germany and in the Hallertau

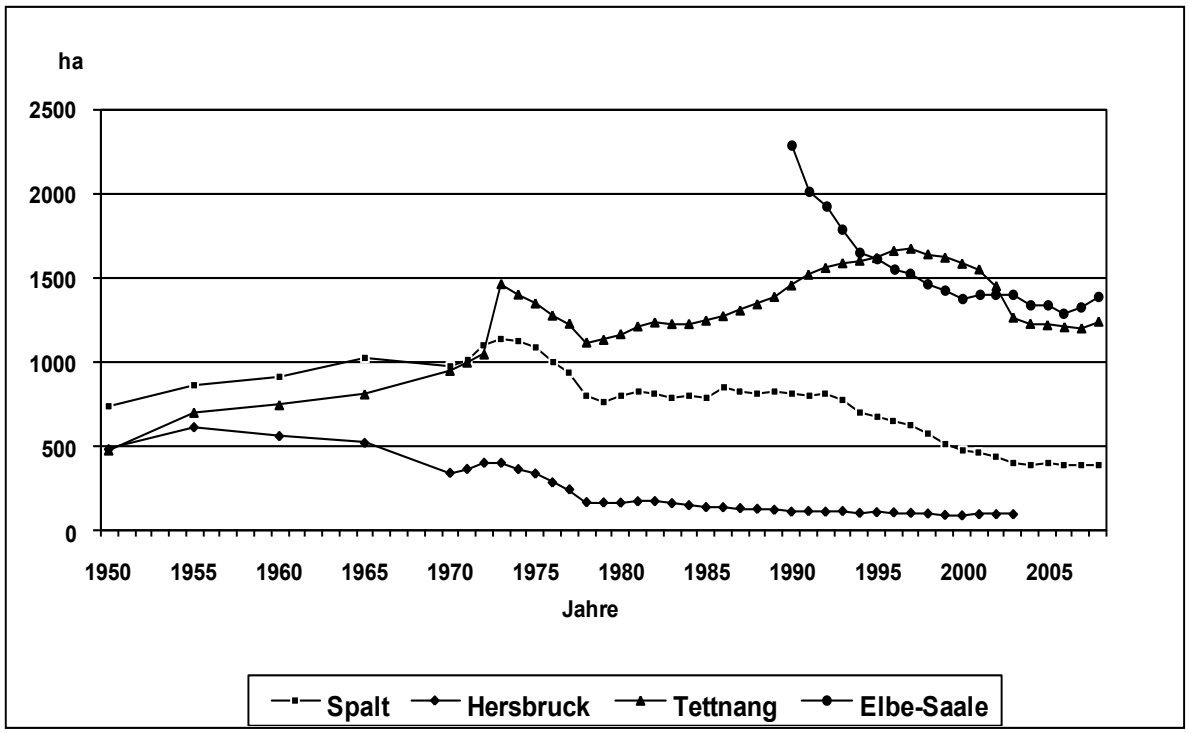


Fig. 3.2: Hop acreages in the Spalt, Hersbruck, Tettnang and Elbe-Saale regions

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

3.1.2 Hop varieties

After years characterized by an increase in aroma varieties, 2008 saw a pronounced production shift toward bitter varieties, the reason being the new, high-alpha Herkules cultivar, which was planted on 1,000 ha during the year under report alone. Altogether 1,868 ha, or 10 % of the total acreage under hop production, have already been planted with Herkules, making it the second-most abundant bitter variety and the fifth-most abundant variety overall in Germany. In 2008, the aroma varieties accounted for only 56.2 % of the total area under hops, compared with 59.1 % in 2007. The acreage planted with bitter varieties thus increased during 2008 from 40.9 % to 43.8 %.

Due to the favourable terms offered by advance contracts, hop production in Germany was expanded by 1,024 ha. Among the aroma cultivars, Perle and Hallertauer Tradition profited slightly from this trend ((+ 52 ha and + 46 ha, resp.). The new aroma cultivars Saphir, Opal and Smaragd were just able to maintain their production acreages or increase them very slightly. The old and noble Saaz aroma variety, planted on a small acreage (11 ha) in the Hallertau and the Elbe-Saale region, is new to the statistics. The acreage planted with bitter varieties saw an increase of 958 ha during 2008, most of which involved the Herkules variety.

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

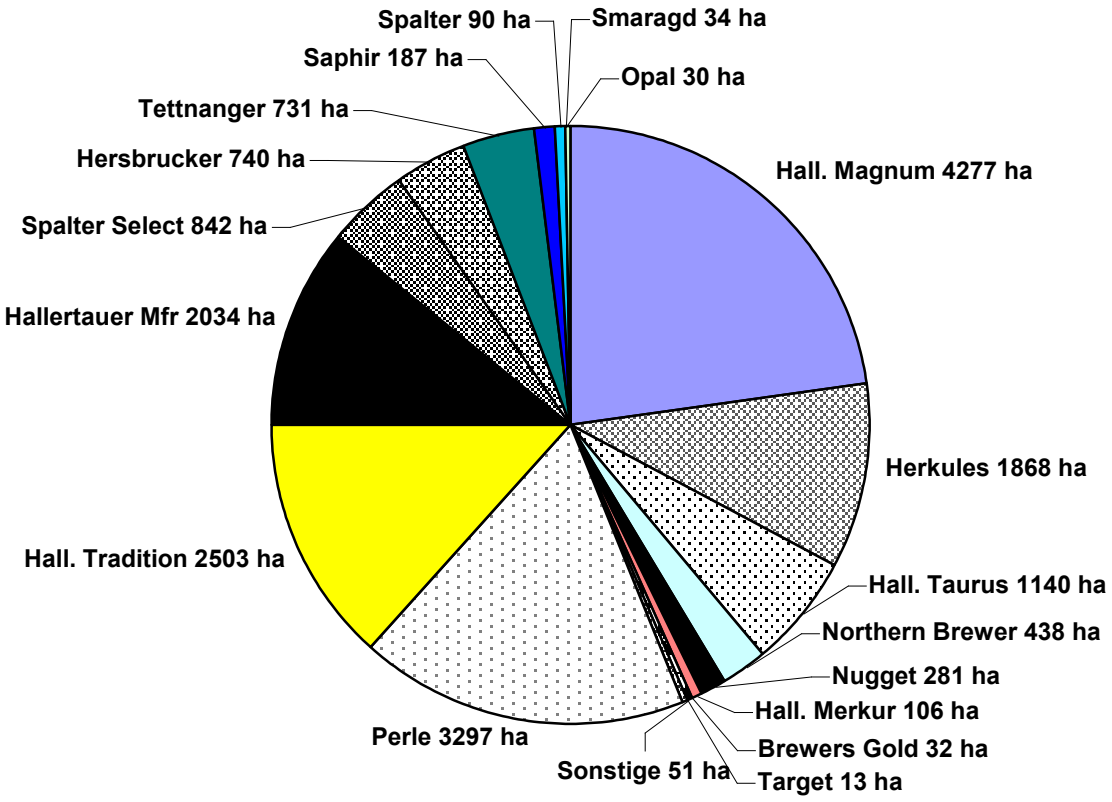


Fig. 3.3: Hop varieties by acreage in Germany in 2008

Table 3.3: Hop varieties by German hop-growing region in ha in 2008
Aroma varieties

Region	Total acreage	HA	SP	TE	HE	PE	SE	HT	SR	OL	SD	Other	Aroma varieties	
													ha	%
Hallertau	15,678	1,557	5		735	3,060	735	2,401	187	30	34	5	8,749	55.8
Spalt	382	106	86		6	23	106	27					353	92.4
Tettnang	1,233	369		731		59		37					1,196	97.0
Baden, Bit-burg and Rhine Pal.	19	1				8	2	5					16	85.8
Elbe-Saale	1,383					147		34				8	188	13.6
Germany	**18,695**	**2,034**	**90**	**731**	**740**	**3,297**	**842**	**2,503**	**187**	**30**	**34**	**13**	**10,502**	**56.2**
% acreage by variety		10.9	0.5	3.9	4.0	17.6	4.5	13.4	1.0	0.2	0.2	0.1		

Variety changes in Germany

2007 ha	17,671	2,082	92	725	747	3,246	846	2,457	186	24	30	2	10,436	59.1
2008 ha	18,695	2,034	90	731	740	3,297	842	2,503	187	30	34	13	10,502	56.2
Change in ha	+ 1,024	- 48	- 2	+ 6	- 7	+ 52	- 4	+ 46	+ 1	+ 6	+ 4	+ 11	+ 66	- 2.9

Table 3.4: Hop varieties by German hop-growing region in ha in 2008
Bitter varieties

Region	NB	BG	NU	TA	HM	TU	MR	HS	Other.	Bitter varieties	
										ha	%
Hallertau	306	32	251	9	3,428	1,109	73	1,699	21	6,929	44.2
Spalt					3		10	16		29	7.6
Tettnang					1	7		20	9	37	3.0
Baden, Bit-burg and Rhine Pal.					2					3	14.2
Elbe-Saale	132		30	4	842	23	23	133	8	1,195	86.4
Germany	**438**	**32**	**281**	**13**	**4,277**	**1,140**	**106**	**1,868**	**38**	**8,193**	**43.8**
% acreage by variety	2.3	0.2	1.5	0.1	22.9	6.1	0.6	10.0	0.2		

Variety changes in Germany

2007 ha	471	31	290	13	4,263	1,146	123	868	31	7,235	40.9
2008 ha	438	32	281	13	4,277	1,140	106	1,868	38	8,193	43.8
Change in ha	- 33	+ 1	- 9	0	+ 14	- 6	- 17	+ 1,000	+ 7	+ 958	+ 2.9

3.2 Crop situation in 2008

Approximately 39,676,470 kg (= 793,529 cwt.) hops were harvested in Germany, compared with 32,138,870 kg (= 642,777 cwt.) in 2007. The crop was thus about 7,537,600 kg (= 150,752 cwt.) more than in the previous year, an increase of around 23.4 %. This may be referred to without exaggeration as a record harvest, especially since alpha content was also above average.

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

	2003	2004	2005	2006	2007	2008
Yield kg/ha and (cwt./ha)	1444 kg (28.9 cwt.)	1900 kg (38.0 cwt.)	2006 kg (40.1 cwt.)	1660 kg (33.2 cwt.)	1819 kg (36.4 cwt.)	2122 kg (42.4 cwt.)
Relative to 100 % (long-term ∅ = 35 cwt.)	82.5	108.6	114.6	94.9	103.9	121.3
Acreage in ha	17,563	17,476	17,179	17,170	17,671	18,695
Total crop in kg and cwt.	25,356,200 kg = 507,124 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.

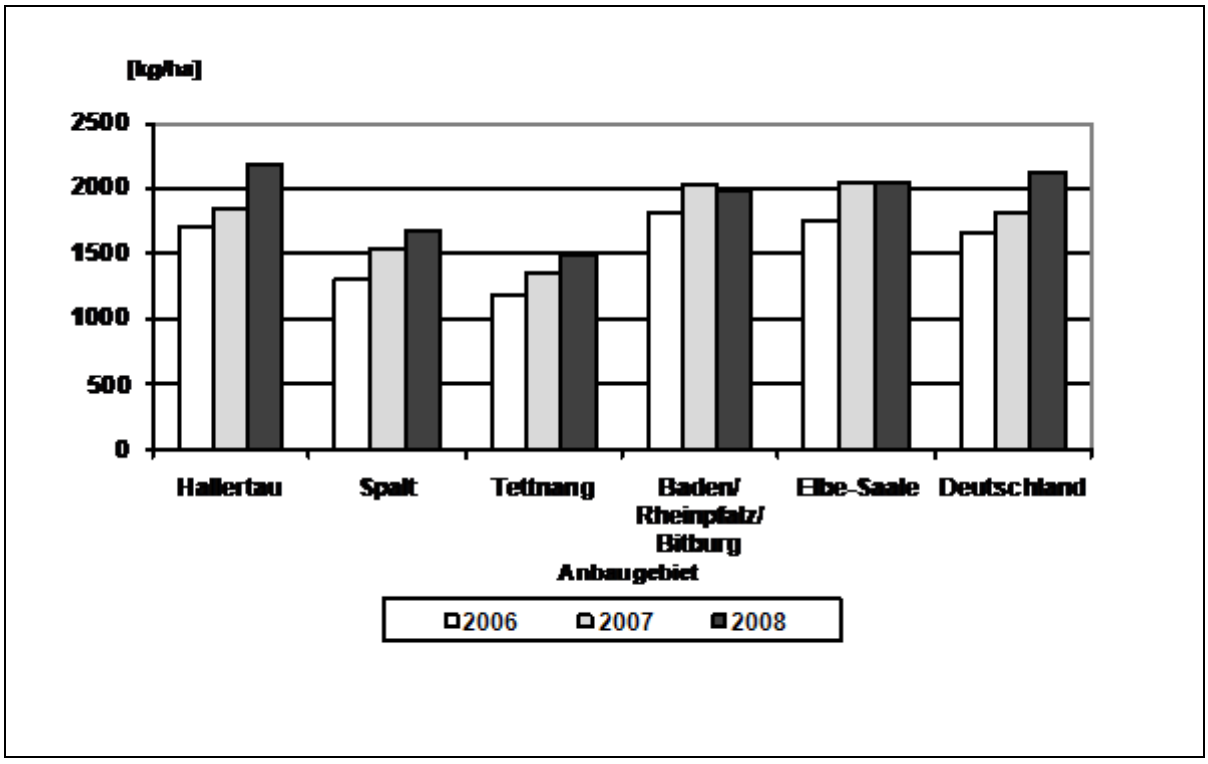


Fig. 3.4: Average yield by hop-growing region in kg

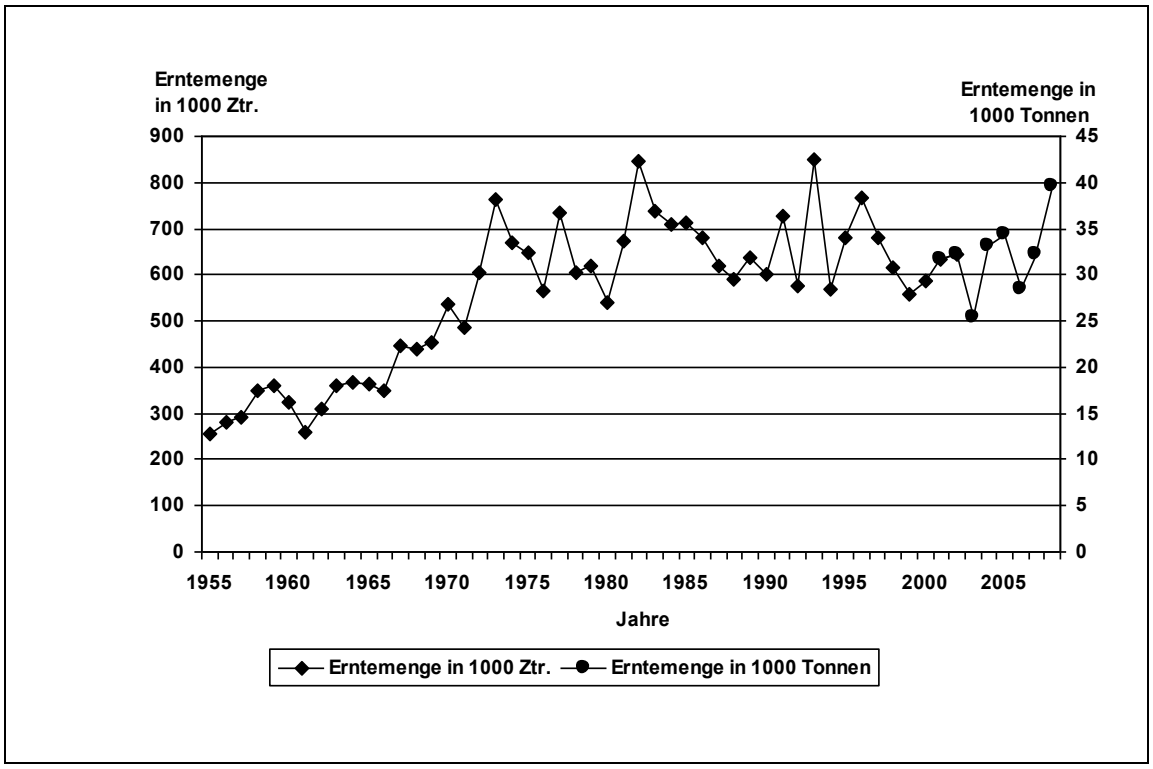


Fig. 3.5: Crop volume in Germany

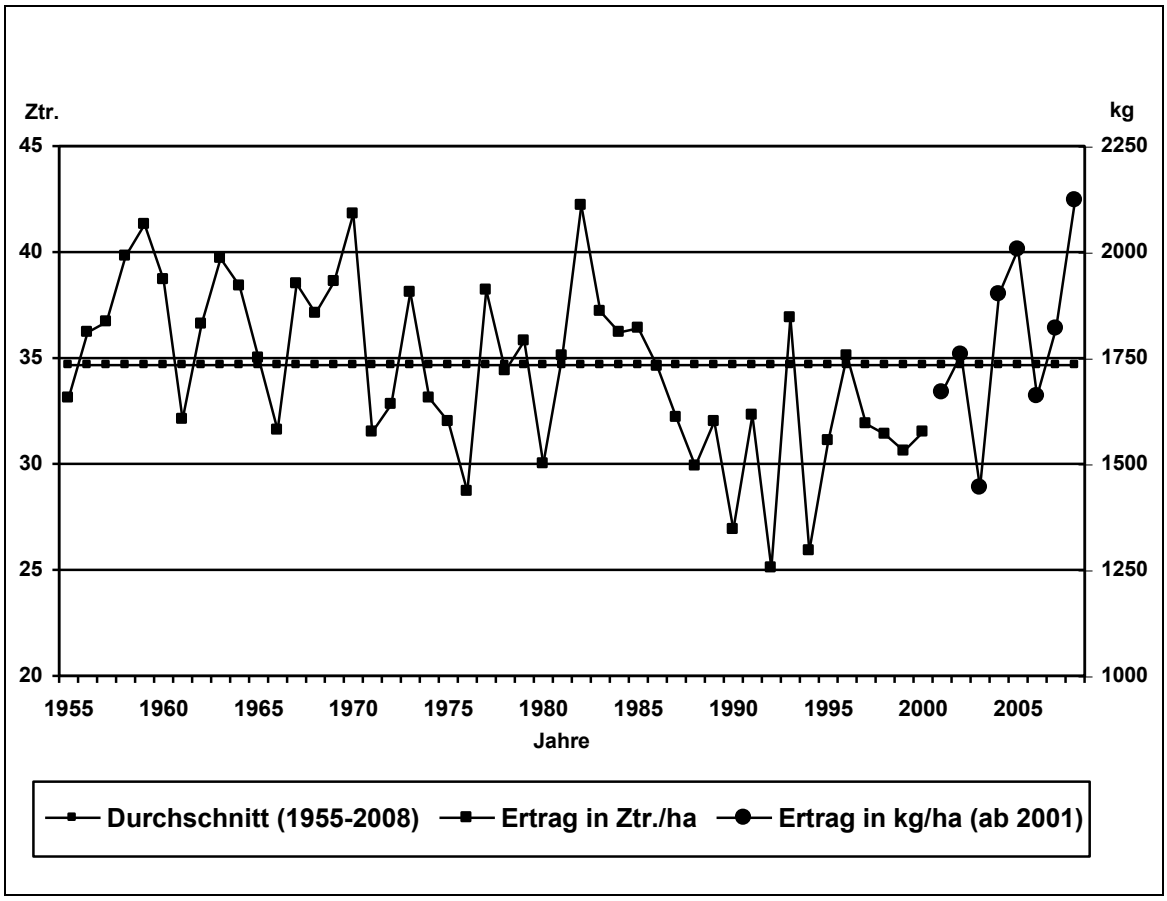


Fig. 3.6: Average yield (cwt. and kg/ha) in Germany

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

Region	Yields in cwt./ha total acreage (from 2001 in kg/ha)								
	2000	2001	2002	2003	2004	2005	2006	2007	2008
Hallertau	33.6	1724	1825	1462	1946	2084	1701	1844	2190
Spalt	20.9	1298	1464	1131	1400	1518	1300	1532	1680
Hersbruck	26.8	1233	1306	983	- *	- *	-*	- *	- *
Tettnang	16.4	1212	1360	1216	1525	1405	1187	1353	1489
Baden/Bitbg. Rhine Pal.	31.6	1445	1763	1936	1889	1881	1818	2029	1988
Elbe-Saale	30.0	1594	1576	1555	1895	1867	1754	2043	2046
∅ yield / ha Germany	31.5	1669 kg	1758 kg	1444 kg	1900 kg	2006 kg	1660 kg	1819 kg	2122 kg
Total crop Germany		31 739 t	32 271 t	25 356 t	33 208 t	34 467 t	28 508 t	32 139 t	39 676 t
(t or cwt.)	585 964	634 782	645 419	507 124	664 160	689 335	570 165	642 777	793 529
Acreage Germany	18 598	19 020	18 352	17 563	17 476	17 179	17 170	17 671	18 695

* 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	1999	2000	2001	2002	2003	2004	2005	2006	2007	**2008**	∅ 5 years	∅ 10 years
Hallertau Hallertauer	4.1	4.9	4.6	4.6	3.1	4.3	4.4	2.4	3.9	**4.4**	**3.9**	**4.1**
Hallertau Hersbrucker	2.1	4.9	3.0	3.2	2.1	3.0	3.5	2.2	2.6	**2.9**	**2.8**	**3.0**
Hallertau Hall. Saphir						3.4	4.1	3.2	4.6	**5.1**	**4.1**	
Hallertau Opal									7.4	**9.4**		
Hallertau Smaragd									6.1	**6.7**		
Hallertau Perle	7.0	8.1	7.0	8.6	3.9	6.4	7.8	6.2	7.9	**8.5**	**7.4**	**7.1**
Hallertau Spalter Select	4.5	6.4	4.8	6.0	3.2	4.9	5.2	4.3	4.7	**5.4**	**4.9**	**4.9**
Hallertau Hall. Tradition	6.0	7.1	6.3	7.2	4.1	6.3	6.3	4.8	6.0	**7.5**	**6.2**	**6.2**
Hallertau North. Brewer	9.0	10.1	9.6	10.1	6.0	9.8	9.8	6.4	9.1	**10.5**	**9.1**	**9.0**
Hallertau Hall. Magnum	13.4	14.4	13.9	14.6	11.7	14.8	13.8	12.8	12.6	**15.7**	**13.9**	**13.8**
Hallertau Nugget	10.0	12.9	11.9	12.4	8.5	10.6	11.3	10.2	10.7	**12.0**	**11.0**	**11.1**
Hallertau Hall. Taurus	15.9	15.6	15.7	16.5	12.3	16.5	16.2	15.1	16.1	**17.9**	**16.4**	**15.8**
Hallertau Hall. Merkur						13.5	13.3	10.3	13.0	**15.0**	**13.0**	
Hallertau Herkules									16.1	**17.3**		
Tettnang Tettnanger	3.8	4.9	4.4	4.6	2.6	4.7	4.5	2.2	4.0	**4.2**	**3.9**	**4.0**
Tettnang Hallertauer	4.2	4.8	4.5	4.8	3.1	5.0	4.8	2.6	4.3	**4.7**	**4.3**	**4.3**
Spalt Spalter	3.8	4.0	4.4	4.6	3.1	4.4	4.3	2.8	4.6	**4.1**	**4.0**	**4.0**
Elbe-S. Hall. Magnum	12.2	14.0	13.9	13.9	10.2	14.0	14.4	12.4	13.3	**12.2**	**13.3**	**13.1**

4 Hop breeding research

RDin Dr. Elisabeth Seigner, Dipl. Biol.

4.1 Conventional 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 wild hops from around the world. This breeding stock is used to carry out around 100 crosses each 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-analysis methods have been used for years to support conventional cross-breeding.

4.1.1 Crosses in 2008

A total of 71 crosses were carried out during 2008. The major breeding goals are stable resistance / tolerance towards hop peronospora, 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 2008

Breeding direction combined with resistance / tolerance towards various hop diseases	Further requirements	Number of crosses
Aroma type	New powdery mildew-resistances from wild hops	23
	Suitability for low trellis systems	7
	High beta-acid content	1
Dual-purpose type	Suitability for developing molecular markers	1
High-alpha-acid type	None	21
	New powdery mildew-resistances from wild hops	2
	High xanthohumol content	1
	High beta-acid content	3
	Suitability for low trellis systems	12

4.1.2 Herkules – the new star among high-alpha varieties

Commercial production with "Herkules" began on around 30 ha in 2005. Three years later, the new high-alpha variety was already being grown on 1,870 ha. Even the name given to the new, sturdy, high-performance breeding line reflected the conviction that this high-alpha cultivar constituted a major breeding advance matching the feats of that mighty hero of Greek mythology. But has Herkules met the ambitious expectations of the hop and brewing industries?

To answer this question, the results of all the Herkules trials in which the new cultivar was compared with the Hallertauer Magnum (Magnum) and Hallertauer Taurus (Taurus) varieties were evaluated separately. These results stem from "Stammes- und Hauptprüfungen" (field trials with less or more advanced selections, with several replications) performed in our Hüll and Rohrbach breeding yards and from "Anbauprüfungen" (trials with highly promising selections on farms). These farms are scattered throughout the Hallertau, allowing promising breeding lines and cultivars to be tested under a variety of climatic, soil and farming conditions. The evaluation comprises a total of 39 data sets on yield and 57 data sets on alpha-acid content, obtained during the nine trial years from 2000 – 2008. All trials were conducted without irrigation.

The enormous crop potential of Herkules is apparent from the comparison of its crop performance with those of Magnum and Taurus (Table 4.2). The mean yield of 3,258 kg/ha is well above that of the other two varieties. With a mean yield of 77 % (40 – 99 %) relative to that of Herkules, Magnum still compares fairly well, albeit with striking annual fluctuations. Especially in years with a very warm spring, as in 2000 and 2007, Magnum is apt to flower prematurely. This leads to reduced flower setting or "burring", and, as a rule, to a disappointing crop. Comparison with Taurus reveals an even more pronounced difference in yield. At only 66 % (53 – 74 %) of the Herkules figure, the yield is a third less. The difference is more than 25 % even in good years.

Table 4.2: Crop performance of Herkules compared with Magnum and Taurus

Year	Yield in kg/ha			Yield relative to Herkules (= 100 %)		
	Magnum	**Taurus**	**Herkules**	**Magnum**	**Taurus**	**Herkules**
2000	1445	2148	3653	40	59	100
2001	2345	1663	3118	75	53	100
2002	2133	2342	3265	65	72	100
2003	2088	1475	2538	82	58	100
2004	3213	2410	3258	99	74	100
2005	3159	2651	3570	88	74	100
2006	2707	1821	2971	91	61	100
2007	2388	2460	3545	67	69	100
2008	2797	2357	3404	82	69	100
Mean	**2475**	**2147**	**3258**	**77**	**66**	**100**

A somewhat different picture emerges for alpha-acid content (Tab. 4.3). Herkules und Taurus are completely on a par in this respect, with an average difference of only 0.1 %.

During the nine years of the trial, Herkules scored slightly better in three and Taurus in six years. This evaluation provides impressive evidence that Taurus has passed on the full extent of its very high alpha-acid potential to its daughter, Herkules.

By contrast, Herkules' superiority over Magnum is more than obvious. In absolute terms, the difference is as much as 2.5 %. Only in 2003, which was extremely hot and dry, was Magnum's alpha-acid content higher than that of Herkules. It must be remembered, however, that this was the first crop year for some of the Herkules stands, which means that their root systems were not yet fully developed.

Table 4.3: Alpha-acid content of Herkules compared with Magnum and Taurus

Year	Alpha-acid content in % (HPLC)			Alpha-acid content relative to Herkules (= 100 %)		
	Magnum	**Taurus**	**Herkules**	**Magnum**	**Taurus**	**Herkules**
2000	12.4	15.8	18.2	68.6	87.2	100
2001	13.6	17.1	17.6	77.1	97.2	100
2002	14.1	16.6	16.1	87.5	102.9	100
2003	12.2	12.1	11.1	110.2	109.3	100
2004	15.4	17.0	16.9	91.2	100.7	100
2005	14.8	17.3	17.5	84.6	98.5	100
2006	12.1	14.7	14.3	84.8	103.2	100
2007	13.3	16.6	16.5	80.9	100.8	100
2008	16.2	18.9	18.5	87.5	102.1	100
Mean	**13.8**	**16.2**	**16.3**	**85.8**	**99.8**	**100.0**

The enormous breeding progress becomes especially clear on comparison of alpha-acid yields (Table 4.4). Whereas Magnum is at least reasonably competitive in terms of crop yield in good years, and Taurus in on a par in terms of alpha-acid content, the product of these two properties, (= alpha-acid yield) reveals striking differences. Herkules is superior to both other varieties by approximately one third. Neither Magnum nor Taurus had an alpha-acid yield anywhere near that of Herkules in any one of the nine trial years. In a number of separately-conducted trials, alpha-acid yields of well above 700 kg/ha were obtained for Herkules. Even if the crop performance of commercially farmed Herkules is 20 % lower than expected, the potential alpha-acid yield is still above 400 kg/ha.

The main reason for the yield stability of Herkules is the huge number of cones produced. If necessary, Herkules can even vary the size of its cones, thus boasting a certain "correction potential." An example of this was seen with the 2008 yield obtained at the Bogenhausen location. Due to early rootstock pruning, the newly established stand was the first to start flowering. It therefore had a lot fewer cones, but the cones were very large ones. Despite the smaller number of cones, the yield exceeded 3 t/ha. The Herkules stand that had been pruned at the customary time and was harvested for the third time displayed vigorous growth and had an exceptionally large number of cones. However, the cones did not go all the way down to the bottom, and the bines were unable to develop all of the cones to a suitable size. The yield was around 3.25 t/ha. The Herkules stand planted back in 2001 was pruned late, together with the adjacent stand of Magnum, and bore an average number of cones. The cones were medium-sized, and the yield was a little over 3.6 t/ha.

Table 4.4: Alpha-acid yield in Herkules compared with Magnum and Taurus

Year	α-acid yield in kg α-acids/ha			α-acid yield rel. to Herkules (= 100 %)		
	Magnum	**Taurus**	**Herkules**	**Magnum**	**Taurus**	**Herkules**
2000	180	340	663	27	51	100
2001	318	284	548	58	52	100
2002	301	388	526	57	74	100
2003	255	179	281	91	64	100
2004	494	409	549	90	74	100
2005	469	458	626	75	73	100
2006	328	268	424	77	63	100
2007	318	408	583	54	70	100
2008	452	445	629	72	71	100
Mean	**341**	**348**	**531**	**67**	**66**	**100**

Besides its enormous crop potential, it is Herkules' favourable agronomic attributes, such as its homogeneous bud break, cylindrical bines and good picking quality that makes it so attractive to farmers. The fact that it matures late is a further advantage, as hop growers can make better use of their existing harvesting equipment and have thus been able to expand their hop acreage without additional investments. With Herkules, the Hüll Hop Research Centre has also satisfied major requirements of the hop and brewing industries. In view of its very high and stable yield and alpha-acid values, combined with the excellent storage stability of its components, Herkules can be expected to help ensure a long-term, reliable supply of premium-quality hops – now and in the future. Last but not least, the new variety has compelling advantages for brewers looking for high quality but also thinking of profits, because, despite its high alpha-acid content, it makes for a harmonious beer that is not excessively bitter.

4.1.3 "Maintenance breeding" of Hallertauer Tradition (HT08)

The Hüll-bred Hallertauer Tradition aroma cultivar has been grown commercially since 1992 and is equally popular with farmers and brewers. From an agronomic point of view, Hallertauer Tradition offers farmers many advantages:

- Healthy plants and uniform bud break
- Very good winding ability
- Broad resistance/tolerance towards all major diseases
- Very good stature and cone set
- High yield potential
- Early maturity

For brewers, too, Hallertauer Tradition is an extremely interesting variety with all the desired properties:

- Very fine aroma
- Good essential-oil profile
- Medium-to-high bittering value
- Good storage stability

Objective

After Hallertauer Magnum and Perle, Hallertauer Tradition is now the third-most common cultivar in Germany. It is now being grown on more than 2,500 ha. Over the years, it has also become the world's second-most important aroma cultivar, and the area under production is still increasing slowly. Hallertauer Tradition is used with great success in many breweries, and during the last few years it has also seen stable sales in Russia and Japan, among other countries. During the next few years, some of the existing stands will have to be renewed. This is because performance potential decreases after 12-15 years. As with the cultivar Perle some years ago, the intention is to introduce a Hallertauer Tradition maintenance stock (foundation stock) to the market.

Methods and procedure

On an approx. 1.8-ha plot planted in 1990 with Hüll planting stock, breeders Ehrmaier and Lutz marked hop plants that were optimally developed and typical of the variety. Later, these 31 plants were harvested separately, analysed and assessed.

Results

Surprisingly distinct differences were revealed. The projected alpha-acid yield/ha varied between 200 and 350 kg. Cuttings will be taken in spring from the ten best plants, which produced above-average results for both yield and alpha-acid content, and examined for virus infections. If necessary, they will be freed of any viruses by means of meristem culture. The plan is to provide hop planters, via contract propagators, with cuttings from our maintenance stock (foundation stock) as from 2010.

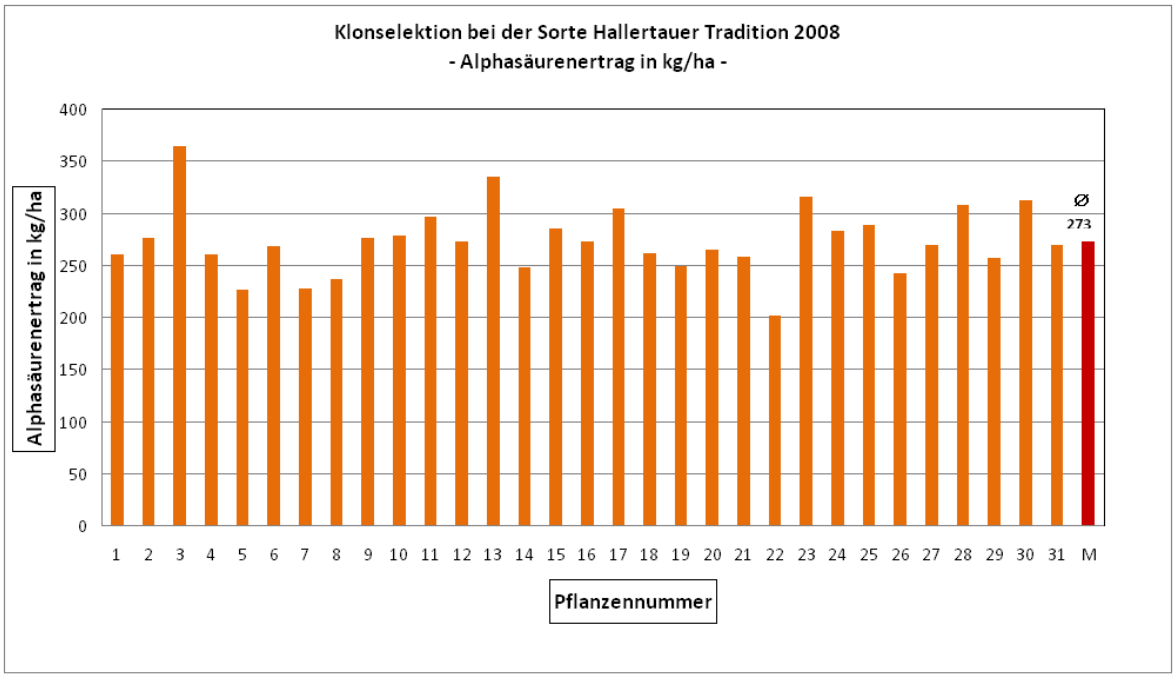


Fig. 4.1: Projected alpha-acid yields (kg/ha) for 31 selected plants of the cultivar Hallertauer Tradition, and mean yield (M = 273 kg/ha).

4.1.4 Monitoring for hop stunt viroid (HSVd) in hops

Hop stunt viroid (HSVd) is an extremely serious hop disease. For a long time, it was confined to Japan and Korea, where it had been found in Japanese varieties since the 1940s (Sasaki et al., 1989). In 2004, HSVd was found for the first time in hop gardens in the USA, and in 2007 it was detected in China, in particular in the US cultivar "Marco Polo" (Guo et al., 2008). Depending on the variety and the weather conditions, this viroid caused massive losses in yield and quality.

In 2007, Dr. Stephan Kenny and Dr. Ken Eastwell reported alpha-acid losses (kg α/ha) of 60 and 75 % for the US cultivars "Willamette" and "Glacier" respectively (http://www.usahops.org/graphics/File/Kenny_Winter_2008.pdf). As the typical symptoms of an HSVd infection, such as stunted growth, curled leaves, small cones and chlorosis, 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 the unhindered spread of the viroid.

There are no effective plant protectives or disinfection agents available, and even heat is unable to inactivate the virus's infectious RNA. To date, there are no effective tissue-culture techniques, either, with which healthy planting stock can be generated – as is possible in the case of virus infections.

Objective

The first step was to establish a reliable detection method for HSVd that would make it possible to judge quickly – irrespective of any disease symptoms – whether or not a certain hop plant was viroid-free. Building on current work on HSVd in the USA by Eastwell and Nelson (2007) and the studies on Hop Latent Viroid performed back in 1999 at the LfL's diagnostics lab (Knabel et al., 1999), we began to establish the RT-PCR (reverse transcription polymerase chain reaction) technique for this other hop viroid.

The ultimate aim was to use this method for testing hops from the Hüll and Rohrbach breeding yards, where there is a constant influx of hop varieties from other hop-growing regions. These initial tests were intended to provide a rough indication of whether HSVd is already present in Germany.

Methods

Symptom-related diagnosis

HSVd-infected hops typically have shortened internodes on the main and lateral bines, and stunted growth. The lower leaves are usually smaller, curled and chlorotic (Fig. 4.2).

Fig. 4.2: In spring, HSVd-infected plants of the US cultivar "Glacier" had yellow-green leaves at the base (left) and showed stunted growth. Yellow speckling was visible along the main veins (right). Photos: Eastwell, K. and Nelson, M., 2007.

Identifying HSVd infections on the basis of such symptoms is highly unreliable, as they do not become clearly visible until 3 to 5 years after infection. Moreover, the extent to which these symptoms are present varies according to climate and variety. In warmer climates, stunting is said to be much more pronounced.

Molecular detection of HSVd by RT-PCR

Molecular biological methods make it possible to extract nucleic acids, such as RNA, from the leaves of hop plants under test – preferably from young leaves collected in spring.

The small, single, ring-shaped strand of hop stunt viroid RNA is co-extracted and can be detected via RT-PCR (reverse transcription polymerase chain reaction) and subsequent electrophoresis as a band of approx. 300 bp (Fig. 4.3). It takes only two days to obtain the test result.

As the RT-PCR method had already been established in the LfL's diagnostics laboratory by Dr. L. Seigner and her IPS 2c team in 1999, it was possible to very quickly establish this detection method for the new hop viroid, too, using the HSVd–specific primer developed by Eastwell and Nelson (2007).

To this end, Dr. Eastwell of Washington State University, USA, provided finely ground, freeze-dried HSVd-infected hop-leaf material for use as a positive control.

Results

In spring 2008, 43 hop samples from the USA, 11 cultivar samples from the Hüll breeding yard and one sample from a hop farm in the Hallertau were tested by RT-PCR, using primers from Eastwell and Nelson (2007). HSVd-RNA was not detected in any of the samples, allowing us to rate the hops as HSVd-free.

Table 4.5: Results obtained for the German hop samples tested for HSVd by RT-PCR in spring 2008.

Variety	Location	Origin	Finding
Hallertauer Mfr.	Hüll	German landrace	Non-detectable
Hersbrucker Spät	Hüll	German landrace	Non-detectable
Northern Brewer	Hüll	England	Non-detectable
Northern Brewer	Rohrbach	England	Non-detectable
Perle	Rohrbach	Hüll cultivar	Non-detectable
Hallertauer Magnum	Rohrbach	Hüll cultivar	Non-detectable
Herkules	Hüll	Hüll cultivar	Non-detectable
Premiant	Hüll	Czech Republic	Non-detectable
Glacier	Hüll	USA	Non-detectable
Columbus	Hüll	USA	Non-detectable
Zeus	Hüll	USA	Non-detectable
Breeding line	Hüll	England	Non-detectable

Outlook

The risk of HSVd infections in Germany cannot be ruled out completely on the basis of these limited results from the Hallertau. Underestimation of the risk could have fatal consequences. These tests will therefore be continued in 2009 with the financial support of the Hop Producer Association HVG. We plan to monitor around 260 hop samples for HSVd during the 2009 project, and hope that this will enable us to rule out HSVd infections in the breeding yards in Hüll, Rohrbach and Freising, in the Society for Hop Research's propagation facilities, and in field crops in the Hallertau, Elbe-Saale and Tettnang hop-growing regions.

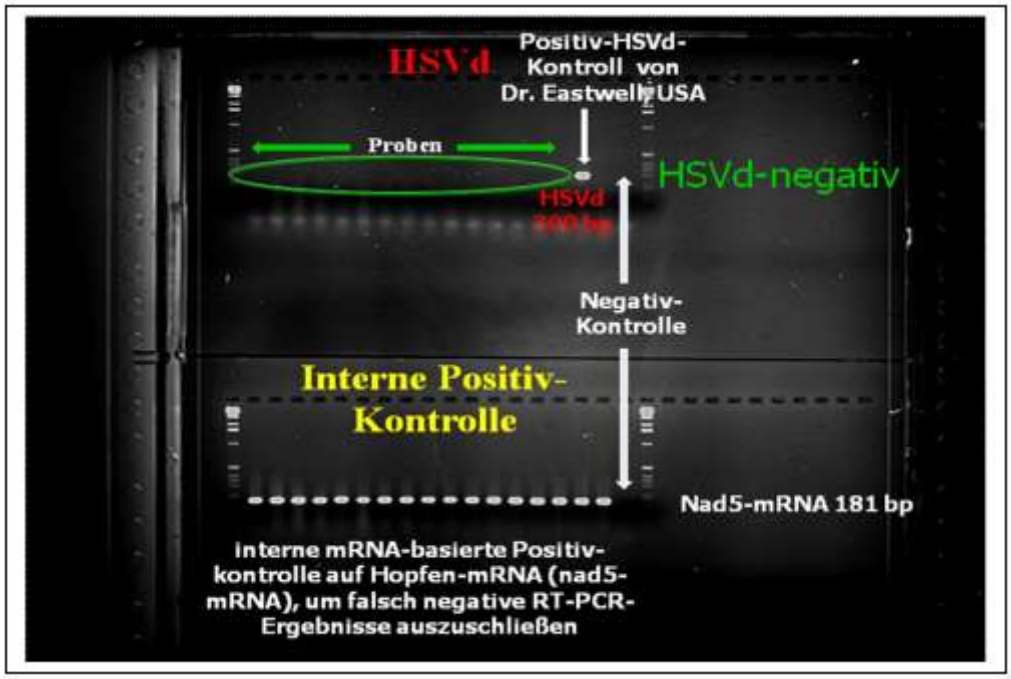


Fig. 4.3: Verification of the absence of HSVd in 12 hop samples from the Hallertau and 3 samples from the USA by RT-PCR (L. Seigner, Plant Diagnostics Laboratory, IPS 2c – 2008)

Our HSVd monitoring technique is a preventive measure against a very real threat. It may enable us to detect initial infection centres early on and implement various phytosanitary measures – of the kind taken in Japan during the 1970s (Takahasi, T. and Yaguchi, S.,1985, Sasaki et al., 1989) – so as to prevent the viroid from spreading further. The economic losses that would be incurred by an HSVd infection would be dramatic, both for German hop-growers and the brewing industry. It is also of crucial importance to monitor hops imported from regions in which HSVd infections have already been detected.

References

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.

Guo, L., Liu, S., Wu, Z., Mu, L., Xiang, B., Li, S., 2008. Hop stunt viroid (HSVd) newly reported from hop in Xinjiang, China. Plant Pathology 57 (4), 764.

Knabel, S., Seigner, L. und Wallnöfer, P.R., 1999. Nachweis des Hop latent Viroids (HLVd) mit der Polymerase-Kettenreaktion (PCR) = Detection of hop latent viroid (HLVd) using the polymerase chain reaction (PCR), Gesunde Pflanzen, Vol. 51, No. 7, 234-239.

Sasaki, M., Fukamizu, K., Yamamoto, K., Ozawa, T., Kurokawa, M., and Kagami, Y., 1989. Epidemiology and control of hop stunt disease. In: Proceedings Int. Workshop on Hop Virus Diseases Rauischholzhausen 1988, (A. Eppler ed.), Deutsche Phytomedizinische Gesellschaft, 165-178.

Takahasi, T. and Yaguchi, S.,1985. Strategies for preventing mechanical transmission of hop stunt viroid: Chemical and heat inactivation on contaminated tools. Z. Pflanzenkr. Pflanzenschutz 92, 132-137.

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 hop production for some years. The aim of this new research project is to characterise the interaction between hop and hop powdery mildew (PM) at cell level in susceptible and resistant varieties. The results allow studying the spatio-temporal reactions. Studies of this kind give us a better understanding of hop – hop powdery mildew interaction, and we can use the new findings in our conventional resistance-breeding work.

A further aim is the functional characterisation of PM-defence-related genes by means of a transient assay system. To this end, individual epidermal cells of PM-resistant or PM-susceptible hop varieties will be transformed with a reporter gene and the test gene.

The behaviour of these transformed cells after contact with the PM fungus will provide information about the function of this gene in the hop – hop powdery mildew interaction (Fig. 4.4). The work is being carried out as part of a Ph.D. Professor R. Hückelhoven of Munich Technical University, Chair of Phytopathology at the Wissenschaftszentrum Weihenstephan, is the cooperation partner.

Method

To establish the transient assay system, a particle gun was used to bombard leaves with gold particles coated with the GUS reporter gene (GUS: glucuronidase). The leaves were then inoculated with powdery mildew spores and the transformed cells stained.

A fluorescence microscope was used to search for transformed cells "attacked" by germinating PM spores. The fluorescent stain WGA-TMR (*Wheat Germ Agglutinin tetramethylrhodamine*) was used to stain for the fungus.

For microscopic investigation of the resistance shown by individual varieties, fungal staining was also performed with an ink/acetic acid solution. To characterise the defence response of hop cells, a fluorescent staining technique for callose and a detection system for H_2O_2 were established (callose is a component of cell-wall appositions, and H_2O_2 accumulates in cell-wall appositions and dead cells).

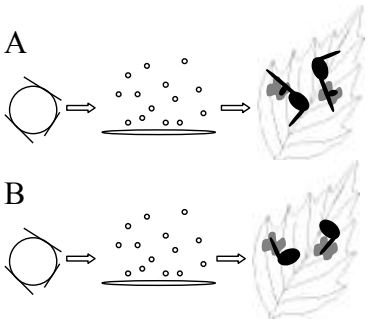


Fig 4.4: Schematic diagram of the transient assay. Gold particles are coated either with just the reporter gene (A) alone or with the reporter gene and, for example, a resistance gene (B). Hop leaves are then bombarded with the particles. Cells of a PM-susceptible variety that have been transformed with the reporter gene only (grey, A) remain "susceptible" (compatible interaction), whereas cells that have been transformed additionally with a resistance gene (grey, B) become "resistant" (incompatible reaction).

Results

Various staining methods for hop powdery mildew were adapted. The fungus is visible in Figs. 4.5 A, B, E and F; it has stained red and yellow with WGA-TMR and blue with ink. In Fig. 4.5 A (inset), haustoria (fungal organs for nutrient uptake) have also stained red. Cell-wall reinforcements and hop cells that die in order to prevent PM infection can be identified with the fluorescent staining technique for callose (Fig. 4.5 B) and the H_2O_2 detection system (Fig. 4.5 D). These methods can therefore be used to characterise defence responses.

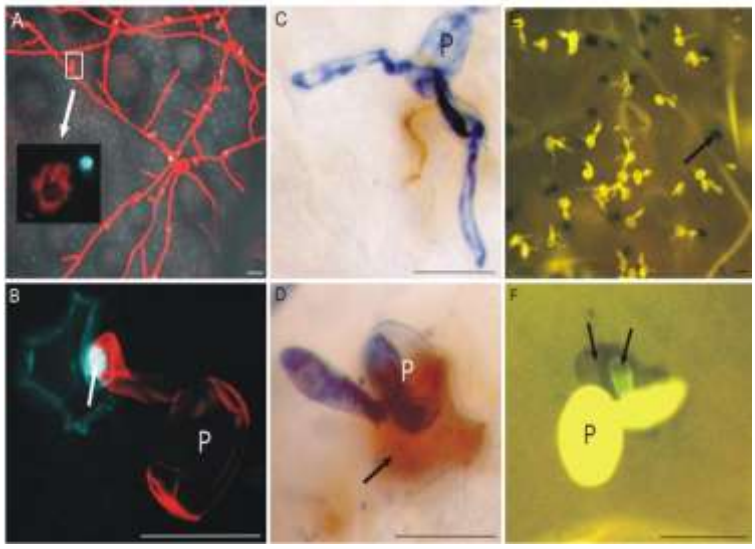


Fig. 4.5: Micrographs of hop – hop powdery mildew interaction (leaf). Scale:bar = 25µm. ***A:*** *Fluorescent staining of hop PM (red) (3 dpi = days post inoculation). A mycelium has formed. Haustoria have also stained red (inset).* ***B:*** *Staining as in A; fungal growth was halted (2 dpi) by cell-wall reinforcement (arrow, blue, contains callose).* ***C:*** *Fungal staining with ink/acetic acid (blue) and staining of H_2O_2 (brown). In contrast to D, a second germ tube indicates successful colonisation (1 dpi).* ***D:*** *Staining as in C; a cell has undergone cell death (arrow) as a defence response. The accumulated H_2O_2 has stained brown (1 dpi).* ***E:*** *Individual epidermal cells have transformed with the help of the GUS reporter gene, and stained blue. The fungal spores have stained yellow (1 dpi) with a fluorescent stain.* ***F:*** *Interaction between a PM spore and a GUS-transformed epidermal cell (blue, arrow). This contains a haustorium (yellow, arrow) (1 dpi). P = PM spore.Micrographs A and B were produced with a Leica confocal laser microscope at the Wissenschaftszentrum Weihenstephan (Prof. Hückelhoven, Munich Technical University), C-F with a Zeiss Axiostar fluorescent microscope at IPZ 5c.*

Following initial tests with GFP (green fluorescence protein), GUS was ultimately chosen as the reporter gene for the transient assay. This gene permits parallel staining of the fungus with WGA-TMR, with which haustoria also become visible. It seems likely from early experiments that 10 - 15 interactions can be evaluated per leaf (Fig. 4.5 F).

Outlook

Now that suitable staining techniques have been established, microscopic examination of varieties interesting for breeding can commence. At the same time, the transient assay will be adapted in a manner that will allow statistically reliable evaluation.

Initially, cells will be transformed with known resistance associated genes that have already proved effective in various other plant species.

4.3 Genome analysis

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

Fig. 4.6: Stages in the isolation of single-spore mycelia from Verticillium-diseased bine sections.

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 have also been affected, not only highly susceptible varieties such as Hallertauer Mittelfrüher. The intention behind this new project, which is being funded by the Hop Producer Association HVG, is therefore to assess the potential risk to the Hallertau by investigating the race spectrum of this fungal pathogen in the Hallertau.

What needs to be clarified is whether agronomic factors, such as excessive mineral fertilisation or the spreading of fresh bine material directly after harvesting, are responsible for the current *Verticillium* problem or whether lethal *Verticillium* strains from England or Slovenia are already making their presence felt in the Hallertau growing region and/or whether new, highly virulent races have meanwhile developed here. The primary aim of this project is to investigate the *Verticillium* race spectrum in the Hallertau in order to develop ways and means of preventing this fungal disease from spreading.

A molecular *in-planta* test based on genetic differentiation and the pathogenicity of the identified strains will also be devised, providing reliable information concerning the risk potential of the specific plants under examination without the need for time-consuming isolation of the fungus. An *in-planta* test will also facilitate the exchange of healthy setts or breeding material.

This project is being conducted jointly with the Slovenian Institute of Hop Research, where *Verticillium* has been a focus of research for many years. The occurrence of lethal strains in Slovenia some 10 years ago necessitated the clearing of around 50 % of the country's entire hop acreage.

Method

In order to differentiate between the *Verticillium* strains collected, the fungus first had to be isolated from each of the infected bines and then cultured. To this end, approximately 2 cm² bine sections from the interior of the 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.

The cultures were then examined microscopically for any foreign fungi, such as *Fusarium* or *Alternaria*, and these petri dishes were removed and discarded. After a further week's incubation, black structures that had developed from the white fungal mycelium were visible in the petri dishes.

These blackish discolorations in the mycelium, visible under the microscope, make it possible to distinguish between the two main *Verticillium* species occurring in hops: whereas *V. albo-atrum* develops black hyphae as resting structures, *V. dahliae* forms black microsclerotia. Once the species had been clearly identified, single-spore mycelia obtained from every petri dish via dilution series with sterile water were plated onto fresh, solidified medium. Optimum genetic differentiation and classification of the newly obtained *Verticillium* samples is only possible with these single-spore isolates.

1-cm² pieces were cut out of the agar plates of the resultant single-spore mycelia and transferred to conical flasks containing 100 ml liquid glucose-peptone medium to allow further growth. Two weeks later, fungal-mycelium growth was sufficient to allow harvesting in a sterile filter paper by means of a suction filter and a water pump. 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 later PCR assays.

Results

In the summer of 2008, work commenced at more than 30 locations on collecting 20-30-cm bine sections from hop yards heavily infected with *Verticillium*. Sections were removed from 123 heavily diseased hop plants and from 28 phenotypically healthy ones in the immediate vicinity of the diseased plants.

Initially, in addition to the above-described culturing of the *Verticillium* fungus (currently 1,845 petri dishes and 300 conical flasks), a qualitative *in-planta* test was performed on the first batch of samples to determine the *Verticillium* species directly from the diseased bines. For these PCR, the primers cited by the European and Mediterranean Plant Protection Organisation (OEPP/EPPO Bulletin, 2007) for detecting *V. albo-atrum* were used.

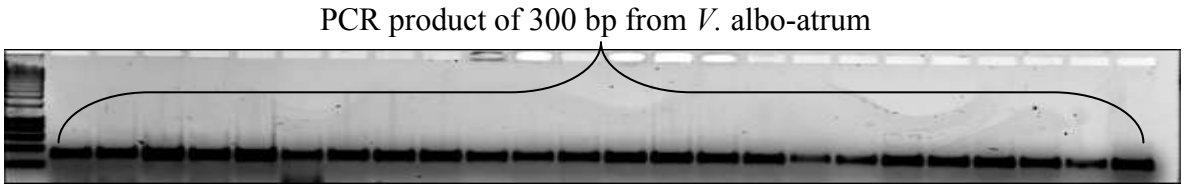


Fig. 4.7: Qualitative in-planta detection of Verticillium albo-atrum in hop bines

Verticillium albo-atrum infection was confirmed microscopically in all 151 samples from severely damaged and phenotypically healthy hop plants. Not a single sample exhibited microsclerotia, which are characteristic of *Verticillium dahliae*. In England and Slovenia, only *V. albo-atrum* has been described as having lethal races.

The DNA is currently being extracted from all 151 samples in order to test it with PCR markers (Radišek et al., 2004; OEPP/EPPO Bulletin, 2007), which differentiated between mild and lethal forms in Slovenian and English *Verticillium* strains. In addition, all the isolates will be differentiated via AFLP.

Outlook

Besides further sampling in the coming summer, the already-sampled hop plants will be observed and evaluated. This will be important for judging the virulence of the Hallertau *Verticillium* strains, and, ultimately, for classifying them as "mild" or "lethal".

In addition, severely diseased hop gardens will be leased to permit better evaluation of the extent to which various crop-husbandry measures influence the *Verticillium*-wilt situation in hop gardens.

References

Doyle, J.J., and J.L. Doyle, 1990. Isolation of plant DNA from fresh tissue. Focus 1990, 12, 13-15.

Radišek, S., Jakše, J., Javornik, B., 2004. Development of Pathotype-Specific SCAR Markers for Detection of *Verticillium albo-atrum* Isolates from Hop. Plant Disease, 88, 1115 -1122.

European and Mediterranean Plant Protection Organisation (OEPP/EPPO) Bulletin, 2007. *Verticillium albo-atrum* and *V. dahliae* on hop, 528-535.

5 Hop cultivation and production techniques

LD Johann Portner, Dipl. Ing. agr.

5.1 N_{min} test in 2008

The N_{min} nitrogen fertiliser recommendation system is now in place and has become an integral part of fertiliser planning on hop farms. In 2008, 3507 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. Average N_{min} levels in Bavarian hop yards were around 20 kg/ha lower in 2008 than in 2007. Compared with the last 10 years, they were average.

As 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 region

Year	Number of samples	N_{min} (kg N/ha)	Recommended amount of fertiliser (kg N/ha)
1983	66	131	
1984	86	151	
1985	281	275	
1986	602	152	
1987	620	93	
1988	1031	95	
1989	2523	119	
1990	3000	102	
1991	2633	121	
1992	3166	141	130
1993	3149	124	146
1994	4532	88	171
1995	4403	148	127
1996	4682	139	123
1997	4624	104	147
1998	4728	148	119
1999	4056	62	167
2000	3954	73	158
2001	4082	59	163
2002	3993	70	169
2003	3809	52	171
2004	4029	127	122
2005	3904	100	139
2006	3619	84	151
2007	3668	94	140
2008	3507	76	153

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 2008.

It can be seen that the highest N_{min} level was recorded in the Spalt hop-growing region and the lowest in the Pfaffenhofen district, followed by Freising and Kehlheim. 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 2008

District / Hop-growing region	Number of samples	N_{min} (kg N/ha)	Fertiliser recommendation (kg N/ha)
Eichstätt	236	83	148
Hersbruck	40	80	135
Landshut	221	77	143
Freising	351	75	153
Kelheim	1414	75	156
Pfaffenhofen	1164	74	154
Hallertau	**3427**	**75**	**153**
Spalt	80	96	125
Bavaria	**3507**	**76**	**153**

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 2008 for various hop varieties in Bavaria

Variety	Number of samples	N_{min} (kg N/ha)	Fertiliser recommendation (kg N/ha)
Herkules	226	74	168
Nugget	60	64	168
Brewers Gold	9	68	165
Hall. Magnum	710	71	160
Saphir	39	72	157
Hall. Taurus	324	78	154
Hersbrucker Spät	167	73	152
Perle	641	76	151
Smaragd	6	70	151
Hall. Tradition	570	81	150
Opal	5	68	150
Spalter Select	191	80	149
Hall. Merkur	13	87	145
Northern Brewer	66	77	144
Hallertauer Mfr.	440	74	142
Spalter	29	95	123
Other	11	89	142
Bavaria	**3507**	**76**	**153**

5.2 Leaf fertilisation trial with Nutri-Phite Magnum S to investigate its influence on yield, alpha acids and plant health

Objective

A three-year trial involving the Nugget cultivar was conducted in a conventionally farmed hop yard to investigate the influence of additional leaf fertilisation with Nutri-Phite Magnum S on yield, alpha-acid formation and plant health. Soil fertilisation was carried out on the basis of the soil test results, including N_{min}.

The product label (as stipulated by the German Fertiliser Ordinance) for Nutri-Phite Magnum S lists 5 % N in the form of ammonium-N, 38 % P_2O_5 in the form of water-soluble phosphate and 15 % K_2O in the form of water-soluble potash. According to the distributor, the phosphorus is present in the form of phosphite, which can be taken up via the leaf.

Method

In variant 1 (0 plot with 2 replications), no Nutri-Phite was applied and the stand was not sprayed until flowering commenced, after which spraying was conducted in response to peronospora spray warnings. However, the stand was examined for peronospora infection at close intervals and immediate fungicide application planned in the event of incipient infection. The intention was to monitor the outbreak of secondary peronospora infections in these plots compared with the treated plot variants 2 and 3.

In variant 2, with 3 replications, Nutri-Phite Magnum S was applied according to the following Table. As of flowering, it was applied in combination with registered fungicides in response to spray warnings.

Table 5.4: Application schedule for Nutri-Phite Magnum S in variant 2

Growth stage	(15) 15–40 cm plant ht.	(35) ½ trellis ht.	(>35) ¾ trellis ht.	(38) Full trellis ht.	(65) Flowering	(75-79) Cone form.
Nutri-Phite Magnum S	1.5 l/ha	1.5 l/ha	1.5 l/ha	1.5 l/ha	1.5 l/ha + Forum	1.5 l/ha + Forum

In variant 3 (customary procedure, with 3 replications), no Nutri-Phite Magnum S was used and secondary peronospora treatments were performed in response to spray warnings.

All the plots were treated once annually with Fonganil Gold to control primary peronospora.

Results

The slightly higher yields (averaged over the 3 trial years) obtained on the plots of trial variants 1 and 3 than on the plots of variant 2 are not significant. By contrast, the lower alpha-acid values (content in % and yield in kg/ha) obtained on the plots treated with leaf fertiliser (variant 2) compared to those obtained on the plots treated in the customary way (variant 3) are statistically significant.

Assessment of the hop stands that received Nutri-Phite leaf fertiliser showed them to be a richer green, to have larger leaves and a healthier appearance. These characteristics did not translate into a measurable increase in yield or components content.

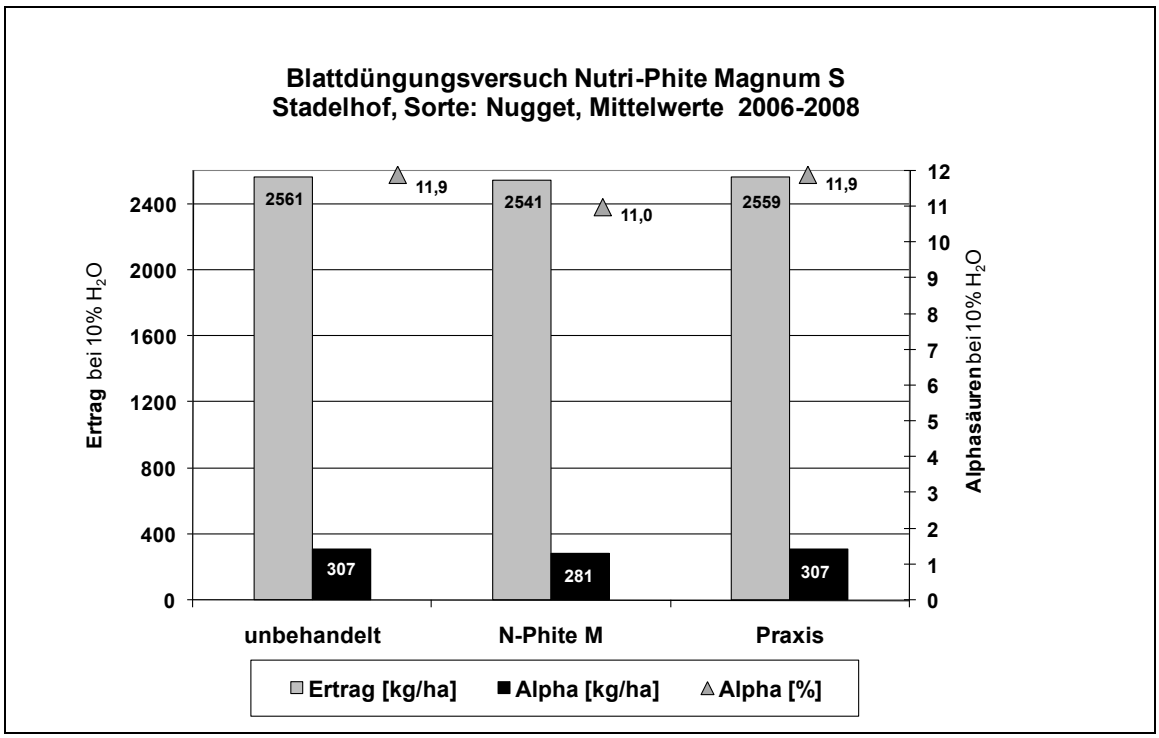


Fig. 5.1: Influence of Nutri-Phite leaf fertilisation on yield and alpha acids

The influence of the six phosphoric-acid applications on crown or rootstock health was assessed early in the spring of the third trial year, at the time of uncovering and pruning the rootstock. Six rootstocks from the middle of each plot were assessed, all of them thus having the same interplant spacing. Each plot comprised 3 rows of 10 plants each. Each crown had up to six shoots, which were evaluated according to the parameters listed in Table 5.5. No clearly evaluable and summable differences between the variants are evident on the basis of these underlying parameters.

Table 5.5: Shoot evaluation directly after rootstock pruning

Parameters	**Variant (mean)**		
	1	**2**	**3**
Number of eyes per shoot	12.2	11.3	12.0
Number of eye levels per shoot	2.2	2.2	2.2
Diameter in mm at pruning site	19.2	18.9	19.3
Fine roots on the shoot; rating 0-10 (plus points)	5.5	5.8	5.7
Health of pruníng site; rating 1-10 (plus points)	5.9	5.9	5.8

Nutri-Phite Magnum S had a fungicidal effect on downy mildew (*Pseudoperonospora humuli*) until cone formation. Despite the spraying of fungicides as of flowering, primary peronospora infections were observed in the 0 plots during advanced cone formation as of mid-August in each trial year. Cone evaluation on dried hops showed that of the 3 trial variants, the Nutri-Phite Magnum S variant was least infected.

However, observations to date indicate that on its own, leaf fertilisation with Nutri-Phite Magnum S is unlikely to be sufficiently effective against secondary peronospora infections.

Table 5.6: Assessment of approx. 250 cones for Peronospora (number of diseased cones and severity of infection)

Vari-ant	Replication mean 2006			Replication mean 2007			Replication mean 2008			Mean 2006-2008		
	high	mediu m	low	High	mediu m	low	high	mediu m	low	high	mediu m	low
1	4.3	7.5	4.0	11.0	9.5	8.0	6.3	6.3	2.0	**7.2**	**7.8**	**4.7**
2	1.3	3.0	3.7	3.0	5.3	6.0	2.7	2.0	1.3	**2.3**	**3.4**	**3.7**
3	5.3	1.7	7.0	4.0	7.0	7.0	5.3	4.3	2.7	**4.9**	**4.3**	**5.6**

5.3 Development and testing of an innovative measuring system to further optimise drying performance

Enhanced performance and energy savings through optimised airflows

Drying performance can be enhanced and energy input minimised by optimising airflows in floor kilns. Since hops lose water as they dry in the kiln, thus becoming lighter, the resistance to the airflow diminishes. A constant rise in air speed can therefore be expected until the hops are tipped. This weight-loss effect is furthermore variety-dependent. Ideal drying performance therefore necessitates continuous air-speed regulation.

Air-speed determination via oil consumption

As spot air-speed measurements are of little use due to uneven drying, the goal was to devise a measuring system that would allow mean air speed across the entire drying surface to be computed. Uneven drying is usually a result of nest formation or non-uniform air distribution in the kiln.

To obtain a meaningful reference value, Dr. Albert Heindl (Heindl GmbH, Mainburg) proposed that air speed during drying be determined via the oil consumption of the air heater. To this end, he provided a thermodynamic formula for compiling a table from which the air speed can be read off in m/s as a function of oil consumption and the temperature difference between drying air and intake air. This method (see Annual Report 2007, p. 46-47) serves initially as a simple and fast way of estimating mean air speed. The drawback is that the current air-speed value is not continuously available.

New measuring system for continuous determination of air speed

Working closely with the LfL's Hop Cultivation/Production Techniques work group, ATEF Euringer & Friedl GmbH has developed a prototype of a fully automated air-speed meter intended to provide highly accurate air-speed measurements on a real-time basis.

This was achieved by means of a purpose-built microcontroller capable of measuring all the drying parameters and performing the thermodynamic calculations in order to reduce the abundance of data to the relevant drying parameters.

New drying parameter: “moisture extraction rate”

The high drying performance associated with the correct air speed is also extremely energy efficient, as a very large volume of water is removed. Air speed must therefore be constantly regulated from the time of loading to the time of emptying a kiln charge in a manner that guarantees maximum water extraction during the entire drying process. This necessitates a measuring system capable of continuously calculating and displaying the extremely important drying parameters “kiln air speed” and “moisture extraction via exhaust air”.

The parameter “moisture extraction rate” proposed by ATEF Euringer & Friedl GmbH, which is displayed as ml water/m² drying surface/min, proved especially useful in practice. In future, it will be possible to monitor and control every kiln at any point in time by means of the thermodynamically computed parameters "air speed" and "moisture extraction rate".

Initial measurements in hop-kiln trials

This measuring system was installed for testing purposes in a number of hop kilns, and was already used in 2008 in experiments to improve and optimise drying performance and energy efficiency.

So far, the air speeds measured in floor kilns have ranged from about 0.25 to about 0.45 m/s, with large differences in drying performance and kiln-specific energy consumption. Numerous evaluations have produced initial trends indicating the range in which optimum drying is possible.

During drying, the current air speed and moisture-extraction rates were displayed in m/s and ml/m²/min respectively. This made it possible, for the first time ever, to set the air speed in each test kiln to a value that will always ensure maximum moisture extraction via the exhaust air. During the 2008 harvest, the moisture-extraction rates in the various trial kilns averaged 280–550 ml/m^2/min. Drying performance ranged from 4 to over 8 kg dry hops/m² drying surface/h drying time. Lower drying performance was associated above all with kilns that had under-dimensioned blowers, making it impossible to increase the air speed to 0.4 m/s when necessary.

The higher the average moisture-extraction rate during the drying period, the higher the drying performance in kg dry hops/m² drying surface/h drying time.

Every kiln offers potential for increased drying performance and/or lower energy input.

Drying performance in kg/m²/h was found to be highest in kilns where, for a total cone depth of 110-120 cm (all floors together), it was possible to increase the air speed to 0.4 m/s at the time of maximum moisture loss from the green hops.

In kilns with sufficient blower capacity, it was possible to increase drying performance still further by regulating the air speed as a function of maximum moisture extraction until the hops on the upper floor were tipped. Controlling the air speed in this way not only increased drying performance but also reduced energy consumption!

After charging the upper floor of kilns with limited blower capacity, it was initially only possible to achieve air speeds of 0.25-0.3 m/s for a total cone depth of 110 -120 cm. Moreover, only a slight increase in air speed was observed up until tipping.

It was found that drying performance in kilns with limited blower capacity can be increased by reducing the cone depth. Depending on the variety, a cone depth was selected which, at full blower output, allowed 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. This height was variety-specific.

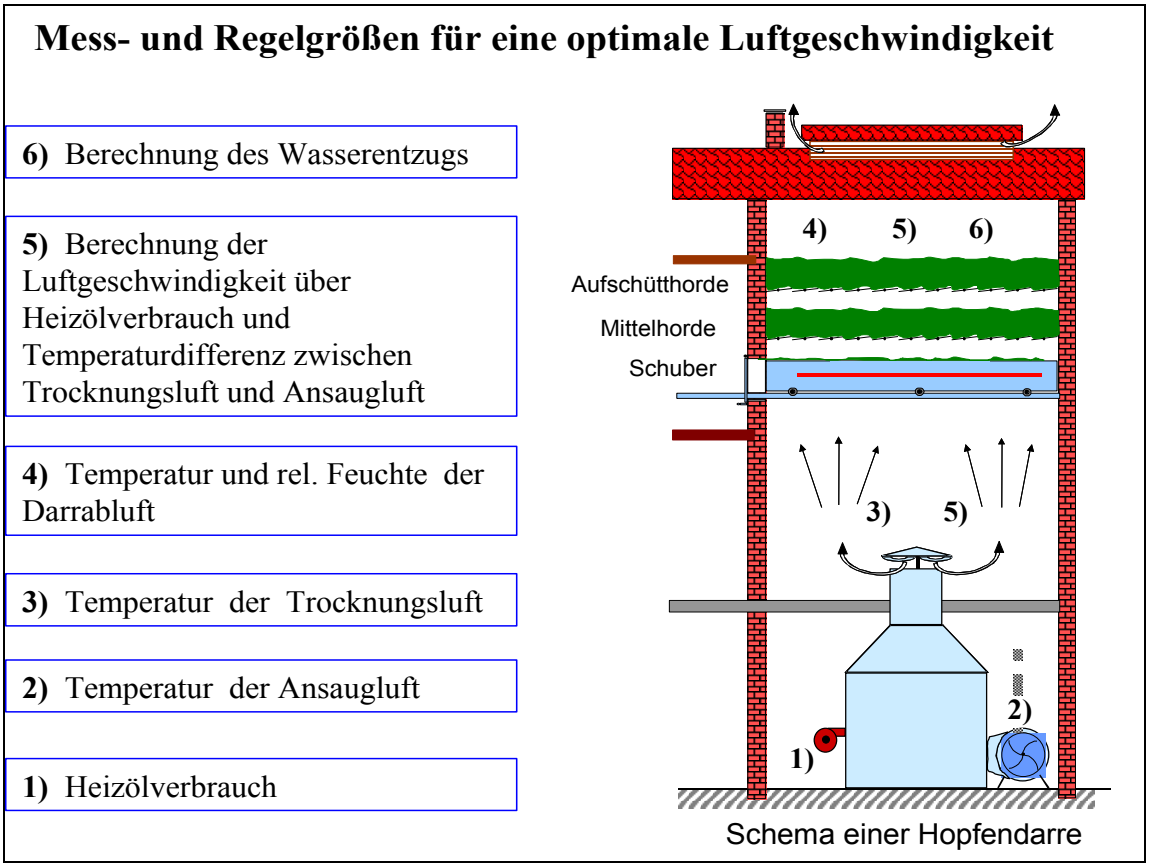


Fig. 5.2: Required drying parameters for the fully automated air-speed meter

Consequences for practical application

For the first time ever, this innovative measuring system will allow the current status of a floor kiln to be determined at any time during operation. It will be possible to analyse any kiln on the basis of the above drying parameters, and, if necessary, to pin-point the best way of optimising its performance. Conditions in kilns with high drying performances can be replicated in other kilns.

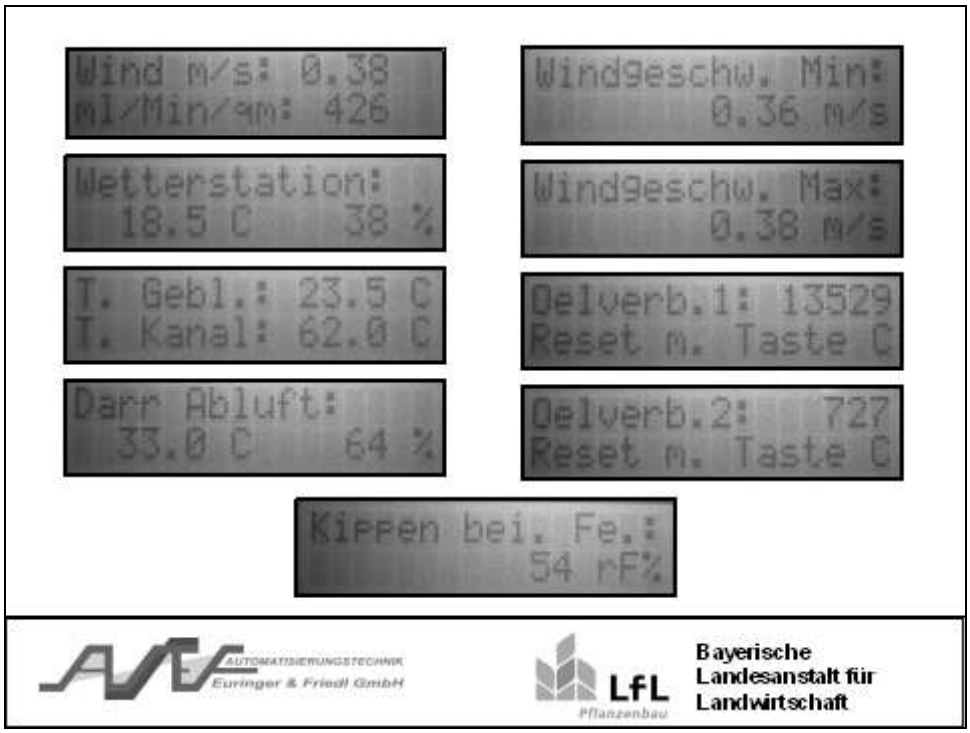


Fig. 5.3: Sample display of practice-oriented drying parameters supplied by the newly developed measuring system.

5.4 Introduction of the Joint Advisory System

Necessity

EU competition law and the continuous cutbacks in agricultural consultancy personnel made it necessary to amend the Law on Assistance to Bavarian Agriculture (Landwirtschaftsförderungsgesetz) in order to ensure the continued availability of a state-wide, competent and unbiased advisory system. As of January 1st, 2008, agricultural production consultancy has been jointly performed by government advisory teams and accredited non-government service providers, as laid down in Art. 9 of the new Rural Economy Law (Agrarwirtschaftsgesetz). In the field of hop production, the Hop Cultivation/Production Techniques work group at the LfL's Institute for Crop Science and Plant Breeding carries out the advisory tasks of the government partner, while the non-government Hallertau Hop Producers' Ring (a branch of the LKP, Bavaria's crop-production association) is the accredited partner. Cooperation between the two partners is regulated by the Joint Advisory System Contract. The government advisory team defines the consultancy goals, liaises with the Ring consultants, provides them with expert support and information, and organizes regular training sessions for them. For their part, the Ring consultants provide state-wide advisory services in specified fields on a case-by-case basis. 50 % of the cost of these services to hop growers is funded by the state. The Ring consultants are also responsible for various other advisory services, e.g. special group-consultancy sessions and the provision of information via circulars, fax, internet and the service hot line.

The aim of the Joint Advisory System is to provide unbiased, competent and affordable advice on a state-wide basis.

Implementation

Both advisory-service partners, the government hop consulting team from the LfL and the Hallertau Hop Producers' Ring, had already cooperated successfully in the past, working next door to each other in the "House of Hops" in Wolnzach. The fact that they already knew one another and their proximity proved very beneficial when the Joint Advisory system was introduced, as was the fact that, through its support initiatives, the Hop Producers's Ring had already had some experience in providing case-by-case advice to hop growers. It was thus possible to build on existing structures during implementation of the Joint Advisory System.

Hop growers seeking case-by-case advice can choose from a number of advisors with different qualifications. While the work of the 14 Ring consultants (as a rule Master Farmers) is limited to performing stand assessments and providing basic fertilisation advice, 2 Ring experts (with degrees in agriculture) and 1 technical consultant are available for providing advice on more complex issues.

Advisory fees thus vary according to consultant qualification and length of consultation. The Ring consultants attend 8 training sessions held fortnightly by the LfL's hop-consulting specialists from mid-May until early August. The LfL team exchanges notes briefly with the Ring experts 3 times a week. These measures ensure that the non-government advisors are always informed about the latest developments, and the LfL's consultancy goals and plant-protection strategies are uniformly implemented.

For the provision of other advisory services, use is still made of media such as circulars, fax messages and the internet. The number of special group-consultancy sessions offered has been increased, and a free-of-charge expert hotline introduced.

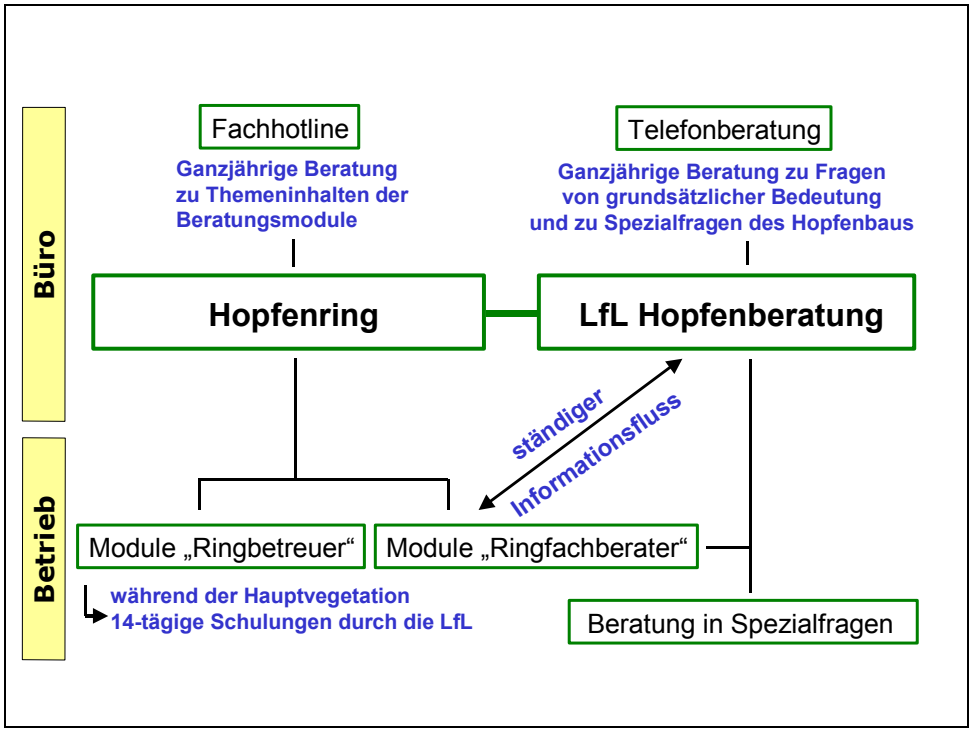


Fig. 5.4: Diagram showing the joint advisory services available to hop growers on a case-by-case basis

Results

Owing to the established advisory structures and the private partner's commitment, contracts involving 639 farm visits were concluded by 408 hop growers during the very first year of the joint advisory system's existence. 409 of these visits were made by Ring advisors and 230 by the Ring experts and technical consultant. Additional advisory services took the form of 58 group consultations, seminars and lectures, 4 circulars, 53 faxes, the provision of diverse information material, and an expert hotline. The fact that as many as 31 % of the relatively small number of hop farms in Bavaria (= 1296) concluded such contracts attests to the successful introduction of the Joint Advisory System for hop growers. The availability of supplementary government consultancy on business management or special issues relating to production techniques makes up for any otherwise existing deficits, meaning that hop growers in Bavaria have access to state-wide, comprehensive, unbiased, competent and, moreover, affordable advisory services at all times.

5.5 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 peronospora warning service and updating the relevant data, cooperating with the hop organisations, providing training and expert support for its joint service provider, the Hop Producers' Ring. The group's training and advisory activities in 2008 are summarized below:

5.5.1 Written information

- The 2008 "Green Pamphlet" on Hops – Cultivation, Varieties, Fertilisation, Plant Protection and Harvest – was updated jointly with the Plant Protection work group following consultation with the advisory authorities of the German states of Baden-Württemberg, Thuringia, Saxony and Saxony-Anhalt. 2880 copies were distributed by the LfL to the national agencies for agriculture (ÄfL) and research facilities, and by the Hallertau Hop Producers' Ring to hop growers.
- 33 of the 53 faxes sent in 2008 by the Hop Producers' Ring to 990 recipients contained up-to-the-minute information from the work group on hop cultivation and spray warnings.
- Updated information was likewise made available at weekly intervals for the weather data fax.
- 3507 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 3 circulars issued by the Hop Producers' Ring and in 8 monthly issues of the magazine "Hopfen Rundschau".
- 598 field records (from 151 hop growers) on the 2008 hop harvest were evaluated with the "HSK" recording and evaluation program and returned to farmers in written form.
- Internet and Intranet

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

5.5.2 Telephone advice and message services

- The peronospora warning service, established jointly by the Hop Cultivation/Production Techniques work group (Wolnzach) and the Plant Protection work group (Hüll) and updated 72 times during the period from 13.05.2008 to 25.08.2008, was available via the answerphone (Tel. 08442/9257-60 and 61) or via the Internet.
- 19 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 Hop Cultivation/Production Techniques work group answered around 3,000 special questions by telephone or provided advice in one-to-one consultations, some of them on site.

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

- 8 training sessions for consultants from the Hallertau Hop Producers' Ring
- Note swapping with the Ring experts 3 times weekly during the vegetation period
- 9 meetings on hop cultivation, organised jointly with the Food, Agriculture and Forestry Offices (ÄLF)
- 70 talks
- 2 exhibition posters
- 20 guided tours through trial facilities for hop growers and the hop industry
- 8 workshops and seminars
- 1 equipment demonstration to test sensor technology in plant protection
- 1 conference and exhibition on hop irrigation
- Hop colloquium (2-day conference) in Spalt

5.5.4 Basic and advanced training

- Setting of 1 Master's examination topic and assessment of 7 work projects for the examination
- 16 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
- One "BiLa" seminar (educational programme for farming), in 4 evening sessions

6 Plant protection in hops

LLD Bernhard Engelhard, Dipl. Ing. agr.

6.1 Pests and diseases in hops

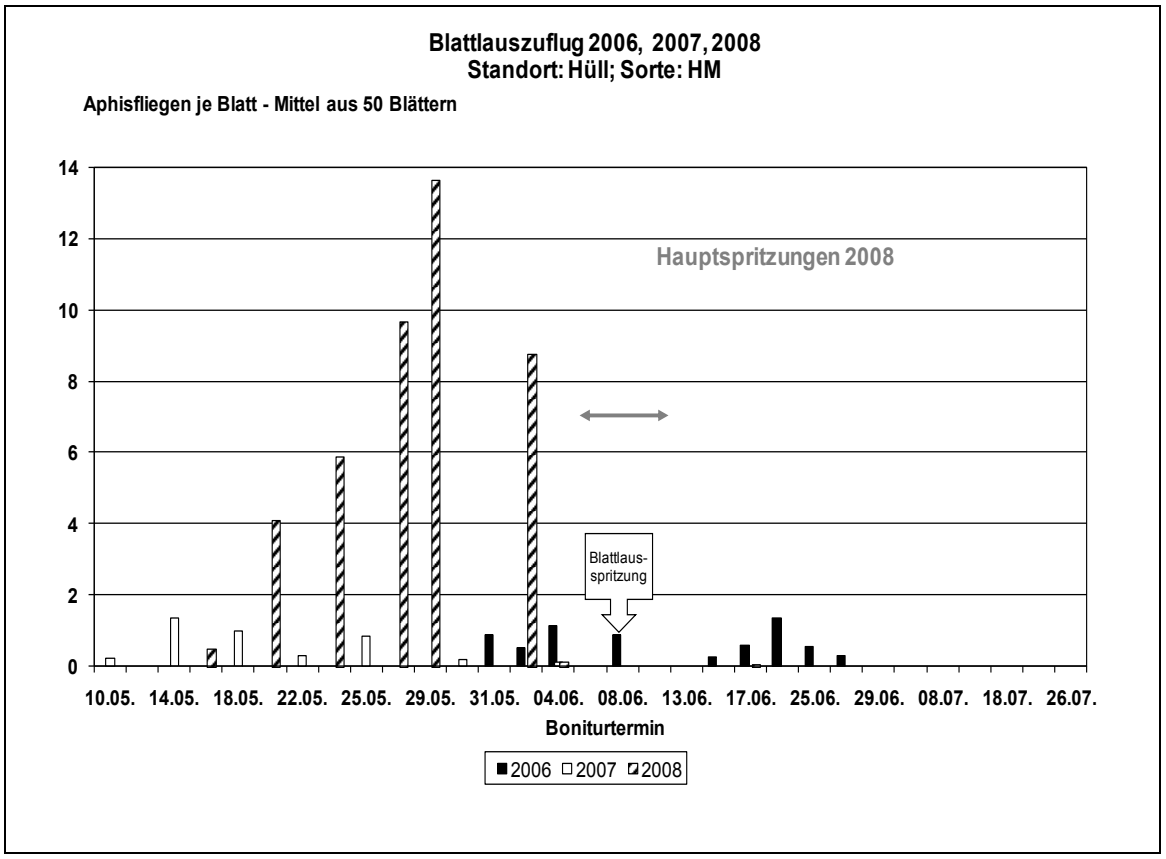


Fig. 6.1: Aphid migration

In 2008, unusually early and very intense aphid migration as of May 13th (individual observations) meant that the control threshold was reached very quickly in many hop yards. On account of the high aphid count per leaf (frequently more than 2,000), a single spray application was insufficient to completely eradicate the pest.

In most cases, two treatments were necessary to ensure an aphid-free hop crop. However, 2008 also saw a decrease in aphid population during the second half of June and early July in almost all the unsprayed plots.

A fungal infection was observed in the aphid colonies and the Asian ladybird beetle (*Harmonia axyridis*), first seen in 2007, had become widespread throughout the Hallertau and probably helped to reduce aphid counts.

6.2 Major scientific findings on the biology of powdery mildew (*Podosphaera macularis*)

Important data on the pest's biology, to be used as the basis of a forecasting model for powdery-mildew (PM), was obtained in the course of a research project.

1. Overwintering form and primary infection source

   - Evidence of a mycelial overwintering form was found in wild hop plants and hop-yard plants that had not been pruned. Individual plants of this kind were shown to be the source of primary infection.
   - Cleistothecia, as the resting form, were overwintered under various conditions:
     dry, 0 – 10 °C = 95 % viability
     frozen, - 18 ° C = 92 % viability
     hop yard = < 0.59 % viability
     Infection tests with viable cleistothecia were then conducted on plants with a high risk potential. It was not possible to induce new infections with the ascospores contained in these cleistothecia.
     So far, it has proved impossible to experimentally induce infection with ascospores.

2. Efficacy of plant protectives as a function of sporulation periods

   - Leaves that emerge after a plant has been sprayed with plant protectives are not protected against new infections by spores; this applies to all currently-registered products for PM control.
     Consequence: spraying must be timed to coincide with sporulation.

3. "Risk potential" studies

   - Leaves from nodes two to four are susceptible. Age-related resistance sets in as of leaf node five.
     The number and surface area of susceptible leaves are combined to produce what is known as the "risk potential".
     The studies show that risk potential rises steeply as of bud break in spring and starts receding as of early June. As of 10 – 15th June, it is no longer possible to infect the hitherto highly susceptible leaves from nodes 2 – 4 with PM.
   - Treatment with plant protectives reduces the risk potential.
   - New: risk potential increases again as of early September. The threat of late PM infection increases as a result.

4. Influence of weather conditions on infection (biological preferences)

- Twenty-five young plants of five different varieties (five plants per variety) were inoculated in sealed plastic cages. A total of 56 different combinations of weather conditions were tested. The most important results:
  - Temperature has a strong influence on infection severity and incubation time; optimum: 8 – 25 °C
  - Day/night temperature differences have a strong influence on incubation time; optimum: < 5 °C

    The microclimate plays a role. The temperature difference between the plant centre and the hop yard is up to -0.5 °C at night and up to + 3.0° C during the day.
  - Relative humidity does not influence incubation time.
  - Light intensity has a strong influence on infection severity.
- Summary of "weather conditions and their influence on incubation time and infection severity":

Strong influence	Slight influence	No influence
Temperature	Leaf-wetness duration	Rel. humidity
Light intensity	Wind speed	Length of day
Day/night difference (°C)	Rain intensity	Dew

Status of a forecasting model for hop powdery mildew

- The data from the LfL's agrometeorological weather station were used, together with the biological preferences, to generate an hourly algorithm. Daily infection values obtained during four-day periods were added together (4-day totals) and averaged. This average was combined with the risk potentials of susceptible and less susceptible varieties to produce variety-dependent disease forecasts. A distinction is still made between
  - disease forecasts based on incubation time (4-day totals) and
  - disease forecasts based on severity of infection (4-day totals)
- In 2008, a "weather-based forecasting model" was developed by project engineer Stefan Schlagenhaufer.

  What still needs to be clarified is precisely when the "threshold" for issuing a variety-dependent spray warning has been reached.
- Comparisons with the existing "preliminary forecasting model" were carried out, and the two models were found to correlate closely.

7 Hop quality and analytics

ORR Dr. Klaus Kammhuber, Dipl. Chemiker

7.1 General

Hops are grown primarily for their components, which is why hop-component analysis is essential to successful hop research. The IPZ 5d team (Hop Quality and Analytics work group) carries out all analytical studies needed to support the experimental work of the other work groups.

The hop plant has three groups of components relevant to brewing: bitter compounds, essential oils and polyphenols. The most important components for qualitative assessment and, to an ever-increasing extent, hop prices, are the α acids. The essential oils give hops their characteristic scent and aroma. Their sedative properties can be exploited medicinally.

The third group of hop components, the polyphenols, are attracting ever-increasing interest. Their ability to function as anti-oxidants and free-radical scavengers endow them with numerous health-giving properties. Two hop polyphenols especially worthy of note are xanthohumol and 8-prenylnaringenin. Most important among the many useful properties of xanthohumol is its significant anti-carcinogenic potential.

8-Prenylnaringenin is one of the most potent phyto-oestrogens, and is responsible for the slightly oestrogenic effect of hops. The wide variety of hop components could open up alternative fields of use for the plant outside of the brewing industry, e.g. in the food industry, as an ingredient in cosmetics and medicines, and in functional foods and dietary supplements.

7.2 Component optimisation as a breeding goal

7.2.1 Brewing industry requirements

In May 2008, an international symposium entitled “Hop Growing in 2020” was held in Wolnzach, which included discussions on component requirements. There is a demand for hop varieties with a maximum α-acid content that fluctuates as little as possible from year to year. A low cohumolone content is of little importance as a quality parameter these days.

For downstream and beyond-brewing products, high-alpha varieties with a high cohumolone content are even sought after.

The essential oils are responsible for hop aroma. To ensure product diversity, the industry wants aroma cultivars with varying combinations of hop oils to be grown. Key substances for hop aroma include linalool, humulene, caryophyllene and myrcene.

Polyphenols are partly responsible for the bitter taste imparted by hops, and sometimes serve an additional functional purpose. The industry would like to see an increase in low-molecular polyphenols, such as xanthohumol, prenylflavonoids and phenolic carboxylic acids.

7.2.2 Alternative uses

Beta acids are of no great importance in beer brewing as they are largely lost during the process. However, they do show antimicrobial activity against gram-positive, pathogenic bacteria. This property can be exploited by utilizing ß-acids as natural biocides wherever bacteria need to be kept under control.

The sugar and ethanol industries, for example, have already begun replacing formalin with ß-acids. Other potential applications exploiting the antimicrobial activity of hop beta acids include 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, there will probably be a considerable demand for hops for use in these fields of application. In Hüll, breeding activities now include selecting for ß-acid content, and there is even a breeding line available which, by virtue of a mutation, produces only ß acids.

Another field of alternative use is that of health and wellness. Hops could be used in dietary supplements, functional foods and medicines. As mentioned in the introduction, xanthohumol, in particular, is a substance with noteworthy properties. Of all the commercially produced hop varieties, the Hüll cultivar Hallertauer Taurus has the highest xanthohumol content, namely 1 %. However, a breeding line containing 1.7 % xanthohumol is already available.

A higher xanthohumol content is a defined breeding goal. 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 %, is a very powerful anti-oxidant. This substance, considerable amounts of which are also contained in apples, is deemed extremely beneficial to health.

The content of other polyphenols, such as the catechins and proanthocyanidins, correlates inversely with alpha-acid content. Aroma hops generally have a higher polyphenol content than bitter hops. As yet, no selective crosses have been performed to increase overall polyphenol content. However, Hüll can react if specific components are desired.

7.3 Development of analysis methods for hop polyphenols

Since hop polyphenols are attracting more and more interest, it is important that analysis methods be developed for this substance group. Hops can contain up to 8 % polyphenols.

More than 80 % of hop polyphenols comprise high-molecular compounds such as catechin tanning agents and tannins. Around 20 % consist of monomeric substances such as xanthohumol, phenolic carboxylic acids, flavonoids and their glycosides (Table 7.1).

Table 7.1: The composition of hop polyphenols and their concentrations in hops

Substances and substance groups	**Concentrations**
Phenolic carboxylic acids	
1) Benzoic acid derivatives	< 0.01 %
2) Cinnamic acid derivatives	0.01 – 0.03 %
Flavonoids	
3) Quercetin glycosides	0.05 – 0.23 %
4) Kaempferol glycosides	0.02 – 0.24 %
5) Catechins and epicatechins	0.03 – 0.11 %
6) Proanthocyanidins	0.06 – 0.11 %
7) Xanthohumol	0.20 – 1.00 %
High-molecular substances	
8) Catechin tanning agents and tannins	2.00 – 7.00 %

There are as yet no official methods available for analysing hop polyphenols. The plan is therefore to develop quantitative methods for determining total polyphenols, total flavonoids and individual components, and to standardize these methods within the *Arbeitsgruppe für Hopfenanalytik (AHA).*

Methods of measuring total polyphenol content and total flavonoid content have already been devised and tested in ring tests. To start with, a hop hot-water extract is prepared. On addition of an iron (III) reagent, the polyphenols form brown complexes that can be measured with a spectrophotometer. The intensity of the discolouration is a measure of the concentration. For the quantitative determination of flavonoids, a p-dimethylaminocinnamaldehyde solution is added to the hot-water extract. The flavonoids react to form violet compounds that can be quantified spectrophotmetrically. The last ring test produced the following results (Table 7.2)

Table 7.2: Ring test to determine total polyphenol and flavonoid contents

Sample	**Mean in %**	**cvr**	**cvR**	**Number of laboratories**
Pellet 1/Total polyphenols	6.65	1.7	9.4	6
Pellet 2/Total polyphenols	3.71	3.5	16.2	6
Pellet 1/Flavanoids	1.19	3.3	9.5	6
Pellet 2/Flavanoids	0.47	5.0	9.7	6

The coefficient of variation, cv, is simply the standard deviation divided by the mean. It should not exceed 5 % for a good analytical method. The cvr's (variation coefficients within the laboratories) are relatively good. The cvR's (overall variation coefficients), especially for total polyphenols, show room for improvement. Work is underway to improve these analytical methods.

Xanthohumol is analysed together with the bitter compounds. The Hüll laboratory has been equipped with a UHPLC system since May 2008, and work on developing methods for analysing low-molecular polyphenols has begun. In hops, quercetin und kaempferol occur exclusively as glycosides. Once the sugar has been split off hydrolytically, they can be determined quantitatively by HPLC. In an initial ring test, the HPLC method was tested on these two substances by 3 laboratories. Table 7.3 shows the results.

Table 7.3: Ring test to determine quercetin and kaempferol

Lab.	Quercetin in %				Kaempferol in %			
	Pellet 1		Pellet 2		Pellet 1		Pellet 2	
	Det. 1	Det. 2	Det. 1	Det. 2	Det. 1	Det. 2	Det. 1	Det. 2
1	0.05	0.05	0.02	0.03	0.03	0.03	0.01	0.01
2	0.10	0.10	0.05	0.04	0.07	0.07	0.02	0.02
3	0.09	0.09	0.05	0.04	0.05	0.05	0.01	0.01

The orders of magnitude are correct, although the very low concentrations involved naturally make for relatively large analytical differences.

7.4 Initial experiences with the UHPLC system

In May 2008, a UHPLC system was commissioned in the Hüll laboratory. 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 silica particles measuring as little as 1.9 µm in diameter. Columns of this kind permit very fast, high-resolution separation. Figure 7.1 shows a chromatogram of hop bitter compounds, performed with a short (100 mm) 1.9 µm column. The analysis takes 4 minutes.

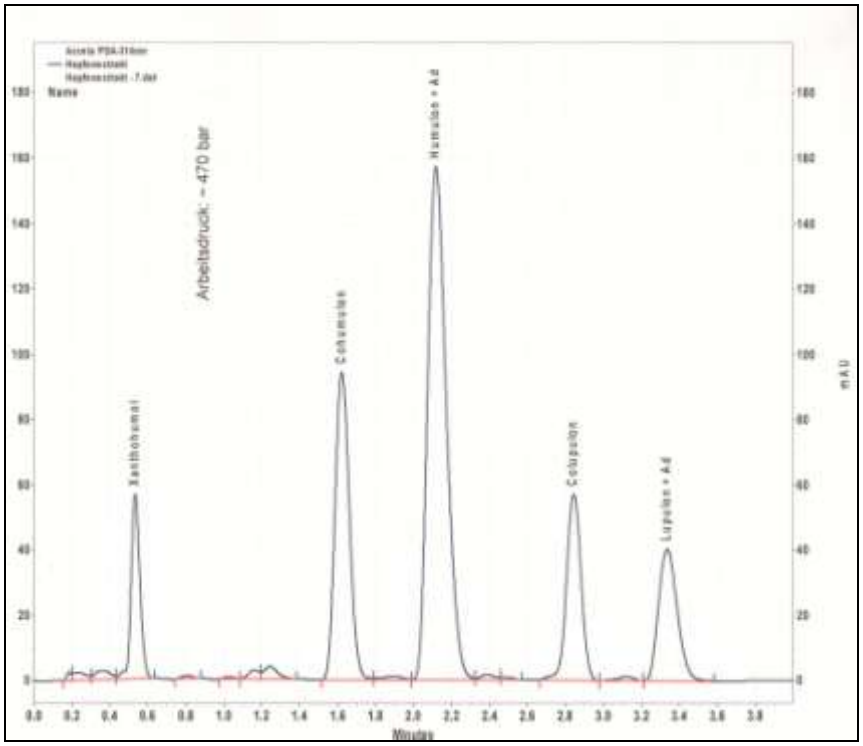


Fig. 7.1: Bitter-compound chromatogram with a 100 mm, 1.9 µm column

A conventional HPLC analysis as per EBC 7.4 takes 25 minutes. The UHPLC clearly brings enormous savings in time and solvent. However, this method has not yet been tested for continuous, routine service. Columns packed with a 1.9 µm filling tend to get blocked easily. For this reason, a 125 mm, 3 µm column is currently being used in Hüll. The analytical run time is 11 minutes, and the method is very stable. The samples provided for the ring test in 2008 were measured by conventional HPLC and by UHPLC. On average, the UHPLC values were 0.92 % higher for the α acids and 4.43 % lower for the ß acids.

A strong innovation drive can currently be witnessed in the development of new equipment and column packings for HPLC analysis, and substantial advances may be anticipated for the future. Procurement of the UHPLC system was an important investment for Hüll, keeping it in line with the latest state of the art in hop analytics.

7.5 World hop range (2007 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 7.4 shows the results for the 2007 harvest. It may be helpful in classifying unknown hop varieties.

Table 7.4: World hop range, 2007

Variety	Myr-cene	2-M.-iso-butyrate	Sub. 14 b	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	2492	788	9	17	37	0	7	287	6	6	4	2	20	0	0	14,8	5,8	0,39	33,5	64,9
Agnus	2888	88	1	4	9	1	3	132	0	5	6	5	13	0	0	10,8	6,6	0,61	39,8	59,1
Ahil	2628	419	18	3	12	1	6	186	32	5	7	5	16	0	0	8,6	3,4	0,40	32,8	63,4
Alliance	840	93	1	2	13	0	4	287	3	6	4	4	15	0	1	4,4	2,9	0,64	27,0	48,9
Alpharoma	343	235	28	4	8	0	13	354	7	11	6	3	25	0	0	7,4	3,8	0,52	29,4	55,3
Apolon	2571	125	10	5	17	0	3	200	31	5	7	4	14	0	0	5,8	3,3	0,56	35,9	60,0
Aquila	1333	60	4	38	28	0	19	18	0	12	87	89	14	111	0	4,1	4,0	0,96	54,3	74,2
Aromat	1939	11	2	6	32	0	20	288	20	7	8	5	17	4	0	2,9	4,0	1,38	24,1	41,6
Atlas	1607	637	19	5	13	1	2	198	22	5	9	6	15	0	0	7,5	3,7	0,50	33,7	61,2
Aurora	6084	187	2	42	32	0	18	262	31	4	4	2	14	0	0	8,6	4,1	0,47	23,2	52,1
Backa	1459	451	4	14	21	0	8	277	13	7	5	3	19	0	0	7,1	4,1	0,58	38,1	62,8
Belgisch Spalter	1731	135	1	9	17	4	6	179	0	6	26	28	15	44	0	5,0	3,8	0,75	26,8	46,3
Blisk	817	376	23	3	17	0	2	235	17	6	7	5	17	0	0	7,4	4,5	0,61	32,7	56,1
Boadicea	1822	87	3	11	5	1	2	125	12	4	5	4	14	0	0	6,9	4,5	0,64	24,4	46,7
Bobek	12025	411	11	151	61	0	16	258	41	4	5	3	14	0	0	5,8	6,0	1,05	26,9	49,9
Bor	2993	147	2	42	7	0	6	287	0	4	3	2	14	0	0	9,2	4,7	0,51	26,3	50,0
Braustern	2486	127	1	39	7	0	4	254	0	5	4	2	16	0	1	9,1	5,6	0,61	27,9	47,1
Brewers Gold	2351	268	7	14	9	0	1	163	0	4	5	4	12	0	0	6,3	4,7	0,75	44,2	68,4
Brewers Stand	4977	915	14	23	53	17	16	58	0	56	90	80	125	98	0	5,3	4,1	0,77	30,0	49,1
Buket	3281	258	3	65	22	0	10	234	18	6	4	2	16	0	1	8,8	5,7	0,64	26,4	47,9
Bullion	786	253	8	8	12	0	3	155	0	7	9	8	16	0	0	6,1	4,7	0,76	42,6	64,8
Cascade	1685	248	17	6	12	0	6	269	9	6	16	11	20	0	0	4,7	5,5	1,17	30,9	43,3
Chang bei 1	777	52	2	2	25	0	11	257	6	9	24	23	20	25	0	3,6	4,1	1,14	31,1	46,9
College Cluster	325	168	9	5	5	0	4	139	2	4	7	7	11	0	0	6,4	2,6	0,41	25,6	48,4
Columbus	839	236	26	4	10	0	4	161	0	25	20	15	50	21	0	11,7	5,4	0,46	30,6	57,6
Comet	607	113	11	10	14	0	4	10	0	2	60	66	7	13	0	7,6	5,2	0,68	30,2	50,5
Crystal	923	32	1	7	25	16	9	202	0	9	39	39	17	53	0	2,8	6,8	2,38	26,6	40,4

Table 7.4 (cont.)

Variety	Myr-cene	2-M.-iso-butyrate	Sub. 14 b	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
Density	1563	137	3	12	32	0	16	285	0	8	7	2	18	0	0	5,2	3,6	0,69	30,9	54,2
Diva	2487	39	4	14	19	0	23	276	5	6	98	97	24	0	0	5,5	5,7	1,04	23,8	47,9
Dunav	2557	136	2	78	6	0	5	205	12	6	4	2	15	0	0	7,3	6,0	0,83	34,0	48,9
Early Choice	1638	92	1	20	5	0	4	235	0	4	52	56	17	0	0	3,8	2,3	0,61	24,9	42,7
Eastern Gold	1035	1	2	3	17	0	7	199	4	13	9	7	45	9	0	9,0	3,3	0,37	28,8	58,7
Eastwell Golding	1176	74	1	5	11	0	4	282	0	6	4	3	15	1	1	6,4	4,0	0,62	25,6	48,6
Emerald	1335	63	2	13	6	1	5	298	0	5	4	3	14	0	1	5,7	5,2	0,91	28,2	45,2
Eroica	1944	457	13	57	5	2	4	169	0	5	9	7	14	0	0	5,9	6,7	1,13	38,4	62,3
Estera	1896	206	1	5	20	0	5	276	9	5	3	2	16	0	0	3,6	4,0	1,10	26,0	44,2
First Gold	3298	301	2	7	19	2	10	265	9	6	100	107	19	0	0	9,3	4,3	0,46	32,3	58,3
Fuggle	2574	206	1	8	17	0	6	263	16	5	4	3	16	0	0	4,0	3,2	0,81	29,0	50,5
Galena	2399	470	26	54	8	4	9	184	0	6	9	6	18	4	0	8,5	6,5	0,77	42,2	58,9
Ging Dao Do Hua	704	455	4	3	16	0	8	290	0	11	46	44	33	0	0	4,9	4,5	0,93	42,9	59,2
Glacier	1238	96	5	4	15	0	9	196	0	4	5	3	15	0	0	6,8	7,7	1,12	14,8	41,7
Golden Star	911	481	1	3	14	0	7	292	0	11	40	39	34	0	0	5,2	4,2	0,81	41,6	61,2
Granit	875	79	3	6	4	2	12	204	3	4	8	7	13	0	1	7,1	4,9	0,69	26,6	47,2
Green Bullet	2633	133	9	7	23	0	11	279	0	10	6	4	17	0	0	5,0	4,6	0,92	41,3	67,5
Hallertauer Gold	1378	103	13	6	21	0	6	301	0	6	3	2	16	0	0	5,5	5,2	0,93	22,5	43,6
Hall. Magnum	5661	184	24	24	8	2	4	281	0	6	2	2	13	0	1	10,5	6,9	0,65	28,6	45,8
Hall. Merkur	3234	163	13	7	16	2	4	288	0	12	4	4	15	0	0	12,9	5,8	0,45	18,6	43,4
Hallertauer Mfr.	466	85	1	2	23	0	8	323	0	8	6	4	21	0	0	3,5	4,0	1,15	19,5	39,6
Hall. Taurus	7228	277	16	18	40	0	11	260	0	7	63	65	18	0	0	16,3	4,8	0,29	24,1	49,1
Hall. Tradition	2865	254	8	6	34	0	6	283	0	5	4	2	16	0	0	6,0	5,3	0,88	25,8	48,2
Herald	7603	485	8	130	11	5	23	205	0	4	31	34	15	0	0	11,5	4,8	0,42	39,2	61,6
Herkules	8422	402	57	132	11	0	8	283	0	4	3	1	14	0	0	16,2	5,6	0,35	36,3	54,4
Hersbrucker Pure	2626	105	1	12	27	15	15	208	0	7	29	30	16	44	0	4,1	2,7	0,66	25,2	47,9
Hersbrucker Spät	637	127	2	3	39	46	11	178	0	10	50	49	19	60	0	2,5	4,7	1,88	23,6	42,1
Horizon	2940	197	4	19	25	0	4	141	7	3	10	10	9	0	0	7,2	5,0	0,70	23,0	45,7

Table 7.4 (cont.)

Variety	Myr-cene	2-M.-iso-butyrate	Sub. 14 b	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
Hüller Anfang	456	63	4	1	14	0	5	314	0	6	3	2	18	0	0	3,4	4,6	1,36	15,0	39,5
Hüller Aroma	457	80	2	2	20	0	7	327	0	9	4	3	21	0	0	4,1	3,7	0,91	21,2	45,9
Hüller Bitter	1635	287	21	6	38	17	9	164	0	42	54	48	89	66	0	4,8	5,5	1,16	27,8	45,3
Hüller Fortschritt	600	25	2	2	15	0	7	317	0	8	4	2	17	0	0	3,4	4,8	1,41	22,7	41,5
Hüller Start	279	16	0	2	8	2	10	341	0	8	4	2	19	0	0	3,5	4,1	1,18	26,3	41,9
Jap. C 730	318	19	13	14	14	0	11	146	9	5	11	9	13	0	0	3,7	3,3	0,89	34,4	53,7
Jap. C 827	276	69	6	3	12	0	6	267	0	6	8	6	16	18	0	5,3	2,8	0,54	29,2	53,4
Jap. C 845	694	8	2	12	3	0	2	285	12	5	3	2	17	1	1	9,2	4,9	0,53	24,6	46,3
Kirin 1	594	433	1	4	13	0	6	298	0	14	41	40	37	0	0	4,8	4,1	0,85	42,2	60,8
Kitamidori	506	7	1	10	2	0	2	287	10	4	3	3	17	0	0	8,6	4,2	0,49	24,1	45,2
Kumir	3326	123	3	15	20	0	6	275	4	6	3	2	14	0	1	11,3	5,1	0,45	25,2	48,5
Late Cluster	7755	817	13	34	47	0	20	51	14	63	98	92	133	91	0	6,0	4,1	0,68	30,9	51,9
Liberty	615	143	3	4	20	0	9	280	0	8	8	6	20	7	0	4,1	4,1	1,00	25,7	47,4
Lubelski	1669	2	2	4	24	0	15	301	24	7	5	2	17	0	0	5,2	5,3	1,02	33,3	43,9
Malling	2099	225	1	5	22	0	6	265	11	5	3	2	15	0	0	3,2	2,9	0,92	27,0	46,4
Marynka	2257	295	3	17	10	4	7	155	58	6	9	8	14	0	0	8,3	4,6	0,55	27,4	49,6
Mt. Hood	106	53	15	1	12	0	6	284	0	12	6	3	26	0	1	4,5	5,0	1,12	26,5	44,8
Neoplanta	2683	111	1	29	17	0	10	249	19	5	4	2	16	0	0	8,5	4,2	0,50	26,3	52,0
Neptun	3969	161	24	6	17	4	2	210	0	5	3	2	15	0	0	13,0	5,1	0,39	22,3	41,7
Northern Brewer	3345	151	1	48	7	0	5	243	0	5	4	2	14	0	1	10,2	5,1	0,50	28,9	50,8
Nugget	2714	109	2	18	12	1	3	168	0	3	6	6	9	0	0	10,4	4,9	0,47	31,6	56,6
NZ Hallertauer	2483	149	3	14	24	0	9	169	7	5	20	21	14	24	0	4,1	6,8	1,63	41,5	49,5
Olympic	761	74	2	6	10	0	3	189	0	4	8	8	11	0	0	11,6	5,3	0,46	28,8	53,6
Omega	1765	269	11	12	12	0	6	280	0	5	49	53	17	0	0	7,0	4,4	0,62	25,1	48,4
Opal	2635	52	13	23	24	0	8	242	0	4	4	2	15	19	0	7,0	5,5	0,78	13,7	33,8
Orion	1135	124	2	6	15	0	5	218	0	7	4	3	17	0	1	7,8	5,2	0,66	30,2	49,9
Pacific Gem.	4453	600	8	26	28	0	13	257	0	8	4	2	17	0	0	10,2	7,2	0,70	38,3	65,3

Table 7.4 (cont.)

Variety	Myr-cene	2-M.-iso-butyrate	Sub. 14 b	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
PCU 280	2383	98	1	15	4	0	3	263	0	4	4	3	14	0	1	9,9	4,6	0,47	28,0	52,6
Perle	1588	78	1	27	4	0	3	254	0	5	3	2	15	0	1	8,9	5,1	0,58	29,4	50,7
Phoenix	3148	237	2	12	8	0	5	249	13	4	53	59	18	0	0	10,1	4,9	0,48	25,7	51,1
Pilgrim	5792	500	4	107	12	4	17	259	0	4	68	74	18	0	0	7,3	3,7	0,50	37,3	62,2
Pilot	6458	442	14	85	40	13	56	81	0	10	394	485	38	0	0	8,6	4,5	0,53	37,4	61,5
Pioneer	4099	309	3	122	7	4	27	226	0	4	33	37	17	0	0	11,4	4,8	0,42	38,0	61,9
Premiant	4883	120	3	20	22	0	7	271	16	4	4	3	15	0	1	9,9	5,1	0,51	21,2	45,8
Pride of Kent	939	28	1	2	19	0	6	299	0	6	4	3	16	0	1	5,8	3,0	0,52	26,4	49,6
Pride of Ringwood	853	72	3	2	8	0	9	14	0	6	94	96	19	0	0	5,0	5,6	1,12	34,1	55,5
Progress	3558	1341	16	24	73	0	24	51	0	74	106	91	158	105	0	5,4	4,1	0,76	30,3	49,1
Saazer	2509	4	1	7	23	0	13	284	32	6	5	3	16	0	0	3,5	4,4	1,26	23,5	41,8
Saphir	4874	91	3	33	33	7	21	189	0	4	16	16	14	21	0	3,5	6,5	1,88	12,4	46,7
Serebrianker	468	37	1	3	20	0	5	174	2	7	31	31	20	0	0	2,8	6,2	2,17	42,1	42,5
Sirem	1855	3	2	5	27	0	14	289	24	8	5	2	19	0	0	3,8	4,4	1,16	23,4	40,7
Sladek	3933	136	3	16	21	0	6	274	10	6	4	3	15	0	1	9,8	4,2	0,43	27,3	52,1
Smaragd	2108	39	9	14	23	0	6	257	0	4	4	2	16	23	0	5,0	4,9	0,99	12,9	31,2
Spalter	2003	4	1	6	27	0	15	305	31	7	6	3	18	0	0	2,8	4,2	1,50	24,3	44,0
Spalter Select	3378	57	8	9	85	20	14	205	27	8	36	36	17	54	0	3,9	4,3	1,10	22,8	43,7
Sterling	1633	162	4	16	12	2	2	174	2	4	7	7	10	0	0	11,3	5,1	0,45	27,7	51,8
Sticklebract	4039	451	2	14	11	0	7	150	0	9	40	44	13	0	0	8,4	6,6	0,78	40,0	64,2
Strisselspalter	746	90	2	6	27	24	8	200	0	10	44	43	17	55	0	2,2	5,8	2,61	32,2	41,9
Super Alpha	3240	340	12	14	33	0	9	285	0	8	4	2	15	0	0	8,1	4,2	0,52	33,3	59,5
Talisman	2817	118	2	45	7	0	4	242	0	4	3	2	15	0	1	8,4	5,1	0,60	30,6	50,1
Tettnanger	1131	3	3	6	32	0	23	324	19	8	7	3	20	0	0	3,8	4,0	1,07	30,6	43,7
Toyomidori	1006	388	21	41	16	0	19	211	0	22	16	10	50	11	0	9,3	4,5	0,48	34,5	64,0
Ultra	266	34	1	2	8	0	3	316	0	6	5	4	17	0	1	3,2	3,6	1,11	20,6	41,7
Urozani	1608	1	1	4	52	0	13	232	23	9	24	24	18	33	0	4,5	6,4	1,43	33,3	45,1
USDA 21055	2193	299	2	104	7	0	4	116	24	5	17	17	14	1	0	8,6	3,7	0,43	48,3	69,2

Table 7.4 (cont.)

Variety	Myr-cene	2-M.-iso-butyrate	Sub. 14 b	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
Vojvodina	3167	208	3	32	8	0	6	248	4	5	4	2	15	0	0	6,6	3,6	0,54	31,6	56,0
WFG	1899	51	2	8	24	0	13	283	16	8	4	2	16	0	0	4,7	4,2	0,88	24,5	40,8
Willamette	1580	187	1	5	14	0	3	257	13	5	4	3	15	0	0	3,3	3,4	1,03	37,4	57,6
Wye Challenger	4353	407	3	43	23	0	9	256	5	4	49	61	17	0	0	4,4	4,5	1,03	25,5	47,9
Wye Northdown	2281	105	2	10	15	0	4	237	0	5	3	2	15	0	1	8,0	6,0	0,76	27,2	45,3
Wye Target	6702	391	13	39	28	2	9	149	0	8	7	7	28	8	0	11,5	5,7	0,49	36,1	59,4
Wye Viking	2091	65	1	26	11	0	11	212	28	5	38	40	16	1	0	5,1	5,0	0,99	23,0	42,1
Yeoman	3379	289	13	15	8	0	5	222	0	5	38	42	16	0	1	14,0	5,4	0,39	27,9	52,0
Zatecki	1917	149	2	8	18	0	4	258	11	4	4	2	14	0	1	3,6	3,6	1,00	24,1	42,3
Zenith	2606	134	1	18	23	0	7	266	0	6	81	105	20	0	1	9,3	4,1	0,44	26,8	50,4
Zeus	2677	120	13	5	5	0	3	154	0	12	13	11	34	15	0	12,7	5,8	0,45	39,2	61,0
Zitic	1672	15	1	11	9	2	6	289	6	6	3	2	15	0	1	5,7	4,9	0,86	27,4	46,3
Zlatan	2148	11	3	8	37	0	23	306	18	8	6	3	19	0	0	4,4	4,4	1,00	29,8	46,1

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

7.6 Ring analyses of the 2008 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 Arbeitsgruppe für Hopfenanalytik (AHA) describes exactly how samples are to be treated (sample division and storage), which laboratories carry out post-analyses and what tolerance ranges are permissible for the analysis results.

In 2008, the IPZ 5d work group was once again responsible for organising and evaluating the ring tests conducted in order to verify the quality of the α-acid analyses.

The following laboratories took part in the 2008 ring tests:

- Hallertauer Hopfenveredelungsgesellschaft mbH, Au/Hallertau plant
- NATECO$_2$ GmbH & Co. KG, Wolnzach
- Hopfenveredelung St. Johann GmbH & Co. KG, St. Johann
- Hallertauer Hopfenveredelungsgesellschaft mbH, Mainburg plant
- Hop Producer Association HVG, Mainburg
- Agrolab GmbH, Oberhummel
- Thuringia State Research Centre for Agriculture (TLL)
- Hops Dept. of the Bavarian State Research Centre for Agriculture (LfL), Hüll

Ten ring tests were conducted during the ten weeks from September 9th - November 14th, 2008, as this was the period during which most of the hop lots were examined in the laboratories. Sample material was kindly provided by Mr. Hörmansperger (Hallertau Hop Producers' Ring). To ensure maximum homogeneity, each sample was drawn from a single bale.

Every Monday, the samples were ground in Hüll with a hammer mill, 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 39 samples were analysed in 2008. The evaluations were passed on to the individual laboratories as quickly as possible. Figure 7.2 shows a typical evaluation.

The laboratory numbering does not correspond to the above list. Grubb's test was performed according to ISO 5725 to detect any outliers among the laboratories. One outlier was detected in 2008. Table 7.5 shows the tolerance limits (critical difference values (CD), Schmidt, R., NATECO$_2$, Wolnzach) derived from the European Brewery Convention's method collection (EBC 7.4, conductometric titration) and the number of results outside the tolerance range for the years 2000 to 2008.

Nr. 14: SR (01.10.2008)

Lab.	Conduc. value		mean	s	cvr
1	4.64	4.73	4.69	0.064	1.4
2	4.46	4.45	4.46	0.007	0.2
3	4.66	4.74	4.70	0.057	1.2
4	4.67	4.57	4.62	0.071	1.5
5	4.68	4.69	4.69	0.007	0.2
6	4.59	4.63	4.61	0.028	0.6
7	4.23	4.28	4.26	0.035	0.8
8	4.52	4.52	4.52	0.000	0.0

mean	4.57
sr	0.042
sL	0.211
sR	0.215
cvr	0.93
cvR	4.72
r	0.12
R	0.60
min	4.23
max	4.74

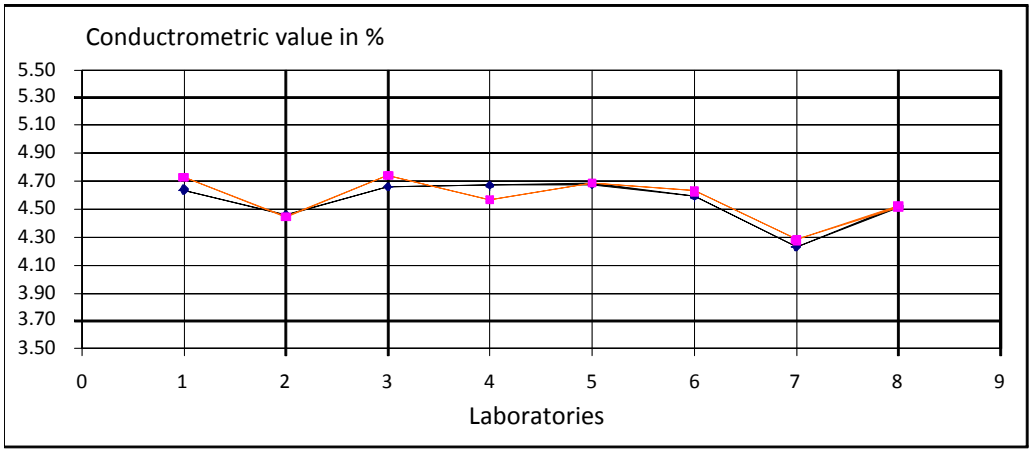


Fig. 7.2: Evaluation of a ring analysis

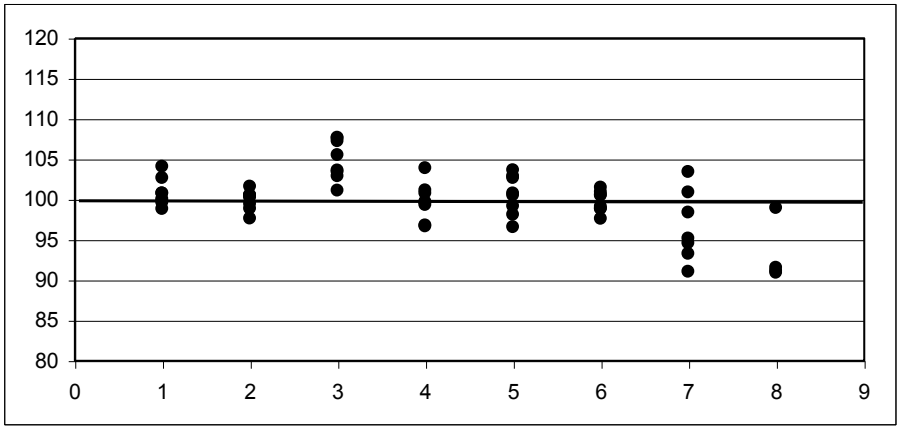
Table 7.5: Tolerance limits as per EBC 7.4 method and number of results outside tolerance range for years 2000 to 2008

	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
Results outside range				
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

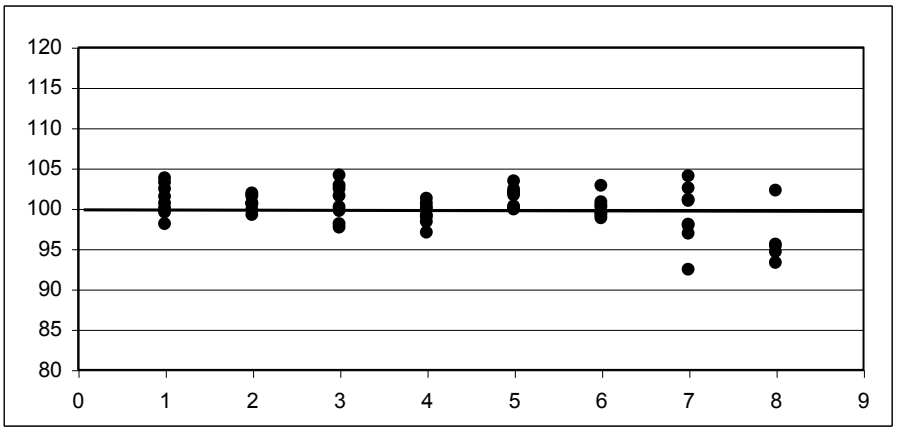
In 2008, a total of 8 results were outside the permissible tolerance range. The number was especially high for the high-alpha varieties, which was most probably a consequence of the extremely high α-acid content of the 2008 crop.

Fig. 7.3 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 ≥ 10 %. The chart clearly reveals whether a laboratory is producing values that are too high or too low.

Samples with α-acids contents < 5 %



Samples with α-acids contents >= 5 % and < 10 %



Samples with α-acids contents >= 10 %

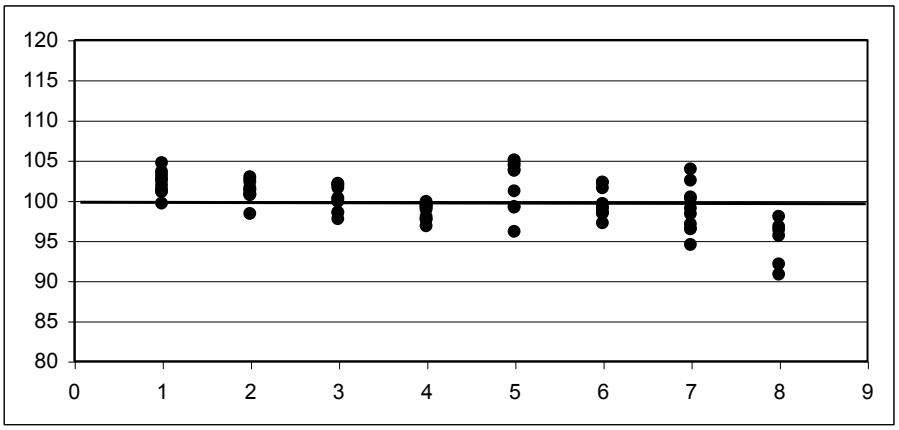


Fig. 7.3: Laboratory analysis results relative to the mean

7.7 NIRS (near infrared reflection spectroscopy) analysis

Alpha-acid content is having an increasing effect on hop prices, explaining the steep rise in the number of α-acid analyses (as per EBC 7.4) performed during recent years. A fast, cost-efficient analytical method would greatly facilitate the work of the laboratories. It was for this reason that work commenced on the development of NIRS methods. The aim was to achieve a level of accuracy making the method acceptable for routine use. Initially, a calibration equation based on conductometric values was established. This calibration incorporated 5527 data sets. However, since the yearly addition of new data sets brought no further improvements, development of an HPLC-data-based calibration equation was commenced. 4619 data sets have meanwhile been incorporated in this calibration equation, too, and it appears that no further improvements are possible. The NIRS method is not accurate enough for hop supply contracts.

The critical-difference values given in Table 7.5 would be twice as high, which is unacceptable where prices are concerned. The laboratories involved therefore decided to discontinue development of a joint calibration equation. At the Hüll laboratory, the NIRS method remains in use as an assay method for determining α-acid content. Hop sample material is highly inhomogeneous, and the sampling error is probably greater than the analytical error. As a screening method for hop breeding, NIRS is fast and relatively cheap. Fig. 7.4 compares NIRS values with conductometric values, which were equated with 100 %, for the 2008 crop. As can be seen from this chart, the NIRS values are higher or lower than the conductometric values, although they do tend to be higher in the case of the high-alpha varieties.

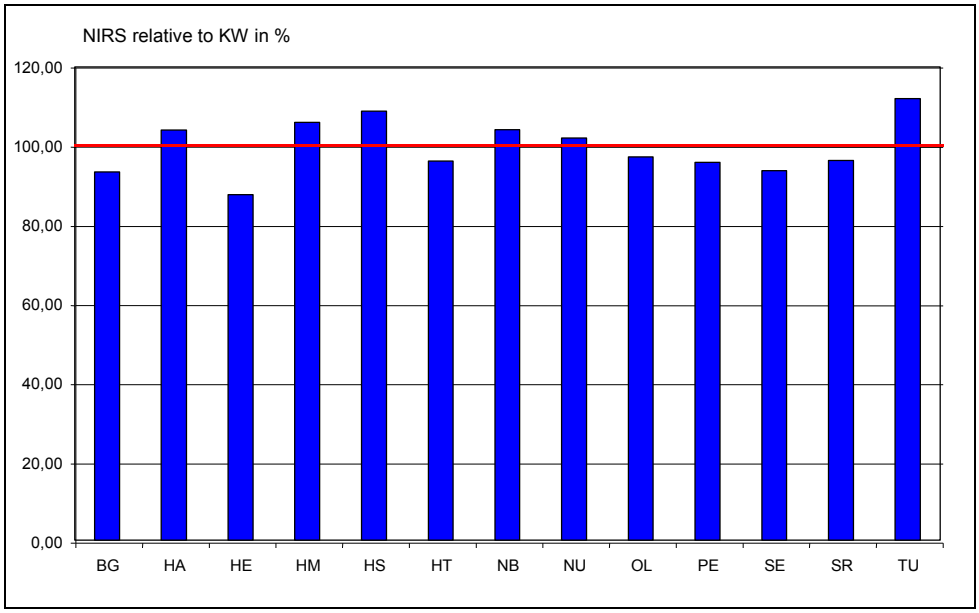


Fig. 7.4: NIRS values relative to conductometric values for the 2008 crop

7.8 Tests for plant-protective residues in hops from the 2008 crop

The annual tests for plant-protective residues in hops provide a very clear picture of the actual situation regarding the use of plant protectives. The 2008 crop, like those of the preceding years, was confirmed free of harmful residues.

The high cost of the tests (approx. € 1,250.00 per sample) meant that the number of analyses in 2008 once again had to be limited to six samples. However, numerous additional analyses covering the same range of substances are commissioned by the hop-trading companies. The Hallertauer Mittelfrüher variety is monitored continuously for the active substances analysed in this study.

Altogether 96 different active substances for plant protectives were analysed in this study, considerably more than are used in practice. In addition to the currently registered active substances, the hops are inspected and monitored for previously registered active substances and substances used on other crops (e.g. grapes). The study thus covers all potentially relevant active substances.

One thing is new regarding the maximum permissible residue levels (MRL). The German MRL Ordinance (RHmV) of Sept. 1st, 1994, and amendments thereto are no longer in force. It has been superseded by "EC Regulation No. 396/2005 of the European Parliament and the Council of 23rd February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin", which came into effect on September 1st, 2008. In Table 7.6, the maximum levels applicable throughout the EU since Sept. 1st, 2008 are listed in the column headed "Maximum permissible level". The previously applicable German values have been superseded by those of the EU Regulation. For legal reasons, the German Ordinance has not yet been repealed.

7.8.1 Sample selection and analysis results

A total of 105 hop samples representing all the important varieties grown in the Hallertau were supplied during the course of the 2008 weighing and certification season to the Hops Dept. of the Bavarian State Research Centre 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 names of the hop farms were unknown to the LfL.

From these hop samples, the LfL selected **two** samples for each of the six varieties listed in the table and made a mixed sample for each variety. The lengthy analytical testing of a mixed sample comprising two separate samples for residues is justified, as the hop lots delivered to the purchasers (breweries) generally comprise more than two individual lots. The sample "R3/08 PE" was a winning sample at a hop exhibition in 2008. The fact that these samples were almost completely free of pests and diseases could point to intensive use of plant protectives.

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 carried out at the BIOANALYTIK Weihenstephan Institute (formerly the Research Institute for Agriculture HVA) of the Munich Technical University in Freising-Weihenstephan.

Table 7.6: Tests for plant-protective residues in the 2008 crop

Active substances listed according to pest/disease	**Maximum permissible level in ppm**	**Milligrammes per kilogramme = ppm**					
		R 1/08	**R 2/08**	**R 3/08**	**R 4/08**	**R 5/08**	**R 6/08**
		HT	**SR**	**PE**	**TU**	**HM**	**HS**
Fungicides mainly effective against							
1. Peronospora							
Azoxystrobin	**20.00**	**1.50**	**2.60**	**0.91**	**0.42**	**0.14**	**3.10**
Captafol	0.10	ND	ND	ND	ND	ND	ND
Captan	0.05	ND	ND	ND	ND	ND	ND
Cymoxanil	2.00	ND	ND	ND	ND	ND	ND
Dimethomorph	**50.00**	**0.13**	**16.00**	**0.17**	**0.69**	**0.24**	**0.13**
Dithiocarbamate	25.00	ND	ND	ND	ND	ND	ND
Fentin-acetate	0.10	ND	ND	ND	ND	ND	ND
Folpet	**150.00**	**5.50**	**3.50**	**22.80**	**0.32**	**0.52**	**81.70**
Fosethyl	**1500.00**	**ND**	**ND**	**ND**	**21.20**	**15.40**	**ND**
Copper compounds	**1000.00**	**193.20**	**313.0**	**221.80**	**164.70**	**97.20**	**130.20**
Metalaxyl	**10.00**	**ND**	**ND**	**<0.10**	**ND**	**ND**	**0,11**
Tolylfluanide	50.00	ND	ND	ND	ND	ND	ND
2. Powdery mildew							
Boscalid	35.00	ND	ND	ND	ND	ND	ND
Chlorthalonil	50.00	ND	ND	ND	ND	ND	ND
Fenarimol	5.00	ND	ND	ND	ND	ND	ND
Fenpropymorph	10.00	ND	ND	ND	ND	ND	ND
Flusilazol	0.05	ND	ND	ND	ND	ND	ND
Kresoxim-methyl	0.10	ND	ND	ND	ND	ND	ND
Myclobutanil	**2.00**	**1.20**	**1.10**	**0.86**	**0.17**	**0.83**	**ND**
Nitrothal-isopropyl	0.05	ND	ND	ND	ND	ND	ND
Penconazol	0.50	ND	ND	ND	ND	ND	ND
Propiconazol	0.10	ND	ND	ND	ND	ND	ND
Pyraclostrobin	10.00	ND	ND	ND	ND	ND	ND
Quinoxyfen	**0.50**	**ND**	**ND**	**ND**	**ND**	**ND**	**<0.10**
Spiroxamine	0.10	ND	ND	ND	ND	ND	ND
Tebuconazol	30.00	ND	ND	ND	ND	ND	ND
Triadimefon	10.00	ND	ND	ND	ND	ND	ND
Triadimenol	**10.00**	**ND**	**ND**	**ND**	**ND**	**0.30**	**ND**
Triforin	30.00	ND	ND	ND	ND	ND	ND
Trifloxystrobin	**30.00**	**0.67**	**0.12**	**<0.10**	**1.10**	**ND**	**6.20**
3. Botrytis							
Dichlofluanid	150.00	ND	ND	ND	ND	ND	ND
Procymidon	0.10	ND	ND	ND	ND	ND	ND
Vinclozolin	40.00	ND	ND	ND	ND	ND	ND

Table 7.6 (cont.)

Active substances listed according to pest/disease	Maximum permissible level in ppm	Milligrammes per kilogramme = ppm					
		R 1/08	R 2/08	R 3/08	R 4/08	R 5/08	R 6/08
		HT	SR	PE	TU	HM	HS
Insecticides mainly effective against							
1. Aphids							
Acetamiprid	0.10	ND	ND	ND	ND	ND	ND
Acrinathrin	0.05	ND	ND	ND	ND	ND	ND
Alphacypermethrin	30.00	ND	ND	ND	ND	ND	ND
Bifenthrin	10.00	ND	ND	ND	ND	ND	ND
Bioresmethrin	0.20	ND	ND	ND	ND	ND	ND
3-Hydroxy-Carbofuran	0.05	ND	ND	ND	ND	ND	ND
Clothianidin	0.05	ND	ND	ND	ND	ND	ND
Cyfluthrin	20.00	ND	ND	ND	ND	ND	ND
Cypermethrin	30.00	ND	ND	ND	ND	ND	ND
Deltamethrin	5.00	ND	ND	ND	ND	ND	ND
Diazinon	0.50	ND	ND	ND	ND	ND	ND
Dibrom	-	ND	ND	ND	ND	ND	ND
Dichlorvos	0.02	ND	ND	ND	ND	ND	ND
Dicrotophos	0.01	ND	ND	ND	ND	ND	ND
Dioxacarb	0.01	ND	ND	ND	ND	ND	ND
Endosulfan	0.10	ND	ND	ND	ND	ND	ND
Ethiofencarb	0.05	ND	ND	ND	ND	ND	ND
Fenvalerat	0.05	ND	ND	ND	ND	ND	ND
Flonicamid	**2.00**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
Flucythrinate	0.10	ND	ND	ND	ND	ND	ND
Imidacloprid	**10.00**	**ND**	**<0.10**	**ND**	**ND**	**ND**	**ND**
Mevinphos	0.02	ND	ND	ND	ND	ND	ND
Omethoat	-	ND	ND	ND	ND	ND	ND
Parathion-methyl	0.05	ND	ND	ND	ND	ND	ND
Permethrin	0.10	ND	ND	ND	ND	ND	ND
Pirimicarb	4.00	ND	ND	ND	ND	ND	ND
Propoxur	0.10	ND	ND	ND	ND	ND	ND
Pymetrozin	**15.00**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
Thiometon	-	ND	ND	ND	ND	ND	ND
2. Alfafa weevil							
Acephate	0.05	ND	ND	ND	ND	ND	ND
Carbofuran	0.05	ND	ND	ND	ND	ND	ND
Carbosulfan	1.00	ND	ND	ND	ND	ND	ND
Chlorpyrifos-methyl	0.10	ND	ND	ND	ND	ND	ND
Fipronil	0.01	ND	ND	ND	ND	ND	ND
Lambda-Cyhalothrin	**10.00**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
Methamidophos	**0.02**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
Methidathion	5.00	ND	ND	ND	ND	ND	ND
Spinosad	22.00	ND	ND	ND	ND	ND	ND

Table 7.6 (cont.)

Active substances listed according to pest/disease	Maximum permissible level in ppm	Milligrammes per kilogramme = ppm					
		R 1/08	R 2/08	R 3/08	R 4/08	R 5/08	R 6/08
		HT	SR	PE	TU	HM	HS
Acaricides against common spider mite							
Abamectin	**0.05**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
Amitraz	0.10	ND	ND	ND	ND	ND	ND
Azocyclotin/Cyhexatin	0.10	ND	ND	ND	ND	ND	ND
Bromopropylate	0.10	ND	ND	ND	ND	ND	ND
Clofentezin	0.05	ND	ND	ND	ND	ND	ND
Dicofol	50.00	ND	ND	ND	ND	ND	ND
Etoxazol	0.05	ND	ND	ND	ND	ND	ND
Fenbutatin oxide	0.10	ND	ND	ND	ND	ND	ND
Fenpropathrin	0.02	ND	ND	ND	ND	ND	ND
Fenpyroximate	**10.00**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
Fluvalinate	-	ND	ND	ND	ND	ND	ND
Hexythiazox	**20.00**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
Malathion	0.02	ND	ND	ND	ND	ND	ND
Propargite	100.00	ND	ND	ND	ND	ND	ND
Pyridaben	10.00	ND	ND	ND	ND	ND	ND
Spirodiclofen	**30.00**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
Herbicides							
Carfentrazone-ethyl	**0.02**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
Cinidon-ethyl	**0.10**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
Fluazifop-P-butyl	**0.10**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
Haloxyfop	**0.05**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
MCPA	**0.10**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
Metribuzin	0.10	ND	ND	ND	ND	ND	ND
Monolinuron	0.10	ND	ND	ND	ND	ND	ND
Trifluralin	0.10	ND	ND	ND	ND	ND	ND

ND = not detectable **Bold print** = Registered or approved active substances in 2008

HT = Hallertauer Tradition TU = Hallertauer Taurus

SR = Saphir HM = Hallertauer Magnum

PE = Perle HS = Herkules

7.8.2 Assessment of the results

The main 2008 crop was characterised by a very high content of value-determining components and good external quality. If hop cones are almost completely free of pests and diseases, this could point to intensive use of plant protectives. This would lead to higher residue values.

The analysis results show that if plant protectives are used properly, healthy hops, too, are free of impermissible residues. The results obtained for the "R6/08, PE" sample attest to this; it was a winning sample at a hop exhibition in 2008.

The fact that fungicides for controlling downy mildew (Peronospora) were detected more frequently in the 2008 crop is attributable to the high infection pressure towards the end of the season. A further two spray warnings (three for late-maturing varieties) were needed in August to keep cones healthy. Table 7.7 summarizes the residue situation for the 2008 crop.

Table 7.7: Residues in the 2008 hop crop (summarized from Table 7.6)

Active substance (trade name)	Incidence n = 6	Min-max. in ppm	MPL in ppm (EU)	MPL in ppm (US)	MPL in ppm (Japan)
Azoxystrobin (Ortiva)	6	0.14–3.10	20.0	20.0	20.0
Dimetomorph (Forum)	6	0.13–16.00	50.0	60.0	60.0
Folpet (Folpan WDG)	6	0.32–81.7	150.0	120.0	120.0
Fosethyl (Aliette)	2	15.40–21.20	1500.0	45	1440.0
Imidacloprid (Confidor WG 70)	1	< 0.10	2.0	6.0	10.0
Copper compounds	6	97.70–313.0	1000.0	ex.	ex.
Metalaxyl (Ridomil Gold Combi)	2	< 0.10–0.11	10	20	10
Myclobutanil (Systane 20 EW)	5	0.17–1.20	2	10	2
Quinoxyfen (Fortress 250)	1	< 0.10	0.5	3.0	3.0
Triadimenol (Bayfidan)	1	0.30	10.0	-	5.0
Trifloxystrobin (Flint)	5	< 0.10–6.20	30.0	11.0	20.0

ex. = exempt

7.8.3 Resumé

2008 was a year with below-average pest and disease pressure (with the exception of Peronospora in August). The levels of plant-protective residues measured were also very low. Residues of only a few active substances were detected, and these in concentrations that were only a fraction of the maximum permissible levels; of the licensed active substances, very few had detectable residues, and no residues of non-licensed active substances were found at all. Negative effects of plant protectives on beer and consumers can accordingly be ruled out.

7.9 Monitoring of variety authenticity

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

Variety checks for the food control authorities

District administrator's offices 21

Complaints 0

8 Publications and specialist information

8.1 Summary of PR work

	Number		Number
Practice-relevant information and scientific papers	44	Guided tours	70
LfL publications	1	Exhibitions and posters	6
Press releases	1	Basic and advanced training sessions	18
Radio and TV broadcasts	3	Final-year university projects	1
Conferences, trade events and seminars	12	Participation in work groups	20
Talks	85	Awards	1
Foreign guests	133		

8.2 Publications

8.2.1 Practice-relevant information and scientific papers

Author(s), title, journal, page

Engelhard, B. (2008): Hopfen ist ohne Rückstände von Pflanzenschutzmittel. Brauerei-Forum 1/2008, p. 16.

Engelhard, B. (2008): Stehen in Zukunft noch ausreichend zugelassene Pflanzenschutzmittel im Hopfen zur Verfügung? Proceedings of the 45th Hop Seminar with international participation, Portoroz / Slowenien, 5.-6. März 2008, p. 97-100

Engelhard, B., Schlagenhaufer, S. (2008): Epidemieverlauf von Echtem Mehltau Podosphera macularis am Hopfen – ein Vergleich von Einzelpustelbeobachtungen mit Bonituren nach EPPO-Richtlinien. Mitteilungen aus dem Julius-Kühn-Institut **417**: 315

Engelhard, B., Weihrauch, F., Schwarz, J. (2008): Einsatz von Quassia zur Blattlausbekämpfung im Hopfen. Mitteilungen aus dem Julius-Kühn-Institut **417**: 316

Fuß, S., Hartmair, A., Portner, J. (2008): Sensorgesteuerte Einzelpflanzenbehandlung im Gießverfahren. Hopfen Rundschau 59 (4), 101-102.

Fuß, S. et al. (2008): Mehr Gewinn? Hopfenrundschau International 2008, 60-63.

Kammhuber, K. (2008): Mehr physikalisch als chemisch, Die Nahinfrarotspektroskpie in der Hopfenanalytik-Möglichkeiten und Grenzen, Brauindustrie 2/2008, 42-44.

Kammhuber, K (2008).: Die antimikrobiellen und bakteriostatischen Eigenschaften der Hopfenbitterstoffe, Tagungsband Internationales Hopfensymposium „Hopfenanbau 2020“, 78 - 81

8.2.1 (cont.) - Practice-relevant information and scientific papers

Kammhuber, K. und Lutz, A. (2008): Der richtige Erntezeitpunkt - Entscheidend für die Qualität des Hopfens, Schule und Beratung 3-4/08, III-7-III-9.

Kammhuber, K., Kneidl, J., Lutz, A., Petzina, C., B. Wyschkon (2008): Bonitierung und Ergebnisse für die Deutsche Hopfenausstellung 2008. Hopfenrundschau 12, 329-332.

Münsterer, J. (2008): Leistungssteigerung und Energieeinsparung bei Hordendarren durch optimale Luftführung. Hopfen Rundschau 59 (4), 99-101.

Münsterer, J. (2008): Kosteneinsparung bei der Hopfentrocknung durch alternative Energiequellen und Wärmerückgewinnung. Hopfen Rundschau 59 (5), 127-129.

Münsterer, J. (2008): Sicherung der Hopfenqualität durch optimale Konditionierung. Hopfen Rundschau 59 (6), 146-148.

Niedermeier, E. (2008): Pflanzenstandsbericht. Hopfen Rundschau 59 (5), 130-132.

Niedermeier, E. (2008): Pflanzenstandsbericht. Hopfen Rundschau 59 (6), 150.

Niedermeier, E. (2008): Pflanzenstandsbericht. Hopfen Rundschau 59 (7), 178.

Niedermeier, E. (2008): Pflanzenstandsbericht. Hopfen Rundschau 59 (8), 213.

Niedermeier, E. (2008): Pflanzenstandsbericht. Hopfen Rundschau 59 (9), 253.

Portner, J. (2008): Aktuelle Hopfenbauhinweise. Hopfenbau-Ringfax Nr. 2; 3; 4; 6; 8; 9; 10; 11; 12; 14; 15; 17; 18; 21; 22; 23; 24; 27; 28; 29; 30; 31; 33; 34, 35; 36; 38; 39; 46; 47; 49; 51; 52

Portner, J. (2008): Überprüfung der Pflanzenschutzgeräte im Hopfenbau – „Spritzen-TÜV“. Hopfen Rundschau 59 (3), 68.

Portner, J. (2008): Nährstoffvergleich bis 31. März erstellen! Hopfen Rundschau 59 (3), 69.

Portner, J. (2008): Erste Nmin-Ergebnisse in Hopfen und anderen Ackerkulturen; Empfehlungen zur Stickstoffdüngung 2008! Hopfen Rundschau 59 (3), 76.

Portner, J. (2008): Gezielte Stickstoffdüngung d. Hopfens nach DSN (Nmin). Hopfen Rundschau 59 (3), 78.

Portner, J. (2008): EU-Erntebericht 2007. Hopfen Rundschau 59 (4), 105.

Portner, J., Steck, U. (2008): Dokumentation von Pflanzenschutzmittelanwendungen im Hopfenbau. Hopfen Rundschau 59 (5), 125-127.

Portner, J., Brummer, A. (2008): N_{min}-Untersuchung 2008. Hopfen Rundschau 59 (5), 129-130.

Portner, J. (2008): Erlaubt ist nur die Ausbringung von zugelassenen Pflanzenschutzmitteln auf Nutzflächen. Hopfen Rundschau 59 (5), 130.

Portner, J. (2008): Peronosporabekämpfung - Planen Sie Ihren Mitteleinsatz. Hopfen Rundschau 59 (6), 148.

Portner, J. (2008): Kostenfreie Rücknahme von Pflanzenschutzverpackungen PAMIRA 2008. Hopfen Rundschau 59 (7), 182.

Portner, J. (2008): Rebenhäcksel bald möglichst ausbringen! Hopfen Rundschau 59 (8), 198.

Portner, J. (2008): Fachkritik zur Moosburger Hopfenschau 2008. Hopfen Rundschau 59 (10), 264-268.

Portner, J. (2008): Hinweise für hop growers zu Aktuelles im Pflanzenschutz und zu Themen der Hopfenberatung. Hopfenring/Erzeugerring-Information v. 12.06.2008, 1-2.

Portner, J. (2008): Aktuelles zum Pflanzenschutz. Hopfenring/Erzeugerring-Information v. 30.07.2008, 1.

Portner, J. (2008): Hinweise für hop growers zu Schlagkarteiauswertung, Fortbildungsveranstaltungen und KuLaP-Förderung. Hopfenring/Erzeugerring-Information v. 31.10.2008, 1-2.

Schlagenhaufer, S., Wolf, P. F. J., Verreet, J.-A., Engelhard, B. (2008): Epidemiologie und Schadrelevanz des Echten Mehltaus Podosphera macularis an Hopfen. Mitteilungen aus dem Julius-Kühn-Institut **417**: 314

8.2.1 (cont.)- Practice-relevant information and scientific papers

Seigner, E. (2008): Hopfen – Sorten aus der Hallertau für die Biere der Welt. In: Die Entwicklung der Pflanzenzüchtung in Deutschland (1908 –2008). 100 Jahre GFP e.V. – eine Dokumentation. Röbbelen (Publ.): 483-490.

Seigner, E., Lutz, A., Oberhollenzer, K., Seidenberger, R., Seefelder, S. (2008): Breeding of Hop Varieties for the Future. In: Proceedings of the 2nd ISHS International Humulus Symposium, Gent, Belgium, 1-5 Sept. 2008.

Seigner, E., Lutz, A., Seefelder, S. (2008): Züchtung neuer, innovativer Sorten für die Zukunft. Tagungsband Hopfenbau 2020 – Internationales Hopfensymposium vom 5.-6. Mai 2008 in Wolnzach: 53-56.

Seigner, E. und Lutz, A. (2008): Robust und leistungsstark – Herkules, eine neue Hochalphasorte mit Zukunft. Brau-Industrie Nr. 2, Februar 2008, 38-41.

Weihrauch, F., Schwarz, J., Engelhard, B. (2008): Quassia, an effective aphid control agent for organic hop growing. Book of Abstracts of the 16th IFOAM Organic World Congress, Modena, Italy, 16-20 June 2008: 247.

Weihrauch, F., Schwarz, J., Engelhard, B. (2008): Quassia, an effective aphid control agent for organic hop growing. In: Neuhoff, D., Halberg, N., Alföldi, T., Lockeretz, W., Thommen, A., Rasmussen, I.A., Hermansen, J., Vaarst, M., Lueck, L., Caporali, F., Jensen, H. H., Migliorini, P. & Willer, H., (eds): Cultivating the Future based on Science. Vol. 1 – Organic Crop Production. Proceedings of the Second Scientific Conference of the International Society of Organic Agriculture Research (ISOFAR), held at the 16th IFOAM Organic World Congress, 18-20 June 2008 in Modena, Italy. ISOFAR, Bonn, IOL, Bonn, FiBL, Frick, & DARCOF, Tjele: 456-459

Weihrauch, F. (2008): Im Handstreich: Die Eroberung der Hopfengärten der Hallertau durch *Harmonia axyridis* im Jahr 2007 (Coleoptera, Coccinellidae). *Nachrichtenblatt der bayerischen Entomologen* 58(1/2): 12-16

Weihrauch, F. (2008). Overwintering of common green lacewings in hibernation shelters in the Hallertau hop growing area (Neuroptera: Chrysopidae). *Journal of Insectology* 61(1): 67-71

Weihrauch, F., Baumgartner, A., Felsl, M., & Lutz, A. (2008): Aphid Tolerance of Different Hop Genotypes: First Attempts to Develop a Simple Biotest for Hop Breeding by the Use of *Phorodon humuli. Book of Abstracts, 2nd ISHS International Humulus Symposium, 1-5 September 2008, Ghent, Belgium:* 39

8.2.2 LfL publications

Name	Work group	LfL publications	Title
Portner, J.	IPZ 5a	"Grünes Heft" ("Green Leaflet")	Hopfen 2008 (Hops 2008)

8.2.3 Press releases

Author(s)/Work group	Title
Portner, J., IPZ 5a	Hopfenbewässerung – Hopfenbauern wappnen sich für den Klimawandel (Hop irrigation – hop farmers gear up for the climate change) Mittelbayerische Zeitung+Hallertauer Zeitung

8.2.4 Radio and TV broadcasts

Name /Work group	Date of broadcast	Topic	Title of programme	Station
Portner, J., IPZ 5a	01.07.2008	Interview on hop irrigation		Radio Charivari
Weihrauch, F., IPZ 5b	13.07.2008	Asian ladybird	Aus Schwaben und Altbayern	Bavarian TV and BR Alpha
Münsterer J., IPZ 5a	26.08.2008	Hop irrigation		IN TV

8.3 Conferences, talks, guided tours and exhibitions

8.3.1 Conferences, trade events and seminars

Organised by	Date /Venue	Topic	Participants
Münsterer, J.	22.01.2008 Wolnzach	Workshop Floor drying	18 hop growers
Münsterer, J.	24.01.2008 Wolnzach	Workshop Belt drying	12 hop growers
Münsterer, J.	20.11.2008 Wolnzach	Seminar Basics of hop drying	30 hop growers
Münsterer, J.	02.12.2008 Wolnzach	Workshop Hop drying	14 hop growers
Münsterer, J.	10.12.2008 Wolnzach	Follow-up seminar Hop drying	28 hop growers
Münsterer, J.	11.12.2008 Wolnzach	Workshop Belt drying	12 hop growers
Münsterer, J.	17.12.2008 Wolnzach	Workshop Irrigation	7 hop growers
Portner, J., Schätzl, J.	29.01.2008 Mühlhausen/Lutzmannsdorf	Innovations in picking techniques	50 hop growers
Portner, J.	28.02.2008 Hüll	“Green Leaflet” meeting	Colleagues from Germany’s hop research facilities
Portner, J., Fuß, S..	09.04.2008 Rohrbach	Watering- equipment demonstration	40 hop growers and guests

Organised by	Date /Venue	Topic	Participants
Portner, J.	01.08. – 02.08.2008 Tettnang	Hops colloquium	Colleagues from advisory and research facilities in the German hop-growing regions
Portner, J.	22.10.2008 Wolnzach	Hop-irrigation info day, Talks and equipment exhibition	250 hop growers and guests

8.3.2 Talks

(WG = Work group)

WG	Name	Topic/Title	Organiser/ Attended by	Date / Venue
IPZ 5	Engelhard, B. Seigner, E. Lutz, A.	Raw material hops – researchers and the hop industry are equipped for the future	VLB -Berlin (Research and training instit. for brewing + malting) / 120 persons	25.04.2008, Dresden
IPZ 5	Engelhard, B.	Latest update on plant protection and Hüll-cultivars	Office for Agriculture and Forestry (ALF), Roth / 60 persons	18.07.2008, Spalt
IPZ 5a	Fuß, S.	Sensor-controlled single-bine treatment	Beiselen GmbH / 15 members of rural trading firms	31.01.2008, Mainburg
IPZ 5a	Fuß, S.	Sensor-controlled single-bine treatment	BayWa / 20 employees	07.02.2008, Mainburg
IPZ 5a	Fuß, S.	Sensor-controlled single-bine treatment	LfL and ALF / 610 hop growers	12.-21.02.2008 9 venues
IPZ 5a	Fuß, S.	Latest update on plant protection	Hop Producers' Ring (HPR) and LfL / 30 hop growers	07.07.2008, Uttenhofen
IPZ 5a	Fuß, S.	Latest update on plant protection	HPR and LfL / 10 hop growers	07.07.2008, Hersbruck
IPZ 5a	Fuß, S.	6 – 7 m trellis trial	LfL and ALF / 50 hop growers	29.09.2008, Attenhofen
IPZ 5a	Münsterer, J.	The latest findings in hop drying and conditioning	Austrian hop growers' cooperative / 50 persons	12.-21.02.2008 9 venues
IPZ 5a	Münsterer, J.	Energy saving in hop drying	Austrian hop growers' cooperative / 50 persons	28.02.2008, Leutschach
IPZ 5a	Münsterer, J.	Hop-card-index evaluation	HPR and LfL / 60 hop growers	05.03.2008, Niederlauterb.
IPZ 5a	Münsterer, J.	Hop-card-index evaluation	HPR and LfL / 25 hop growers	10.03.2008, Wolnzach
IPZ 5a	Münsterer, J.	Current hop-cultivation issues	HPR (Eschelbach group) / 18 persons	02.04.2008, Eschelbach
IPZ 5a	Münsterer, J.	The latest findings in hop drying and conditioning	Wolnzach hop-growers' round-table discussion / 14 persons	04.07.2008, Wolnzach

WG	Name	Topic/Title	Organiser/ Attended by	Date / Venue
IPZ 5a	Münsterer, J.	Energy saving in hop drying	HPR (Koppenwall group) / 22 persons	06.08.2008, Koppenwall
IPZ 5a	Münsterer, J.	Alternative energy sources for hop drying	HPR, ISO-certified farms / 60 hop growers	01.12.2008, Aiglsbach
IPZ 5a	Niedermeier, E.	Soil conditioners and plant tonics in hop cultivation	Young hop growers' assoc. / 122 persons	15.01.2008 Niederlauter-bach
IPZ 5a	Niedermeier, E.	Soil conditioners and plant tonics in hop cultivation	HPR / 42 persons	15.02.2008 Hiendorf
IPZ 5a	Niedermeier, E.	Soil: suitability for hops, nutrient supply	HPR / 48 ISO-certified farmers	09.04.2008 Biburg
IPZ 5a	Niedermeier, E.	Latest update on plant protection in hop-growing, 2008	Hop syndicate / 27 persons	21.05.2008 Niederlauterb.
IPZ 5a	Niedermeier, E.	Optimum liming of hop land	Young hop growers' assoc. / 70 persons	18.11.2008 Niederlauterb.
IPZ 5a	Niedermeier, E.	Hops: Fertilising with primary nutrients and micronutrients	Elbe-Saale hop-growers' association / 55 persons	27.11.2008 Grimma
IPZ 5a	Portner, J.	Hop advisory services: what's new and what's changed?	Beiselen GmbH/15 persons from rural trading firms	31.01.2008, Mainburg
IPZ 5a	Portner, J.	Hop advisory services: what's new and what's changed?	BayWa / 20 employees	07.02.2008, Mainburg
IPZ 5a	Portner, J.	Hop advisory services: what's new and what's changed?	LfL and ALF / 610 hop growers	12-21.02.2008 9 venues
IPZ 5a	Portner, J.	Testing sensor technology in hop cultivation	Julius Kühn Institute (JKI) Braunschweig/20 specialists	11.03.2008, Geisenheim
IPZ 5a	Portner, J.	Pflant protection in hops (2008) from the viewpoint of the advisory services	ALF Landshut / 15 hop growers (WG)	17.03.2008, Haunsbach
IPZ 5a	Portner, J.	Use of sensors in plant-protective spraying	Soc. of Hop Research (GfH) / 20 members of the tech. sci. committee	02.04.2008, Wolnzach
IPZ 5a	Portner, J.	Cost efficiency and competitiveness in hop growing	Fed. Min. of Food, Agric. + Consumer Prot. (BMELV) / 120 internat. guests	05.05.2008, Wolnzach
IPZ 5a	Portner, J.	Tasks and responsibilities of the Joint Advisory Service	HPR and LfL / 15 Ring consultants	15.05.2008, Wolnzach
IPZ 5a	Portner, J.	Process engineering in hop growing	Weihenstephan univ. / 8 students	10.06.2008, Weihensteph.
IPZ 5a	Portner, J.	Latest update on plant protection	HPR and LfL / 30 hop growers	01.07.2008, Koppenwall
IPZ 5a	Portner, J.	The current plant-protectives situation	HPR and LfL / 25 hop growers	02.07.2008, Forchheim
IPZ 5a	Portner, J.	Drip irrigation in hop growing	HPR / 60 ISO-certified farmers	21.07.2008, Ilmendorf
IPZ 5a	Portner, J.	Current situation and harvesting dates	HPR / 180 persons	18.08.2008, Grubwinn
IPZ 5a	Portner, J.	Current situation and harvesting dates	HPR / 40 persons	19.08.2008, Lutzmannsdf.

WG	Name	Topic/Title	Organiser/ Attended by	Date / Venue
IPZ 5a	Portner, J.	Hop irrigation	Hop syndicate / 80 persons	21.08.2008, Kolmhof
IPZ 5a	Portner, J.	Expert hop review (2008)	Town of Moosburg / 150 guests	18.09.2008, Moosburg
IPZ 5a	Portner, J.	Ring consultant training – 2008 in review	HPR / 10 ring consultants	12.12.2008 Wolnzach
IPZ 5a	Schätzl, J.	Review of plant-protective situation – outlook for 2008, peronospora warning service	LfL und HPR / 28 hop growers	10.03.2008 Wolnzach
IPZ 5a	Schätzl, J.	Latest update on fertilisation, plant protection and soil pests	HPR and LfL/ 15 ring consultants	15.05.2008 Wolnzach
IPZ 5a	Schätzl, J.	Results of wild-hop-control trials and their relevance in practice	Spalt hop growers' association /7 persons (experts and guests)	20.05.2008 Spalt
IPZ 5a	Schätzl, J.	Training in forecasting, latest update on plant protection	LfL and ALF Roth / 65 hop growers	27.05.2008 Spalt
IPZ 5a	Schätzl, J.	Latest update on plant protection, particularly noteworthy aspects of aphid control	LfL and HPR / 15 Ring consultants	27.05.2008 Hüll
IPZ 5a	Schätzl, J.	Pest and disease control in 2008	LfL and HPR / 16 Ring consultants	10.06.2008 Hüll
IPZ 5a	Schätzl, J.	Warning service, diseases and pests, current control strategies	LfL and HPR / 15 Ring consultants	24.06.2008 Hüll
IPZ 5a	Schätzl, J.	Growth dysfunctions, soil conditioning, erosion-protection measures	HPR and LfL / 17 Ring consultants	08.07.2008 Hüll, Birnfeld
IPZ 5a	Schätzl, J.	Latest update on plant protection, wilting and preventive measures	HPR and LfL / 16 Ring consultants	22.07.2008 Hüll, Rohrbach
IPZ 5b	Engelhard, B. Portner, J. Fuß, S. Münsterer, J.	New aphid-control strategies and general survey of available plant protectives in 2008	BayWa 25 persons	07.01.2008, Mainburg
IPZ 5b	Engelhard, B. Portner, J Fuß, S. Münsterer, J.	New aphid-control strategies and general survey of available plant protectives in 2008	Rural trading firms 15 persons	31.01.2008, Mainburg
IPZ 5b	Engelhard, B. Portner, J. Fuß, S. Münsterer, J.	New aphid-control strategies and general survey of available plant protectives in 2008	9 venues – Hallertau, Hersbruck and Spalt	12. - 21.02.2008,
IPZ 5b	Engelhard, B.	Will there still be a sufficient range of registered plant protectives available in future for hop-growing?	IHPS (Slovenian Instit. of Hop Reseach and Brewing), Žalec / 90 persons	05.03.2008, Portoroz, Slovenia
IPZ 5b	Engelhard, B.	Third-party-financed research projects in the IPZ 5b WG	GfH / 38 members of the tech. sci. committee	02.04.2008, Wolnzach
IPZ 5b	Engelhard, B. Schlagenhaufer, S.	Development of an innovative forecasting model for the control of powdery mildew in hops	Fed. Instit. för Food and Agric. (BLE) / 75 persons	16.04.2008, Bonn

WG	Name	Topic/Title	Organiser/ Attended by	Date / Venue
IPZ 5b	Engelhard, B. Weihrauch, F. Schwarz, J. Lachermeier, U.	Development of integrated methods of plant-protection against the alfafa weevil in hop growing	JKI 20 persons	17.04.2008, Braunschweig
IPZ 5b	Engelhard, B.	Can established hop quality still be upheld with the future plant-protection regulations?	Hop syndicate / 70 persons	21.08.2008, Niederlauter-bach
IPZ 5b	Engelhard, B.	Plant-protectives situation in German hop-growing – outlook for 2009	Hobby brewers soc. (VdH) / 40 persons	26.08.2008, Wolnzach
IPZ 5b	Engelhard, B. Schlagenhaufer, S.	Progress of a powdery-mildew epidemic in hops – a comparison of individual pustule observations with assessments as per the EPPO guidelines	German plant-protection conference (DPST) / approx. 100 persons	23.09.2008, Kiel
IPZ 5b	Engelhard, B. Weihrauch, F. Schwarz, J.	Use of quassia for aphid control in hops	DPST / approx. 100 persons	23.09.2008, Kiel
IPZ 5b	Engelhard, B. Weihrauch, F. Schwarz, J. Lachermeier, U.	Use of entomopathogenic nematodes (EPN) for the biological control of the Lucerne weevil *Otiorhynchus ligustici* in hops	Geisenheim Research Centre / 35 persons	27.11.2008 Geisenheim
IPZ 5b	Schlagenhaufer, S.	Research project "Powdery Mildew Forecast" – current status	BAYER AG / 15 persons	27.08.2008, Bad Gögging
IPZ 5b	Schwarz, J.	Entomopathogenic fungi and other alternative aphid-control agents for organic hop growing	Bioland / 25 persons	13.02.2008, Plankstetten
IPZ 5b	Weihrauch, F.	Organic hop-growing trial results for 2007	Bioland / 25 persons	13.02.2008, Plankstetten
IPZ 5b	Weihrauch, F. Engelhard, B. Schwarz, J.	Quassia, an effective aphid control agent for organic hop growing.	2nd ISOFAR Scientific Conference held at the 16th IFOAM Organic World Congress / approx. 120 persons	19.06.2008, Modena (Italy)
IPZ 5b	Weihrauch, F. Baumgartner, A. Felsl, M. Lutz, A.	Aphid tolerance of different hop genotypes: first attempts to develop a simple biotest for hop breeding by the use of *Phorodon humuli*.	2nd ISHS International Humulus Symposium, approx. 60 persons	03.09.2008 Ghent (Belgium)
IPZ 5b	Weihrauch, F.	Where did the aphids disappear to in 2008? Presentation of a current research project on aphid control	HPR round-table discussion on hop growing / approx. 35 persons	15.12.2008 Oberlauterbach

WG	Name	Topic/Title	Organiser/ Attended by	Date / Venue
IPZ 5b	Weihrauch, F.	Where did the aphids disappear to in 2008? Presentation of a current research project on aphid control	HPR round-table discussion on hop growing / approx. 20 persons	16.12.2008 Mitterstetten
IPZ 5c	Seigner, E.	Gene transfer in hops	Prof. Hückelhoven, WZW; IPZ-L and IPZ colleagues	14.01.2008, Freising
IPZ 5c	Seigner, E.	Hop breeding goals up till 2020	Soc. of Hop Research / 38 members of the tech. sci. committee	02.04.2008, Wolnzach
IPZ 5c	Seigner, E.	Continuation of the current EHRC project	EHRC / 8 persons	03.04.2008, Hüll
IPZ 5c	Seigner, E.	Breeding of new, innovative varieties for the future	Internal hop symposium / approx. 80 persons	05.05. - 06.05.2008, Wolnzach
IPZ 5c	Seigner, E.	PM isolates and resistance testing systems for PM-resistance breeding in hops	Members' meeting, Wissenschaftl. Station für Brauerei in Munich / approx. 50 persons	17.06.08, Munich
IPZ 5c	Seigner, E.	Ongoing research work of the Hop Breeding Research WG	Spalt hop colloquium	05.08.2008, Georgens-gmünd
IPZ 5c	Seigner, E.	Research activities at the Hüll Hop Research Centre – hop breeding tools	Carlsberg Breweries visit / 8 persons	12.08.2008, Freising
IPZ 5c	Seigner, E.	Breeding of hop varieties for the future	2nd ISHS International Humulus Symposium, approx. 60 persons	02.09.2008, Ghent, Belgium
IPZ 5c	Seefelder, S.	Genotyping of *Verticillium* pathotypes in the Hallertau – basic findings concerning *Verticillium*-infection risk assessment	HVG producer group – management and supervisory boards	22.01.2008, Wolnzach
IPZ 5c	Seefelder, S.	Molecular selection markers for powdery mildew resistance	GfH / 38 members of the tech. sci. committee	02.04.2008, Wolnzach
IPZ 5c	Seefelder, S.	Development of molecular markers for powdery mildew resistance in hops to support breeding for resistance	European Hop Research Council / 4 persons	24.09.2008, Hüll
IPZ 5c	Seidenberger, R.	Development of molecular markers linked to powdery mildew resistance genes in hops to support breeding for resistance	EHRC / 8 persons	03.04.2008, Hüll

WG	Name	Topic/Title	Organiser/ Attended by	Date / Venue
IPZ 5c	Oberhollenzer, K.	Hop Powdery Mildew Pathosystem – newly started microscopic investigations and future plans	Doctoral-student seminar, Chair of Phytopathology, WZW	28.07.2008, Freising
IPZ 5c	Lutz, A.	Breeding of resistant dwarf hops particularly suited to low-trellis systems	BLE / 75 persons	16.04.2008 Bonn
IPZ 5c	Lutz, A.	Hop quality – cone evaluation	"Alt-Weihenstephaner Brauerbund" / approx. 25 persons	05.11.2008, Freising
IPZ 5c	Lutz, A.	Hop varieties	Students of the Pfaffenhofen School of Agriculture / 7 persons	12.11.2008, Pfaffenhofen
IPZ 5d	Kammhuber, K.	The antimicrobial and bacteriostatic properties of hop bitter compounds	Internal hop symposium / approx. 80 persons	06.05.2008, Wolnzach
IPZ 5d	Kammhuber, K.	Hop ingredients and their importance for brewing and for health	Daiichi-Sankyo, Pfaffenhofen, 7 persons	27.08.2008, Hüll

8.3.3 Guided tours

(WG = Work group)

WG	Name	Date	Topic/Title	Guest institution	No. of partic.
IPZ 5	Engelhard, B.	16.01.2008	Current hop research	Retired hop growers	~ 35
IPZ 5	Engelhard, B.	28.03.2008	Hop research	US hop growers	2
IPZ 5	Engelhard, B. Seigner, E. Kammhuber, K.	31.03.2008	Breeding, plant protection	Anheuser-Busch managers	4
IPZ 5	Engelhard, B.	03.04.2008	Hop breeding	SAB South Africa	2
IPZ 5	Engelhard, B. Portner, J. Münsterer, J. Fuß, S. Niedermeier, E.,	05.05.2008	Technical innovations in hop production	BMELV/BLE hop symposium	~ 80
IPZ 5	Engelhard, B.	08.05.2008	Hop research	Euro motorhome e.V., Druckhaus Kastner GmbH	55
IPZ 5	Engelhard, B.	09.05.2008	Hop research	Raw materials experts from AmBev, Brazil/HVG	3
IPZ 5	Engelhard, B.	10.05.2008	Hop research	Geology students fr. Augsburg univ., Prof. Wicorec; coopers from Pfaffenhofen	70

WG	Name	Date	Topic/Title	Guest institution	No. of partic.
IPZ 5	Engelhard, B. Kammhuber, K. Weihrauch, F.,	20.05.2008	Hop research	Raw materials experts from SAB-Miller/HVG	4
IPZ 5	Engelhard, B.	26.05.2008	Hop research	Bavarian Red Cross, Wasserburg	45
IPZ 5	Engelhard, B.	29.05.2008	Hop research	Wolnzach and Gebrontshausen horticultural societies	35
IPZ 5	Engelhard, B. Kammhuber, K. Weihrauch, F.,	12.06.2008	Hop research, AHA work group	$NATECO_2$	5
IPZ 5	Engelhard, B.,	12.06.2008	Hop research, hop growing	Kaufmanns Casino Munich	25
IPZ 5	Engelhard, B., Lutz, A.	13.06.2008	Current hop research	Vocational school students from Pfaffenhofen	12
IPZ 5	Engelhard, B.	13.06.2008	Hop growing, hop research	Fruit farmers from the Reutling district	50
IPZ 5	Engelhard, B. Seigner, E. Lutz, A.	16.06.2008	Hop research	WG: GPZ/Phyto Societies.	~ 45
IPZ 5	Engelhard, B. Portner, J.	08.07.2008	Training	BAYWA	20
IPZ 5	Engelhard, B. Seigner, E. Kammhuber, K.	10.07.2008	Hop research	Grub Institute for Animal Husbandry (ITZ)	25
IPZ 5	Engelhard, B. Seigner, E.	15.07.2008	Hop research	Students of brewing and malting, Munich Technical University (TUM)	40
IPZ 5	Engelhard, B. Weihrauch, F.	21.07.2008	Hop research	Steiner employees	3
IPZ 5	Engelhard, B. Weihrauch, F.	24.07.2008	Hop research	BLE employees	2
IPZ 5	Engelhard, B. Seigner, E. Kammhuber, K. Weihrauch, F.	28.07.2008	Hop research	TUM Chair of Plant Breeding	15
IPZ 5	Engelhard, B. Schwarz, J.	14.08.2008	Tour of trial plantings	Spiess-Urania	7
IPZ 5	Engelhard, B.	18.08.2008	Hop research	Dr. Schuster, German MP	3
IPZ 5	Engelhard, B.	20.08.2008	Plant protection for hops	Colleagues from Poland	5
IPZ 5	Engelhard, B. Weihrauch, F. Münsterer, J.	26.08.2008	Current research projects	“Hopfenrundfahrt”	ca. 150
IPZ 5	Engelhard, B. Seigner, E. Kammhuber, K.	27.08.2008	Hop varieties and their components	DAIICI-SANKYO	6
IPZ 5	Seigner, E. Kammhuber, K.	28.08.2008	Hop Research at Hüll	Kirin, Mitsubishi	6

WG	Name	Date	Topic/Title	Guest institution	No. of partic.
IPZ 5	Engelhard, B.	29.08.2008	Tasks of the Hop Research Centre	Hallertau Hop Weeks	40
IPZ 5	Engelhard, B. Lutz, A.	02.09.2008	Hop research	Anheuser-Busch with English journalists	22
IPZ 5	Engelhard, B.	04.09.2008	Harvesting techniques	Craft brewers from USA	5
IPZ 5	Engelhard, B. Lutz, A. Kammhuber, K.	18.09.2008	Hop research	Munich vocational school for brewing and malting, 3rd-year students	30
IPZ 5	Engelhard, B. Kammhuber, K.	18.09.2008	Hop research	Colleagues from ALF Ingolstadt	40
IPZ 5	Dr. Doleschel, P. Seigner, E. Kammhuber, K. Weihrauch, F.	25.09.2008	Hop research	French brewers, German embassy in Paris	30
IPZ 5	Dr. Doleschel, P. Engelhard, B.	08.10.2008	Hop research	Chief administrative officer Schäch, Pfaffenhofen district, mayor Machold, Wolnzach	2
IPZ 5	Engelhard, B. Kammhuber, K.	13.11.2008	Hop research in Bavaria	Indian delegation via the BMELV	7
IPZ 5a	Portner, J.	09.01.2008	"House of Hops"	Country Women's Association, Landshut	20
IPZ 5a	Münsterer, J.	05.05.2008	Drying and conditioning with a fully automated all-inclusive system	International Hop Symposium	90
IPZ 5a	Fuß, S.	06.05.2008	Sensor-controlled single-bine treatment	International Hop Symposium	90
IPZ 5a	Niedermeier, E.	06.05.2008	Man-hour requirements of var. bine-training methods	International Hop Symposium	90
IPZ 5a	Münsterer, J.	15.05.2008	Construction and arrangment of conditioners	Ring consultants	15
IPZ 5a	Portner, J.	03.06.2008	"House of Hops"	Weihenstephan university students (Triesdorf)	20
IPZ 5a	Schätzl, J.	02.07.2008	Current plant protection and stand monitoring in Osseltshausen	Hop growers from the Freising and Pfaffenhofen districts	44
IPZ 5a	Münsterer, J.	04.07.2008	The latest crop-production tips	HPR (Kehlheim groups)	35
IPZ 5a	Niedermeier, E.	08.07.2008	Current plant protection and stand monitoring	HPR (Haunsbach group)	36
IPZ 5a	Schätzl, J.	09.07.2008	Current plant protection and stand monitoring in Gebrontshausen	Hop growers from the Pfaffenhofen district	36
IPZ 5c	Seigner, E.	11.07.2008	Biotechnological work of the IPZ	Bav. Ministry of Agric. and Forestry departmental outing (former Dept. B)	70

WG	Name	Date	Topic/Title	Guest institution	No. of partic.
IPZ 5a	Niedermeier, E.	31.07.2008	Current plant protection and stand monitoring in Rottenegg	Hop growers from the Geisenfeld area	52
IPZ 5a	Niedermeier, E.	06.08.2008	Current plant protection and stand monitoring	Wolnzach hop growers	16
IPZ 5a	Portner, J. Niedermeier, E.	07.08.2008	Tour of trial plantings	Association of graduates from Kehlheim Agricultural College	60
IPZ 5a	Münsterer, J.	08.08.2008	Fully aurtomated drying and conditioning	Tettnang hop growers	82
IPZ 5a	Portner, J.	11.08.2008	Tour of trial plantings	Freising hop growers	20
IPZ 5a	Portner, J. Niedermeier, E.	12.08.2008	Tour of trial plantings	Association of graduates from Landshut Agricultural College	25
IPZ 5a	Portner, J. Niedermeier, E.	12.08.2008	Tour of trial plantings	Young Hop Growers' Association	80
IPZ 5a	Schätzl, J.	13.08.2008	Current plant-protection situation	HPR (Abens group)	18
IPZ 5a	Schätzl, J.	21.08.2008	Hop-stand inspection, final plant-protective applications, harvest date	ALF Roth / hop growers and guests from Hersbruck	40
IPZ 5a	Niedermeier, E.	26.08.2008	Hop tour (irrigation, aphid project)	Guests of the Hallertau Hop Growers' Association	48
IPZ 5b	Weihrauch, F.	18.02.2008	Hop research	Anheuser-Busch managers	4
IPZ 5b	Weihrauch, F.	23.07.2008	Organic hop growing	Dr. S. Kühne/JKI, Hop research colleagues from Zatec/Czech Republic	3
IPZ 5b	Weihrauch, F.	22.08.2008	Organic hop growing	G. Brits/SAB Miller	1
IPZ 5c	Lutz, A.	29.07.2008	Hop breeding and hop varieties	Students and trainee teachers from the School of Agriculture in Pfaffenhofen	13
IPZ 5c	Lutz, A.	30.07.2008	Hop yard in Rohrbach	HPR group	50
IPZ 5c	Lutz, A.	08.09.2008	Hüll Hop Research Centre	Heineken / raw materials expert for Italy	1
IPZ 5c	Lutz, A.	22.09.2008	Hüll Hop Research Centre	US brewing experts with Dr. Buholzer	3
IPZ 5c	Lutz, A.	15.12.2008	Biogenesis trials with hops, 2008	Hopsteiner	2
IPZ 5c	Lutz, A.	15.12.2008	Biogenesis trials with hops, 2008	HVG	2
IPZ 5c	Lutz, A.	15.12.2008	Biogenesis trials with hops, 2008	Hop growers' association	4
IPZ 5c	Lutz, A.	16.12.2008	Biogenesis trials with hops, 2008	Barth	4
IPZ 5c	Lutz, A.	17.12.2008	Biogenesis trials with hops, 2008	HVG supervisory board	6

WG	Name	Date	Topic/Title	Guest institution	No. of partic.
IPZ 5c	Lutz, A.	17.12.2008	Biogenesis trials with hops, 2008	"Neutrale Qualitätskontrolle"	2

8.3.4 Exhibitions and posters

(WG = Work group)

Name of Exhibition	Exhibition objects/projects and poster topics	Organiser	Duration of exhibit	WG
International hop-growing symposium	Hop growing in 2020 - poster on hop drying and conditioning	BMELV	05.-06.05.2008	IPZ 5a
LfL annual conference	Poster on hop drying: integrated energy-saving concept in a fully-automated all-inclusive system	LfL	04.11.2008	IPZ 5a
International hop-growing symposium	Development of integrated methods of plant protection against the Lucerne weevil in hops	BMELV / BLE	05.-06.05.08	IPZ 5b
International hop-growing symposium	Development of an innovative forecasting model for the control of powdery mildew in hops	BMELV / BLE	05.-06.05.08	IPZ 5b
International hop-growing symposium	Breeding of dwarf hops for low trellis systems	BMELV / BLE	05.-06.05.08	IPZ 5c
LfL annual conference	Hop components	LfL	04.11.08	IPZ 5d

8.4 Basic and advanced training

Name, Work group	Topic	Participants
Münsterer J., IPZ 5a	Drip irrigation in hop growing	10 agricultural trainees (hop growing)
Portner, J., IPZ 5a	Hop drying and conditioning	3rd-semester students of the Pfaffenhofen School of Agriculture
Portner, J., IPZ 5a	Peronospora	1st-semester students of the Pfaffenhofen School of Agriculture
Portner, J., IPZ 5a	Low-trellis systems	3rd-semester students of the Pfaffenhofen School of Agriculture

Name, Work group	Topic	Participants
Portner, J., IPZ 5a	Botrytis and powdery mildew	1st-semester students of the Pfaffenhofen School of Agriculture
Portner, J., IPZ 5a	Other diseases	1st-semester students of the Pfaffenhofen School of Agriculture
Portner, J., IPZ 5a	Hop aphid	1st-semester students of the Pfaffenhofen School of Agriculture
Portner, J., IPZ 5a	Common spider mite	1st-semester students of the Pfaffenhofen School of Agriculture
Portner, J., IPZ 5a	Good Plant Protection Practice (GPPP); registration situation	1st-semester students 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	Organisation and tasks of the Hop Cultivation/Production Techniques work group	10 agricultural trainees (hop growing)
Portner, J., IPZ 5a	Cultivation, fertilisation, plant protection and marketing of hops (4 evenings)	29 participants in the "BiLa" educational programme
Schätzl, J., IPZ 5a	Diseases and pests, current plant-protection methods, warning service	2nd-semester students of the Pfaffenhofen School of Agriculture
Schätzl, J., IPZ 5a	Hop-growing topic for examination candidates from the Pfaffenhofen and Freising districts	Trainees (majoring in hop-growing)
Schätzl, J., IPZ 5a	Hop-growing topic for examination candidates in Attenhofen	Exam. candidates from the Kehlheim and Pfaffenhofen districts
Dr. Seefelder, S. IPZ 5c	Plant genome analysis	Biology-lab.-technician trainee (Carolyn Püschel)
E. Seigner, IPZ 5c	Hop research in Hüll	4 upper-grade civil-service trainees
E. Seigner, IPZ 5c	Hop research	On-the-job trainee, 14.07.-18.07.08

8.5 Final-year university projects

WG	Name	Subject/Title of final-year university project	Duration	LfL supervisor, Cooperation
IPZ 5a	Hartmair, Albert	Development and testing of sensor technology for plant protection in hop growing	March 07 – Feb. 08	J. Portner, Weihenstephan Univ. (Triesdorf), Prof. U. Groß

8.6 Participation in work groups, memberships

Name	Memberships
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
Portner, J.	• Member of the Master-Farmer examination committee in Lower Bavaria
Engelhard, B.	• Chairman of the Scientific Commission of the International Hop Growers's Convention • Member of the German Phytomedical Society
Kammhuber, K.	• Member of the Analysis Committee of the European Brewery Convention (Hops Sub-Committee) • Member of the AHA (Hop Analytics) work group
Seefelder, S.	• Member of the Society of Hop Research • Member of the Society of Plant Breeding • Member of the LfL-KG public relations team
Seigner, E.	• Secreatry of the Scientific Commission of the International Hop Growers' Convention • Member of the "Hop Bulletin" editorial board, Institute of Hop Research and Brewing, Zalec, Slovenia • Member of the Society of Plant Breeding
Weihrauch, F.	• Member of the Bavarian Entomologists' working group • Member of the German Society for Orthopterology • Executive Board member of the Society of German-Speaking Odonatologists • Member of the Society of Tropical Ecology • Member of the Munich Entomological Society • Member of the Society for the Protetion of Dragonflies in Baden-Württemberg • Member of the Worldwide Dragonfly Association • Member of the Bavarian Environmental Protection Agency's working group for red-listed grasshoppers and dragonflies in Bavaria • Editor of the magazine "Libellula"

8.7 Awards and commendations

8.7.1 Commendations

Silvia Weihrauch, IPZ 5d, 25 years of service (2.12.2008)

9 Current research projects financed by third parties

WG Project manager	Project	Dura-tion	Sponsor	Cooperation
IPZ 5a J. Portner	Automatic hop-yield recording and mapping	2008-2009	Erzeugergemeinschaft Hopfen HVG (Producers' association)	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 Cellar (I)
IPZ 5a J. Portner	Development of fully automated wire-stringing equipment for hop-growing	2008-2010	BLE (Federal Institute of Food and Agriculture)	ILT, Freising; Soller GmbH, Geisenfeld
IPZ 5b B. Engelhard	Development of an innovative forecasting model for the control of powdery mildew (*Podosphaera macularis*) in hops	2007-2009	BLE) Erzeugergemeinschaft Hopfen HVG	Christian-Albrecht University, Kiel; Hopfenring Hallertau (Hallertau Hop Producers's Ring); GfH (Society of Hop Research); 8 hop farms
IPZ 5b/IPZ 5c B. Engelhard	Development of a system to test aphid resistance in hop seedlings during hop breeding	2005-2008	Erzeugergemeinschaft Hopfen HVG Anheuser-Busch GfH (Society of Hop Research);	
IPZ 5c Dr. Seigner A. Lutz	Breeding of resistant hops particularly suited for growth on low-trellis systems	2007-2010	BLE; GfH	Hop growers J. Schrag and M. Mauermeier; GfH
IPZ 5c Dr. Seigner A. Lutz S. Seefelder	Powdery mildew isolates and leaf resistance test in the laboratory as a basis for breeding powdery mildew resistant hops	2006-2010	Wissenschaftliche Station für Brauerei in München e.V.	Epilogic

WG Project manager	Project	Dura-tion	Sponsor	Cooperation
IPZ 5c Dr. Seefelder Dr. Seigner	Development of molecular markers linked to powdery mildew resistance genes in hops	2004-2009	Europ. Hop Research Council (EHRC)	Epilogic
IPZ 5c Dr. Seefelder Dr. Seigner	Genotyping of *Verticillium* pathotypes in the Hallertau – basic findings concerning *Verticillium*-infection risk assessment	2008-2010	Erzeugergemeinschaft Hopfen HVG	Herr Niedermeier, IPZ 5a; Dr. Radisek, Slovenian Institute of Hop Research and Brewing
IPZ 5c Dr. 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; Epilogic

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 peronospora forecasting models and preparation of information for the warning service	Ongoing	
5a	Optimisation of plant-protective application methods and equipment; 2008: Spray-coating measurements with various blower models	Ongoing	IHPS (Slovenia)
5a	Trials to investigate irrigation control in hop growing	2005-2011	Dr. Rötzer; Mosler
5a	Leaf fertilisation with Nutri-Phite Magnum S	2006-2008	
5a	Potash fixation trial	2006-2009	
5a	Determining the optimum harvest time for the Herkules cultivar	2006-2009	
5a	Optimizing drying performance and ways to save energy in hop drying	2006-2009	ATEF
5a	Spacing and bine-training trial with the Herkules cultivar	2006-2009	
5a	Fungicide treatment with and without strobilurins	2007-2009	
5a	Nitrogen enrichment trial to compare broadcast and banded fertiliser	2007-2011	
5a	Development of fully automated wire-stringing equipment for hop-growing	2008-2009	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

WG	Project	Duration	Cooperation
5a	Leaf fertilisation with Pentakeep	2008-2010	
5a	Testing of the Adcon weather model for the peronospora warning service	2008-2013	Hop Producers'Ring
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 – official 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 – 15 trial variants	2008	1 hop grower
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 F, CZ, SLO, GB, PL
5b	Trials aimed at reducing the amount of copper used in the control of peronospora	2006-	Spiess-Urania
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	Monitoring for hop stunt viroid in hops	2008-2009	Dr. L. Seigner, IPS (Institute for Plant Protection), IPS 2c; Dr. Eastwell, Washington State University, USA
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

WG	Project	Duration	Cooperation
5d	Performance of all analytical studies in support of the work groups, especially Hop Breeding Research, in the Hop Department	Ongoing	IPZ 5a, IPZ 5b, IPZ 5c
5d	Development of an NIRS calibration model for alpha-acid content based on HPLC data	2000-2008	AHA (Work Group for Hop Analytics)
5d	Development of analysis methods for hop polyphenols	2007-	AHA
5d	Introduction and establishment of UHPLC in hop analytics	2008-	

11 Personnel at IPZ 5 – Hops Department

The following staffs were employed at the Bavarian State Research Centre for Agriculture – Institute for Crop Science and Plant Breeding – at Hüll, Wolnzach and Freising in 2008. (WG = Work Group):

IPZ 5

Coordinator: Engelhard Bernhard

Dandl Maximilian
Felsl Maria
Graßl Christine (01.07. until 31.08.2008)
Hertwig Alexandra
Hock Elfriede
Krenauer Birgit
Maier Margret
Mauermeier Michael
Pflügl Ursula
Presl Irmgard
Suchostawski Christa
Waldinger Josef
Weiher Johann

IPZ 5a

Hop Cultivation/Production Techniques WG

Portner Johann

Fischer Elke (as of 01.09.2008)
Fuß Stefan
Heilmeier Rosa (until 31.08.2008)
Münsterer Jakob
Niedermeier Erich
Schätzl Johann

IPZ 5b

Plant Protection in Hop Growing WG

Engelhard Bernhard

Ehrenstraßer Olga
Hesse Herfried (until 30.04.2008)
Lachermeier Ute (as of 01.04.2008)
Meyr Georg
Riedl Daniela (01.08. - 31.08.2008)
Schlagenhaufer Stefan
Schwarz Johannes
Dr. Weihrauch Florian

IPZ 5c

Hop Breeding Research WG

Dr. Seigner Elisabeth

Bogenrieder Anton
Forster Brigitte (as of 17.11.2008)
Hager Petra (as of 14.08. parental leave)
Kneidl Jutta
Lutz Anton
Mayer Veronika
Nadler Stefanie (09.02. until 15.09.2008)
Oberhollenzer Kathrin (as of 01.04.2008)
Petosic Sabrina
Seidenberger Rebecca (until 30.04.2008)
Dr. Seefelder Stefan

IPZ 5d

Hop Quality and Analytics WG

Dr. Kammhuber Klaus

Neuhof-Buckl Evi
Petzina Cornelia
Weihrauch Sylvia (as of 18.10. p. leave)
Wyschkon Birgit