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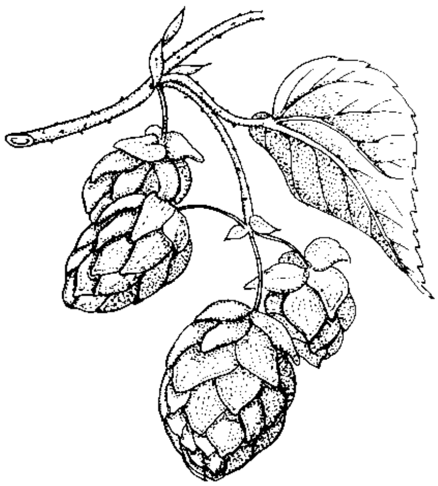
Bayerische Landesanstalt für Landwirtschaft

GfH

Gesellschaft für Hopfenforschung e.V.

Annual Report 2010

Special Crop: Hops



Bavarian State Research Center for Agriculture

- Institute for Crop Science and Plant Breeding -

and the

Society of Hop Research e.V.

March 2011

LfL-Information

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Change is the only constant

As of 1st April 2011, we, Dr. Fritz-Ludwig Schmucker and LLD Bernhard Engelhard, will no longer play an active role at the Hüll Hop Research Centre. After ten years of service as Managing Director of the Society of Hop Research e. V. (GfH) and almost 17 years of hop research focussing on plant protection (Bavarian State Research Center for Agriculture (LfL), Dept. IPZ 5b), we would like to take the opportunity to present a brief review of major changes that took place and yet went almost unnoticed during this comparatively short period of time.

For the GfH, a private society, the following milestones must be highlighted:

- Our society saw an increase in its membership from 128 to 330 as the result of intensive and sustained canvassing efforts. This has stabilized the funding situation for hop research.
- After the change in name from "German Society of Hop Research (DgfH)" to "Society of Hop Research e.V." (GfH), an "Advisory Board" consisting of leading brewing scientists and representatives from the brewing industry was established. This body crafts valuable proposals aimed at ensuring practice-oriented research.
- Research projects and objectives are continuously scrutinized and adjusted to the relevant situation by the GfH and the LfL's government-funded hop research organisation for the benefit of the hops and brewing industries.

All work groups within the Hops Department of the LfL have posted successes:

- New varieties have enabled German hop growers to continue competing successfully on the competitive global market. Whereas global hop acreage was reduced by 50 % within 16 years, acreage in Germany declined by a "mere" 23 % within the same period. The acreage planted with Hüll aroma cultivars increased from 51 % to 81 % in Germany and that planted with Hüll bitter/high-alpha varieties from 20 % to as much as 93 % – a genuine success story.
- Improved application techniques for plant protectives, new irrigation methods and technical equipment optimizing hop drying and conditioning have been put into practice.
- Great efforts were necessary to provide hop growers with sufficiently authorised plant protectives for combating harmful organisms. Despite much tighter regulations, solutions were found again and again with the help of the crop science companies and above all the growers' associations.
- New valuable components such as xanthohumol have been included in analytical and breeding programmes.

There are numerous signs allowing us to conclude that the Hüll Hop Research Centre has achieved greater national and international recognition during the past decade. However, the centre cannot take all the credit for this recognition, which is also due to the work of highly motivated teams in Hüll, Wolnzach and Freising. We regard the awarding of the Order of the Hop by the International Hop Growers' Convention (IHGC) as recognition of the hop research as a whole. The conferment of the rare level-2 'Officer of the Order of the Hop' award may be seen, in particular, as overall recognition of the Hüll Hop Research Centre.

We would like to thank all those with whom we have had the honour of collaborating for what has been a very positive working climate. We have enjoyed the opportunity to work at Bavaria's Hop Research Centre in Hüll for the benefit of the hops and brewing industries.

Dr. Fritz Ludwig Schmucker
Managing Director of the GfH

LLD Bernhard Engelhard
Coordinator, Hops Department, LfL

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1.1 Current research projects

Breeding of dwarf hops for low trellis systems

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtung und AG Hopfenqualität/Hopfenanalytik *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Breeding Research and WG Hop Quality/Hop Analytics*
Financed by:	Bundesanstalt für Landwirtschaft und Ernährung (BLE) *(Federal Agency for Agriculture and Food)* HVG Hopfenverwertungsgenossenschaft e.G. *(HVG Hop Processing Cooperative)*
Project managers:	Dr. E. Seigner, A. Lutz
Project staff:	A. Lutz, J. Kneidl, A. Bogenrieder (all from IPZ 5c) Dr. K. Kammhuber, C. Petzina, B. Wyschkon, B. Sperr, (all from IPZ 5d)
Cooperation:	Gesellschaft für Hopfenforschung (GfH); *(Society for Hop Research)* Hop farms: J. Schrag and M. Mauermeier
Duration:	01.04.2007 - 31.12.2011

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 modified 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 raising hops could also have considerable environmental benefits because the required pesticide and fertilizer volumes are lower. Plus, recycling tunnel sprayers can be employed and potential drift thus reduced.

Results

The preliminary selection of seedlings from the 21 crosses (8 aroma- and 13 bitter-type) performed in 2009 began early in March. In mid-May, the seedlings pre-selected for their disease resistance/tolerance towards powdery mildew and downy mildew were planted out in the vegetation hall, where their growth vigour and, once again, their resistance towards fungal attack were monitored under natural conditions until autumn. The plants were classified as male or female on the basis of flowers that formed as from July. A DNA marker was used to sex any seedlings that had not produced any flowers by autumn. Any plants that showed considerable weaknesses, such as severe aphid infestation, mildew or root rot, or which were of unsuitable growth type, were dug up by autumn.

In spring, 2011, the female and male seedlings were planted out in the high-trellis breeding yards in Hüll and Freising respectively, where their growth vigour on 7-metre trellises, their resistance towards downy mildew and powdery mildew under natural infection conditions and, for the first time, their resistance to *Verticllium* wilt will be monitored over the next 2 to 3 years. Testing for resistance to *Verticillium* wilt requires the plant's root system to be fully developed.

Crosses in 2010

The goal of 15 additional crosses (6 aroma- and 9 bitter-type) performed in July, 2010 was to breed hops suitable for low-trellis systems. Seeds were obtained from all the crosses in autumn.

Cultivation on the low-trellis systems in Starzhausen and Pfaffenhofen

English dwarf varieties, low-growth breeding lines and traditional high-trellis Hüll cultivars have been grown on both low-trellis systems since 1993 to provide experience with this new form of cultivation. Very good yields were obtained at the Starzhausen location, where only the alpha-acid values were below average – a result of the cool and cloudy summer in 2010. Less satisfactory crops were harvested on the heavy, clay soil in Pfaffenhofen, due to downy mildew infection as well as to damage caused by drought and moisture.

Some of the breeding lines showed highly promising alpha-acid levels and yields, but high downy-mildew and red-spider susceptibility are still obstacles to profitable and eco-friendly cultivation.

The 2011 harvest will be of particular interest because it will provide reliable information on yield, resistance and components for a number of seedlings obtained from special crosses performed for this low-trellis project.

PM isolates and their use in breeding PM-resistant hops

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtungsforschung Hopfen *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Breeding Research)*
Financed by:	Wissenschaftliche Station für Brauerei in München e.V. *(Scientific Station for Brewing in Munich)*
Project managers:	Dr. E. Seigner, A. Lutz, Dr. S. Seefelder
Project staff:	A. Lutz, J. Kneidl, Dr. S. Seefelder S. Hasyn (EpiLogic)
Cooperation:	Dr. F. Felsenstein, EpiLogic GmbH Agrarbiologische Forschung und Beratung, Freising
Duration:	01.05.2006 – 31.12.2010

Objective

PM isolates and the two established resistance-testing systems, in the greenhouse and the lab, have become pivotal to the breeding of PM-resistant hops at the Hüll Hop Research Centre. Only with the help of these innovative selection and assay methods is it possible to breed hop cultivars that guarantee optimum brewing and food quality along with reliable supplies even in years marked by high levels of fungal attack.

Results

A selection of 11 different single-spore isolates of *Podosphaera macularis*, the fungus that causes powdery mildew in hops, and the above resistance-testing systems were used in 2010 for the following purposes:

- To assess the breeding stock's resistance properties in the greenhouse, to which end PM races already widespread throughout the Hallertau region of Bavaria were chosen. 252 seedlings, selected via mass screening from the thousands obtained from over 95 crosses performed in 2009, were monitored further as individual plants. Greenhouse testing was also used to assess 56 wild hop and 10 foreign varieties. Hop plants which showed no signs of PM pustules in the greenhouse were re-assessed by EpiLogic in laboratory leaf tests. 140 breeding lines and 49 wild hops were tested, first with an English PM isolate (R2 resistance gene) and then with an isolate of regional importance from the Hallertau growing area. Assessing resistance properties in this way permitted selection of 52 breeding lines and 45 wild hops that show broad resistance to powdery mildew. Only these PM-resistant hops were used for advanced breeding purposes.
- To assess the virulence situation of PM populations in the Hallertau region and worldwide. This must be done every year to establish the effectiveness of the resistance mechanisms of the varieties under cultivation and the breeding stock. It was found, for instance, that resistance in the Hüll cultivar "Hallertauer Merkur" is still fully effective, whereas in the "Herkules" cultivar, it has already broken down in certain regions. It was also found, and confirmed, that PM strains from the Hallertau region are able to overcome the resistance shown by a promising wild hop frequently used over the past few years as resistance carrier in crosses. It is thus urgently necessary to again intensify the search for new PM resistances in wild hops.
- To investigate PM/hop interactions by way of histological and molecular methods. Closer insight into the various resistance mechanisms found in Hüll varieties and in breeding stock was obtained using various virulent and avirulent PM isolates. Such knowledge is essential if different resistance mechanisms with mutually complementary effects are to be combined successfully in future varieties.
- To assess the function of suspected resistance genes using the transient leaf expression system. Gene transfer techniques are used to introduce potential resistance genes into hop leaf cells. The reactions of the fungus and of the leaf cell are then monitored in the lab. The main aim is to identify hop-specific genes that are involved in PM resistance and can therefore be used in conventional resistance breeding.

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

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtungsforschung Hopfen *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Breeding Research)*
Financed by:	Erzeugergemeinschaft Hopfen HVG e.G. *(HVG hop producer group)*
Project manager:	Dr. E. Seigner
Project staff:	K. Oberhollenzer, B. Forster, A. Lutz
Cooperation:	Professor R. Hückelhoven of Munich Technical University, Chair of Phytopathology at the Wissenschaftszentrum Weihenstephan *(Centre of Life and Food Sciences)* Dr. Michael Reichmann, IPZ 3b Dr. F. Felsenstein, EpiLogic GmbH Agrarbiologische Forschung und Beratung, Freising
Duration:	01.04.2008 – 30.09.2011

Objective

The aim of this research project is to characterise the hop/hop powdery mildew interaction in various wild hop varieties intended for use as new resistance carriers for breeding.

Another component of this project supports resistance breeding via a molecular biological approach in which the functions of genes involved in defence responses are characterised. This involves the use of what is known as a transient transformation assay system.

Methods

PM resistance is assessed microscopically by inoculating various hop varieties with PM and stopping the infection at various points in time after inoculation. Various staining techniques were developed to visualize the fungus and cell-level defence responses.

Various candidate genes were selected for the transient transformation assay. Gene expression, i.e. gene activity, following PM infection was examined in susceptible and resistant varieties. A functional analysis was performed on individual candidate genes via transient transformation of hair cells by particle bombardment.

Results

A number of wild hop varieties from the USA, Japan, Turkey and Germany are currently being investigated. Apoptosis is the main form of defence in all wild hops investigated so far. Cell-wall apposition seems to play a minor role in these wild hops. The fungus was able to establish haustoria in a wild hop variety as well as in Northern Brewer, the susceptible control variety. Surprisingly, it was found that hair cells even of hops with macroscopically resistant genotypes are susceptible.

Functional characterisation of an Mlo gene was initiated using the transient transformation assay system. Knock-down experiments in the susceptible Northern Brewer variety showed that cells that had undergone transient knock-down of this susceptibility gene contained fewer haustoria than the control. In other words, silencing the gene makes the cells less susceptible.

Investigation of *Verticillium* infections in the Hallertau district

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtungsforschung Hopfen und AG Hopfenbau/Produktionstechnuk *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Breeding Research and WG Hop Cultivation/Production Techniques*
Financed by:	Erzeugergemeinschaft Hopfen HVG e.G. *(HVG hop producer group)*
Project managers:	Dr. S. Seefelder, Dr. E. Seigner
Project staff:	K. Drofenigg , C. Püschel, S. Petosic, E. Niedermeier
Cooperation:	Dr. S. Dr. S. Radisek, Slovenian Institute of Hop Research and Brewing, Slovenia Prof. B. Javornik, Lublijana University, Slovenia Prof. G. Berg, University of Graz, Austria IPZ 5a (Work Group for Hop Production/Production Techniques)
Duration:	01.03.2008 - 31.05.2013

Objective

Exceptionally high incidence of wilt in all hop varieties is now causing considerable yield reductions in some regions of the Hallertau. The intention is therefore to investigate various aspects of the disease in a number of sub-projects. In addition to analysing the genetics and virulence of *Verticillium*, the fungus that causes hop wilt, and looking at the causes, measures to contain the disease will be explored. The focus of the investigation will be on establishing a fast diagnostic system for hop farmers and testing the effectiveness of bioantagonists, bacterial adversaries of *Verticllium* used to protect hop plants from infection.

Methods

- Conventional breeding techniques to cultivate single-spore *Verticillium* isolates from hop bine samples
- DNA isolation from pure cultures of fungi, hop bines and soil samples
- Molecular and microscopic examinations to differentiate between *Verticillium albo-atrum* and *V. dahliae*
- Molecular analytical characterisation of the *Verticillium* isolates using AFLP and SCAR markers

- Infection test to determine virulence
- Isolation of hereditary *Verticillium* material directly from hop bines and soil particles
- Testing of specific bioantagonists as possible control measures
- Conducting of field trials on leased hop yards seriously affected by wilt

Results

Evidence of the occurrence of both milder and more aggressive forms of *Verticillium* in the Hallertau region was obtained for the first time during this project. To this end, bine sections from hop yards heavily infected with wilt were collected and processed via extremely labour-intensive steps to produce pure fungus cultures. Single-spore isolates were cultivated from these pure cultures and the *Verticillium* species then determined using molecular genetic methods and, to some extent, microscopy. The fungal material was allowed to continue growing so as to produce sufficient DNA for more detailed molecular examination. The Hallertau *Verticillium* isolates were genotyped by means of AFLP analysis and compared with reference isolates from Slovenia and England. Analysis with specific AFLP primer combinations showed an identical DNA band pattern in isolates from Hallertau hop yards seriously affected by wilt and in lethal Slovenian and English *Verticillium* races. An initial artificial *Verticillium* infection test performed in Slovenia in 2009 was verified in 2010 under optimized conditions. In this repetition test, lethal Slovenian and English reference isolates showed the same high virulence as Hallertau isolates from previously wilt-tolerant cultivars such as Northern Brewer or Hallertauer Tradition. Mild reference isolates from abroad and *Verticillium* isolates from only slightly damaged Hallertau hop yards demonstrated similar, much lower, levels of virulence. Previous molecular findings indicating the occurrence in the Hallertau growing region of very aggressive *Verticillium* races were thus confirmed. As part of a recently commenced dissertation, promising experiments on the establishment of an urgently needed rapid diagnostic test were carried out. With the help of a homogenizer, special glass/ceramic mixtures and a commercial fungus isolation kit, hereditary *Verticillium* material was extracted directly from hop bines. This method would make it possible to avoid the hitherto tedious and expensive fungal-cultivation step.

Outlook

Centre-stage, in addition to further molecular and virulence assays, will be the recently commenced testing of specific bacterial strains for their effectiveness, as bioantagonists, in protecting young hop plants from *Verticillium* attack in seriously wilt-infected hop yards. Another focus will be on potential resistance selection in wild hops and Hüll breeding lines planted in 2010 on seriously *Verticillium*-contaminated leased land.

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

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenschutz, AG Pathogendiagnostik und Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtungsforschung Hopfen *(Bavarian State Research Center for Agriculture, Institute for Plant Protection, WG for Pathogen Diagnostics, and Institute for Crop Science and Plant Breeding, WG for Hop Breeding Research)*
Financed by:	Erzeugergemeinschaft Hopfen HVG e.G. *(HVG hop producer group)*
Project managers:	Dr. L. Seigner, Institute for Plant Protection (IPS 2c); Dr. E. Seigner, A. Lutz (both from IPZ 5c)
Project staff:	M. Kappen, C. Huber, M. Kistler, D. Köhler, F. Nachtmann, L. Keckel (all from IPS 2c); J. Kneidl (IPZ 5c)
Cooperation:	Dr. K. Eastwell, Washington State University, Prosser, USA
Duration:	01.04.2009 - 30.09.2010

Objective

Hop stunt viroid (HSVd) causes huge losses in hop yields 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. Until such time as reliable curative methods are available for HSVd-infected hops, the best form of protection is to constantly monitor our breeding yards, the propagation facilities and hop yards as closely as possible.

Method

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

Results

RT-PCR-based monitoring for HSVd infections in hops, commenced in 2008, was maintained in 2010. Tests were conducted on 104 leaf samples from hop farms, 33 from the Society of Hop Research's propagation facilities, 40 from foreign varieties and 200 from the breeding yards in Hüll, Rohrbach, Freising and Schrittenlohe. No HSVd was detected in any of the leaf samples from hop farms in the Hallertau, Elbe-Saale and Tettnang hop-growing regions. All plants tested since 2008 for the Eickelmann propagation facility were likewise confirmed HSVd-free. During our 2010 monitoring activities, however, we discovered Hop stunt viroid for the first time ever in all five plants of the US "Horizon" variety that were growing in our Hüll cultivar yard. This variety had come from the USA in 2001. During subsequent systematic screening of the plants in the vicinity of the infected plants, the viroid was identified in another four hop plants growing close to the focus of infection. In accordance with the phytosanitary measures recommended by our US colleague Dr. K. Eastwell, all 9 HSVd-infected plants (bine and rootstock) were immediately killed by glyphosate injection, the bines and rootstocks burnt and the area around the rootstock locations treated several times with glyphosate, so as to eradicate all HSVd-infected components. The area was immediately cordoned off and will not be planted next year, either.

The high cost of RT-PCR testing makes it impossible to screen every plant. Our findings to date suggest that it is essential to test for this viroid in varieties originating from previously or currently affected regions and being grown on hop farms. This also applies to imported breeding material, including wild hops, and to foreign varieties received at Hüll for variety registration testing. We will also ensure that all mother plants in the GfH's propagation facility are tested for HSVd. The monitoring programme will be continued in 2011 with the financial support of the Scientific Station for Brewing in Munich, and will include testing hop samples for virus diseases.

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

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

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

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

Section 6.3, pages 88 to 91, contains a detailed report.

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

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Pflanzenschutz Hopfen *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Plant Protection)*
Financed by:	Bundesanstalt für Landwirtschaft und Ernährung (BLE) *(Federal Agency for Agriculture and Food)*
Project manager:	B. Engelhard
Project staff:	U. Lachermeier, J. Schwarz
Cooperation:	Part of the integrated project "Erarbeitung von integriertenPflanzenschutzverfahren gegen Bodenschädlinge" *(Development of integrated methods of plant protection against soil pests)*
Duration:	01.03.2008 – 31.12.2010

Objective

- To control weevil larvae in the soil by means of entomopathogenic nematodes (EPN), with the aim of obtaining a permanent EPN colony if possible.
- To identify and log *Otiorhynchus* species that actually occur as pests in German hop-growing areas.

Results 2008 - 2010

- Field trials
  The efficacy of entomopathogenic nematodes (*Steinernema carpocapsae, Heterohabditis bacteriophora*) in controlling the Lucerne weevil was tested in several replications on trial stands in Oberulrain, Untermantelkirchen and Schweinbach. Untreated stands and stands treated with plant protectives served as controls. Evaluation was by means of beetle counts conducted from April to July on the hop plants and on sods of red clover that had been planted as bait plants in-row among the hops. The red clover sods were dug up in autumn and the larvae counted. At the conclusion of the three-year experiment, eight crowns from each hop variety were removed at the Oberulain location by digging down to a depth of 60 cm. The crowns were then monitored for beetles and larvae. Unfortunately for this project, weevil infection was low to very low in all three years. No significant difference was detected between the hop variants.

- Semi-outdoor trials
  In pot trials, specified numbers of Lucerne weevil eggs were introduced into each experimental pot. The eggs had been produced by beetles collected from hop fields and kept in containers, where they were fed lucerne and red clover. 25 eggs were transferred to the root collar of the red clover planted in each pot. The pots were either left untreated (controls), or treated with EPN or entomopathogenic fungi (EPF). The EPF showed a higher efficacy (up to 70 %) than the EPN. These experiments will be continued in 2011.

- To identify and log those *Otiorhynchus* species occurring in German hop-growing areas, separate traps were set up. This work has not yet been concluded. A detailed report is available from the LfL's Plant Protection in Hop Growing work group.

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

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Pflanzenschutz Hopfen *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Plant Protection)*
Financed by:	Erzeugergemeinschaft HVG e. G. *(HVG hop producer group)*
Project manager:	B. Engelhard
Project staff:	J. Schwarz, G. Meyr
Duration:	01.01.2010 – 31.12.2012

Objective

A preliminary forecasting model based on empirical data and a weather-based forecasting model based on scientific data have been developed over a number of years and already tested in field trials. The infection pressure in several untreated plots was too low during this period to permit conclusive statements on the reliability of the forecast. The tests serve to clarify the issue.

Results

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

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

The three test variants comprised untreated plots of approx. 500 m² and plots that were treated in accordance with spray warnings based on the preliminary and the weather-based forecasting models.

Unfortunately for this research project, PM outbreak on the untreated plots was again too low in 2010 to furnish conclusive results.

The "preliminary model" responded with spray warnings for all varieties on June 3rd, June 18th, and August 8th, and for susceptible varieties also on July 7th.

The weather-based model responded very differently at the six agrometeorological weather stations in the Hallertau. On April 6th, the control threshold was reached at 2 of 6 locations; on June 6th at 3 of 6 locations. Later, the main period during which the threshold was exceeded was from 12-17 August. If the criteria for overshooting the threshold are interpreted strictly, the weather-based model was a better basis for spray warnings that were actually necessary.

To minimize the risk for hop farmers, two spray warnings were issued for tolerant varieties and four for susceptible varieties.

Reducing or replacing copper-containing plant protectives in organic hop farming

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Pflanzenschutz Hopfen *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Plant Protection)*
Financed by:	Bundesanstalt für Landwirtschaft und Ernährung (BLE) *(Federal Agency for Agriculture and Food)*
Project manager:	B. Engelhard
Project staff:	A. Sterler, J. Schwarz
Cooperation:	G. Pichlmaier, Haushausen
Duration:	19.04.2010 - 18.03.2013

Objective

According to the German Federal Environment Agency, which has assessed the toxicological effects of copper-containing plant protectives on the environment and users, the use of these products should be discontinued. However, organic hop farmers are currently unable to do without this active agent. The aim of this three-year experimental project is thus to test the extent to which the amount of copper used per season can be reduced without affecting hop quality. The intention is to reduce the currently permitted copper dose rate of 4.0 kg/ha/year by at least 50 %.

2010 Results

- For the first time, a downy mildew station for monitoring zoosporangia was set up on an organic hop farm and the findings evaluated. Surprisingly, zoosporangium counts were up to 10 times higher than at comparable stations in conventional hop yards. The numbers of zoosporangia increased and decreased according to identical time patterns.
- Copper dose rates of 4.0, 3.0 and 2.0 kg/ha were used on three trial hop stands, divided into six sprayings. Conventional organic products (stone dust, brown algae and wettable sulphur) were added arbitrarily to each spray.
- New formulations based on copper hydroxide were used for the 3.0 and 2.0 kg Cu/ha dose rates.

- Marketable hops were produced under all test conditions (except in the control plot with no copper).
- Addition of plant tonics (Herbagreen, Biplantol, Frutogard) enhanced the effect.
- It should be noted when assessing the results that the experiment was carried out on the Perle variety, which is tolerant towards downy mildew.

Behaviour of bees in the hop yard and guttation studies in hops

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Pflanzenschutz Hopfen *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Plant Protection)*
Financed by:	Erzeugergemeinschaft HVG e. G. *(HVG hop producer group)*
Project manager:	B. Engelhard
Project staff:	Dr. K. Wallner, Apicultural State Institute at Hohenheim University
	Dr. I. Illies, Bavarian State Research Centre for Viticulture and Horticulture, Veitshöchheim, Knowledge Centre bees
	Julius Kühn Institute, Braunschweig
	Members of the Pfaffenhofen beekeepers association
	G. Meyr, IPZ 5b
Duration:	2010

Objective

Following the ban on Tamaron (active agent: methamidophos), there has been a gap in the range of plant protectives available for controlling soil pests. Actara could fill this gap, but its active agent (thiomethoxam, a neonicotinoid) is known to be very toxic to bees.

The aim of the project is to test whether use of the product by single-plant application on the ground, before or after crowning, has any negative influence on bees. Since the active agent can also be spread via guttation, it was necessary to observe closely whether this phenomenon occurs at all in hops.

Results

- Guttation: Regular checks were made during the morning hours at two locations (Königsfeld and Hüll). Whereas guttation occurred very frequently in lady's mantle (*Alchemilla sp.*) planted between the hops, it was only observed to a small extent in hops, on May 28th.
- Influence on bees: Two lots of eight bee colonies were set up in/directly adjacent to hop yards. All the nearby hop yards were treated with Actara. The other plant protection measures were carried out in the customary manner. None of the monitoring activities

conducted by beekeeping experts indicated any abnormalities compared with control colonies located some distance away from hop yards. Monitoring was supplemented by detailed analyses performed on bees (water carriers, pollen/nectar collectors) and on honey. No active-agent residues were found. Publications on these projects are planned.

Leaf surface development in hop cultivars during the vegetation period

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Pflanzenschutz Hopfen *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Plant Protection)*
Financed by:	Syngenta Agro GmbH
Project manager:	B. Engelhard
Project staff:	U. Lachermeier
Duration:	01.04. - 30.11.2010

Objective

Hop cultivars differ greatly in growth type and leaf size. The aim was to determine leaf surface development and distribution and how this may impact plant-protective dose rates and the amount of water needed for application purposes.

Results

The study was conducted on field crops of Hallertauer Tradition (HT), Saphir (SR) and Herkules (HS) and involved removing the bines of six uniformly strung hop plants of each variety in mid-June, mid-July and mid-August. The bines were divided into seven sections: base, middle and upper part, in each case with stem and offshoots, and the head region above the wires attached to the barbed wire. In mid-June, it was possible to measure the surface area of each individual leaf per scanalyser. In mid-July, this was only possible with HT. It was still possible to measure the total leaf surface area for HS, but not for SR. In mid-August, the leaves from each section were divided into 17 groups and an average size determined for every 10 leaves. It should be noted that SR and HS have approximately 10,000 individual leaves.

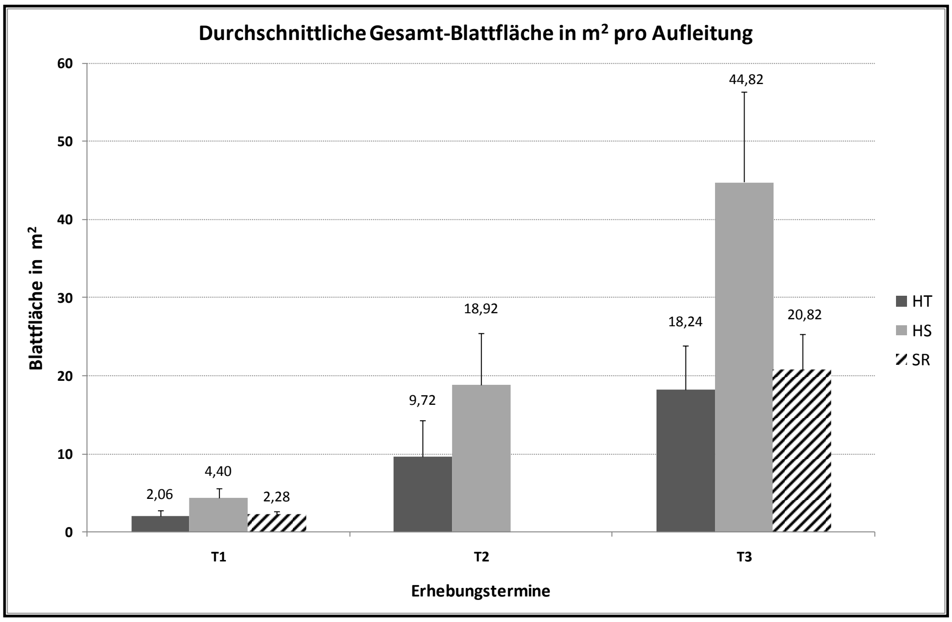

Fig. 1.1: Leaf development in hops

At the end of two fifths of the vegetation period and after reaching two thirds of the trellis height (BBCH 37), a hop plant has only 10 % of the maximum leaf surface area reached by mid-August. The figures given in the chart for surface areas do not include the cones! With the cones, HS has a green surface area of around 30 m² on each wire as from mid-August. This translates into 120,000 m²/ha that have to be protected from pests (also at the centre of the strung plant).

Other project components involved testing an indirect method of measuring leaf surface area with what is known as a ceptometer (measurement of photosynthetically active radiation). The results correlated well with direct leaf surface-area measurements.

Tracer-based deposit measurements will be discussed in separate publications.

Differentiation within the global range of hop varieties on the basis of low-molecular polyphenols

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Hopfenqualität und -analytik *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Quality/Hop Analytics)*
Financed by:	Bayerisches Staatsministerium für Ernährung, Landwirtschaft und Forsten *(Bavarian State Ministry for Food, Agriculture & Forestry)*
Project manager:	Dr. K. Kammhuber
Project staff:	Dr. K. Kammhuber, B. Sperr
Duration:	01.01.2010 - 31.12.2011

Objective

The intention was first to devise a suitable sample preparation technique and HPLC method for analysing the entire world hop range available in Hüll. The aim was then to establish whether it is possible to differentiate among hop varieties and to classify them, possibly also by country.

Results

The entire global range of hop varieties was analysed using the sample preparation technique and HPLC method devised for the purpose. Quercetin and kaempferol glycosides are particularly suitable for variety differentiation. Some varieties are easily distinguishable but others, such as the landrace varieties, are very similar. A country-based classification is not possible.

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

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

Objective

To automate the stringing of training wire, currently performed manually. To this end, the company Soller, assisted by the LfL, was commissioned to develop a prototype and test it in the field, the plan being to attach the fully-automated wire-stringing equipment to the tractor's loading shovel. As the tractor moves forward, the sensor-controlled equipment attaches the training wire to the trellis at given intervals and a height of 7 m. The great advantage of automation is that there is no need for workers (often seasonal workers) on the hop platform, or "crow's nest", the risk of accidents is lower and the job less dependent on weather conditions.

Results

In 2008, hydraulics and mechatronics specialists from the LfL’s Institute for Agricultural Engineering and Animal Husbandry tested a Soller prototype for weaknesses and carried out a fault analysis. At the end of 2009, a second prototype with improved hydraulics and a redesigned winding head fitted with hydraulic swivel motors was tested in the field for the first time. A stringing rate of 0.17 ha/h (= 6 h/ha) was measured. Some minor improvements to increase the work speed and minimize hiccups were made before the project ended in spring, 2010. Further field trials in winter 2010/11 were scheduled in order to establish when the equipment can be introduced for routine use.

The final report on the research project is available for download at www.LfL.bayern.de/ipz/hopfen (homepage of the Bavarian State Research Centre for Agriculture, Hops Dept.).

Automatic hop-yield recording and mapping

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding)*
Financed by:	Erzeugergemeinschaft Hopfen HVG e.G. *(HVG Hop Processing Cooperative)*
Project Manager:	J. Portner
Project staff:	J. Portner
Cooperation:	Rottmeier, Erding; A. Widmann, Hüll
Duration:	01.01.2008 – 31.12.2010

Objective

To develop an automatic yield-measuring system on the cone conveyor belt. The intention was to match up the yield with the position in the field by means of a GPS tracking unit. If the yield data was successfully recorded and matched up with the position in the field, specially developed software could be used to depict the recorded data in colour as a yield map based on a 10 x 10 m grid.

Potential application fields would include advisory services relating to the detection of problems caused by viral attack, soil differences and micronutrient deficiency, and optimisation of fertilisation and plant-protection measures.

Measuring the yield in test hop stands could be an easy way of showing the influence of different production techniques. The yield maps would provide information about the homogeneity of a hop yard, thus facilitating the selection of trial plots for scientific tests.

An additional spin-off might include documentation of the harvest date and duration, the crop volume, etc.

Results

A belt weigher was installed between the cone delivery belt and the conveyor belt to the green-hop silo in order to automatically monitor the yield. As an alternative monitoring system, ultrasonic sensors that determined the yield volumetrically were fitted above the conveyor belt. The advantage of measuring volumes is that differences in hop moisture content, which may falsify weights, are irrelevant. It had already been established in 2009 that ultrasonic volume measurements correlate closely with belt weights.

Yields were matched with field positions by means of a bine counter on the intake arm of the picking machine. This enabled the measured yield to be matched with the bine's position in the harvested row following a time delay. Using a GPS tracking system, it was possible to reconstruct the chronological order in which the rows in the field had been harvested. Once the data had been combined, specially developed software depicted the recorded data as a form of yield map.

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

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding)*
Financed by:	Erzeugergemeinschaft Hopfen HVG e.G. *(HVG hop producer group)*
Project Manager:	J. Portner
Project staff:	S. Fuß
Cooperation:	Mitterer, Terlan
Duration:	01.01.2008 – 31.12.2011

Objective

In this project, the height of the hop trellis was reduced from 7 m to 6 m in trial plots in a number of commercial hop yards (growers of various hop cultivars). The aim is to study the reaction of various cultivars to reduced trellis height (plant growth, susceptibility to disease/pests, yield and quality). Tests are being conducted on the following aroma varieties: Perle und Hallertauer Tradition, and on the following bitter varieties: Hallertauer Magnum, Hallertauer Taurus and Herkules.

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

Results

The project has been extended by a year because four of the six trial locations were destroyed by hail in 2009. As a result, further investigations will be necessary before any conclusions can be drawn concerning the influence of reduced trellis height on growth and yield.

Following slight modifications, the Mitterer sprayer was tested further during 2010 in a 7-m trellis system and compared with other sprayers. Wetting appeared to be good. A systematic fault has unfortunately prevented evaluation of the exact deposit measurements. The spray-application trials will be repeated in 2011 and an efficacy test performed.

Studies to investigate the structural design of hop trellis systems

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding*
Financed by:	Erzeugergemeinschaft Hopfen HVG e.G. *(HVG hop producer group)*
Project Manager:	J. Portner
Project staff:	S. Breitner (civil engineer)
Cooperation:	Prof. O. Springer, Regensburg University of Applied Sciences, Faculty of Civil Engineering
Duration:	2010 – 2011

Objective

Disastrous storm damage during the last few years, which caused hop trellis systems in the Hallertau region to collapse prior to harvesting, has prompted studies to investigate the strengths and weaknesses of the various trellis designs in the different growing areas and ascertain whether structural improvements are possible.

Results

Within the framework of a project and with the assistance of a civil engineer who comes from a hop farm and has experience in structural engineering, civil engineering students at the Regensburg University of Applied Sciences carried out extensive bibliographical research, undertook excursions to the Hallertau, Tettnang and Elbe-Saale hop-growing regions and held discussions with consultants and trellis builders. With the help of simulations performed with the various trellis designs (Hallertau, Tettnang and Elbe-Saale trellises), their strengths and weaknesses were identified and proposals for possible improvements made.

1.2 Main research areas

1.2.1 Hop breeding

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

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

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

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

Objective

The growing demand on the part of craft brewers for hops with new aromas for their specialty beers was recognized early on at Hüll. For years, an increasing number of crosses have been carried out with the aim of developing additional varieties with novel aromas that will subsequently be imparted to the finished beer. Seedlings and breeding lines are currently being selected that have diverse floral, pine and citrus fragrances and sometimes even exotic aromas such as those of tangerines, melons, mangos or redcurrants. In addition, hops for areas of use other than brewing are being developed. On account of their bacteriostatic and antimicrobial effects, Hüll breeding lines with high bitter-acid levels, especially those with beta-acid levels as high as 20 %, are of interest to the food and ethanol industries as harmless, environmentally compatible preservatives. Promising studies being conducted worldwide, e.g. at the German Cancer Research Centre in Heidelberg, repeatedly highlight the anti-carcinogenic effect of xanthohumol, thus making our Hallertauer Taurus cultivar and also new strains containing 1.2 and 1.7 % of this polyphenol particularly interesting for the medical/pharmaceutical sector.

Measures and results

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

Breeding line/ cultivar	Alpha-acid content	Beta-acid content	Alpha- + beta-acid content	Xanthohumol
2003/067/002	9.5 – 14.5	11.0 – 14.0	20 – 27	0.6 – 0.8
2003/067/005	12.0 – 16.5	9.0 – 12.0	21 – 26	0.6 – 0.8
2003/067/044	2.7 – 5.5	15.3 – 21.2	19 25	0.9 – 1.5
2001/101/704	10.0 – 15.0	3.2 – 4.7	13 – 19	1.4 – 2.1
2000/109/728	16.5 – 23.5	5.0 – 6.4	21 – 29	0.7 – 1.0
Hall. Taurus	13.0 – 20.0	4.0 – 6.0	17 – 26	0.7 – 1.0

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

Project manager: Dr. E. Seigner

Project staff: B. Haugg, U. Ziegltrum, A. Lutz

Cooperation: O. Ehrenstraßer, IPZ 5b

Goal and method

Meristem culture is a means of producing virus-free hop plants. The shoot tips are first heat-treated prior to excision of the uppermost growth zone (= meristem), located at the apex of the shoot. Following heat treatment, these 0.2-0.3 mm cytogenous centres are considered virus-free. The meristems are transferred to special culture media, where they develop into complete plants. To verify that hops grown via meristem culture are really free of virus infections, their leaves are examined for apple mosaic and hop mosaic virus with the ELISA (enzyme linked immunosorbent assay) technique.

Results

Ever since this tissue culture method was established at the Hüll Hop Research Centre during the 1980s, meristem excision had been carried out routinely every year by Mr. Hesse of IPZ 5b so as to provide virus-free mother plants for the Society of Hop Research’s propagation facilities. Following Mr. Hesse’s retirement, the technique has had to be newly set up at IPZ 5c. The importance of virus-free planting stock as part of our quality drive will be explained in Section 4.1.4. In addition, we have optimised our *in vitro* propagating medium to meet the special requirements of diverse genotypes.

1.2.2 Hop cultivation and production techniques

Trials to investigate irrigation control in hop growing

Project staff: J. Münsterer

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

Positioning of drip hose in hop irrigation

Project staff: J. Münsterer

Trials are being conducted at Ilmendorf, Kolmhof und Oberempfenbach, which have different types of soil, to determine the extent to which growth and yield are affected by differences in drip-hose positioning during routine hop irrigation. Irrigation via a hose positioned on top of the hilled row is being compared with a technique where the drip hose is buried permanently in the ground alongside the row. In actual practice, hop farmers also position drip hoses in the middle of the tractor aisles in order to reduce labour costs. This alternative is being investigated in a further experiment being conducted on a clay soil in Unterhartheim and a sandy soil in Eichelberg.

Initial trials to optimise belt driers

Project staff: J. Münsterer

Hop farmers can significantly increase drying performance in floor kilns by selecting the correct air speed and cone depth or weight. For the 2010 harvest, the findings from long-term trials in floor kilns were used for the first time on a commercial hop farm to optimise hop drying in a belt drier. The trial involved determining the air speed at which maximum drying performance is achieved. Section 5 contains a more detailed report.

Fungicide treatments with and without strobilurins

Project staff: J. Schätzl
S. Fuß

Duration: 2007 – 2010

In addition to their fungicidal effect, plant protectives from the stobilurin group are said to produce a certain “greening” effect and to positively influence yield and component formation. No significant differences in yield or alpha content had been found by the end of the four-year scientific investigation, which was carried out on Hallertauer Magnum. Two downy mildew treatments per year (one with a strobilurin preparation and one with a reference preparation from another group of active agents) were applied to a field crop, and the yield and alpha-acid content measured.

Testing alternative training materials

Project staff: J. Schätzl

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

In 2010, coir string was tested and compared with wire in a commercial hop yard. Stringing with coir proved difficult because the bulky material is awkward to store on the hop platform and, due to its rough surface, is also difficult to extract from the bundle. No problems were encountered with respect to the durability, i.e. tear strength, of the coir or to bine sagging.

Optimising nitrogen fertilisation by means of banded application

Project Manager: J. Portner

Project staff: E. Niedermeier

Duration: 2007 – 2011

Earlier trials in the Hallertau and in Thuringia show that if fertiliser is applied by banding rather than by broadcasting, the same yield can be achieved with up to a third less fertiliser. In addition to beneficial environmental effects, there are advantages for hop farmers at 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 is investigating whether the surplus limit of 60 kg N/ha for hop farms is sufficient and whether nitrogen can really be saved via banded fertiliser application.

Leaf fertilisation with "Pentakeep super"

Project Manager: J. Portner

Project staff: E. Niedermeier

Duration: 2008 – 2010

In addition to various primary nutrients and micronutrients, Pentakeep super leaf fertiliser contains the compound aminolevulin acid, which is said to have a stress-compensating effect that increases yield and alpha-acid content. The leaf fertiliser was tested on the aroma variety Perle and the bitter variety Hallertauer Magnum in two commercial hop yards. It was applied by spraying (the control plot remains unsprayed) according to 2 different regimens specified by the manufacturer. The one treatment involved spraying 6 times, each time with a Pentakeep solution of 0.5 kg/ha in 1,000 l water/ha. The other treatment involved 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. At the end of the trials, significant but also contradictory yield differences were ascertained. They were not indicative of a trend nor did they allow a definite conclusion to be drawn. No increase in alpha content due to spraying with Pentakeep was detected.

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

Project Manager: J. Portner

Project staff: J. Schätzl

Duration: 2008 – 2013

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

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

1.2.3 Hop quality and analytics

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

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

Hops are grown and cultivated mainly for their components. Component analysis is therefore essential to successful hop research. The IPZ 5d team (Hop Quality and Analytics work group) carries out all analytical studies needed to support the experimental work of the other work groups. Hop Breeding Research, in particular, selects breeding lines according to laboratory data.

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

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

Work on the development of an HPLC-data-based NIRS calibration standard for alpha-acid content commenced in Hüll and the laboratories of the hop-processing companies in 2000, with the rising number of wet chemical analyses having prompted the decision to look for a cheap, fast alternative method with acceptable repeatability and reproducibility for routine use. It was decided within the Working Group of Hop Analysis (AHA) that such a method would be deemed suitable for routine use and for use as an analytical method for hop supply contracts if it was at least as accurate as conductometric titration according to EBC 7.4.

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

Development of analytical methods for hop polyphenols

Project manager: Dr. K. Kammhuber

Cooperation: Working Group of Hop Analysis (AHA)

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

Duration: 2007 to (open-ended)

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

During the most recent international ring tests, however, the total variation coefficients (cvR) were still too high for these techniques to be accepted as official methods. Work is therefore being done to improve them. In an initial ring test, an HPLC method for analysing quercetin and kaempferol contents was also tested. The results obtained were comparable. The next step is to develop an HPLC method for the entire range of low-molecular polyphenols.

Introduction and establishment of UHPLC in hop analytics

Project manager: Dr. K. Kammhuber

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

Duration: May 2008 to (open-ended)

In May 2008, a UHPLC system was set up in Hüll. UHPLC stands for Ultra HPLC and is a refinement of conventional HPLC. The system can generate pressures of up to 1,000 bar, making it possible to use columns filled with particles measuring less than 2 μm. Analysis runs are much shorter, without any loss in resolution. The HPLC method according to EBC 7.4 takes 4 minutes. This makes for significantly faster throughput and less solvent waste. Procurement of the UHPLC system means that the Hüll laboratory is now once again equipped with the latest state of the art.

1.2.4 Plant protection in hops

Testing of plant protectives for licensing and approval, and for the 2010 advisory-service documentation

Project manager: B. Engelhard

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

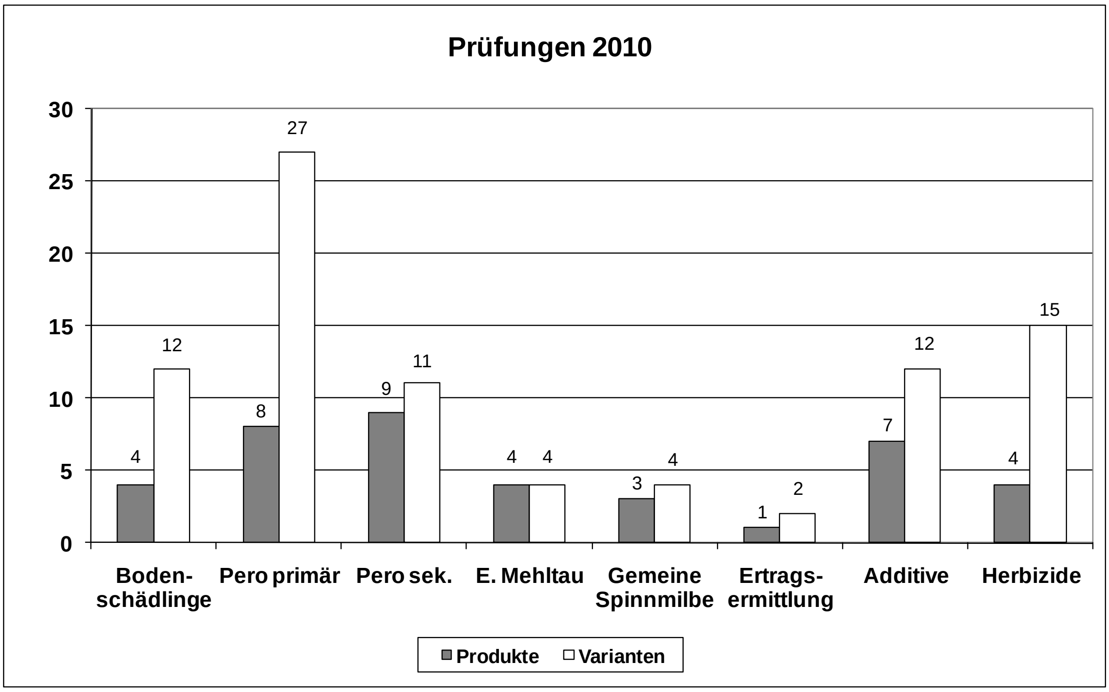

Fig. 1.2: Tests

Testing of adjuvants to improve the efficacy of Teppeki and Milbeknock

Project manager: B. Engelhard

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

During 2009 and 2010, five spray adjuvants of various categories (wetting agents, stickers and penetrants) were added to the insecticide Teppeki in order to test the need for adjuvants. In 2009, conditions for use of the insecticide were excellent (average aphid colonisation levels, soft leaves, warm, sunny weather) and the spray was 99.93 % efficient without adjuvants. In 2010, although conditions were extremely unfavourable (e.g. 582 aphids per leaf, drought, thick cuticles), the spray was 99.96 % efficient on its own. The use of adjuvants to enhance efficacy was thus shown to be unnecessary.

The effect of adding Break-Thru S240 and reducing water volumes from 2,000 to 1,000 l/ha was also tested. No differences in spray efficacy were detected in either 2008 or 2009 (Perle variety).

The addition of penetrants in the tests with Vertimec and Milbeknock for control of the common spider mite produced a distinct improvement.

Growth regulator for improving yields and alpha-acid content

Project manager: B. Engelhard

Project staff: J. Schwarz, G. Meyr, J. Weiher, Dr. K. Kammhuber

A bioregulator was tested in 2008 and 2009, and a growth regulator in 2010. The regulators were applied in each case during the same two vegetative periods: BBCH 37-39 to increase the yield and BBCH 71-75 to increase the level of specific components, especially alpha acids.

In contrast to other crops, where these products produce a distinct effect, no improvement was obtained in either hop yield or hop quality.

2 Fickle weather in 2010 – effects on production-related measures in the Hallertau

LLD Bernhard Engelhard, Dipl. Ing. agr.

By 2010, very few of the hop yards affected by the violent hailstorm of 26.05.2009 still bore recognizable traces of the damage done at the time. What a strange stroke of fate, however, for a hailstorm to ravage an almost comparable area on the same day of the following year – or is this perhaps something we can expect more frequently in the future?

On 26.05.2010, approx. 3,000 ha hops located in the middle of the Hallertau region on a swathe of land running from Geisenfeld to Aiglsbach and Meilenhofen were so badly damaged that the official crop estimate put the loss at about 40,000 cwt. (2009: 4,000 ha with a loss of approx. 100,000 cwt.). Even greater losses could be averted only through retraining, which involved considerable additional labour.

Special weather abnormalities and their effects:

- Delayed start of the growing season

Phenological records in the Pfaffenhofen region as of 1980 show that the start of the vegetation cycle has advanced by two weeks as a general trend. The latest vegetation commencement date (green-up of vines and uncultivated grassland) recorded in that period was that of 1992, viz. 28th April. The fact that the start of the growing season in 2010, 26th March, is now classed as very late is a general indication of the trend in climate development.

A long winter, with well-below-average temperatures in February and even in March, led to delayed commencement of springtime work. After the frost period had ended, the soil was saturated with water and became compacted if driven over too soon.

- A very dry and also very cold April

A temperature of 0.7 °C below the 10-year average and approx. 10 mm rain, instead of 61 mm were the first extreme conditions seen:

  - Very strong dust generation during;
  - Contrary to normal practice, rape catch crops were planted even prior to stripping;
  - Slow bud break and growth of hops, which meant that pruning and training did not commence until 28.04. (considerable problems organizing seasonal workers).

- Much too cold and wet until 22nd May

The combination of sustained precipitation in the form of steady rainfall and cool night (and day) temperatures was typical of the weather up to 22nd May:

  - Difficult stripping and training conditions (wet, cold); the positive side was that “runaway growth”was prevented;
  - Necessary sprayings (Ring fax of 07.05.!) could not be performed;
  - depressed growth and leaf paling were evident;
  - No spray warning to combat powdery mildew

- Sharp rise in temperature as of 23rd May (Whitsun)

Despite this rise in temperature, the average temperature in May was almost 3°C below the 10-year average. With a rainfall volume that was 50 % above the average together with cool temperatures, the downy mildew fungus in the hop plants apparently still had optimum conditions for multiplication, as witnessed by the fact that the commencement of hop growth from Whitsun onwards was accompanied by the following phenomena:

  - Primary downy mildew infection on a hitherto unknown scale, and
  - Weather conditions that allowed protection measures to be conducted on only two or, at most, three days in the whole month. The Hallertauer Taurus variety was especially severely affected.
  - Estimated losses resulting from the primary downy mildew infection amounting to 15,000 cwt.

- Hail on 26th May
- Then cold and cloudy again in June, too much rain until the start of summer (21.06.)
  - Vegetation growth was delayed in all crop plants; maize was only 20 cm high on 15.06.; its lowest level since 1987;
  - Only a small percentage of the hop bines had reached trellis height by 24.06; advantage: no early flower-setting as in 2009;
  - Plant-protection measures, especially against downy mildew, were virtually impossible or had to be conducted under very adverse conditions during this period;
  - Growth disorders in the form of "paling" and "yellowish discolouration" of the lower leaf nodes.

- Heat wave in July

The only month with above-average temperatures was July, which saw 11 days with temperatures of over 30 °C!

- From 22.06. onwards, it was possible to conduct plant-protection measures under good conditions for the first time;
- The long hot and dry period killed off the downy mildew. Without this natural control, this disease would have led to even greater problems;
- Aphids and the common spider mite caused no problems;
- Powdery mildew was kept under control with the help of a total of two sprayings (04.06. and 21.06.);
- Overall, an unusually small number of plant protection measures were necessary in July;
- The second hilling and sowing of catch crops were conducted under optimum conditions.

- July as a "hops patcher"

From 12th to 17th July, 20 - 60 mm of rain (depending on the area) fell - in the nick of time. From 22nd July onwards, the average July rainfall level of 104 mm was reached throughout the area.

- The time lag in vegetation growth from the spring was not made good in summer: Early varieties began to flower up to 15 days later than normal, late varieties from three to seven days later.

- Double the normal rainfall in August, with below-average temperatures

The very fickle summer weather affected the harvest date, yield and quality:

- Unusually late start of harvesting; at many farms, not until 3rd September
- Small cones
- Too cool for complete alpha-acid formation
- Downy mildew infection in almost all varieties

To put it in a nutshell: the vagaries of the weather created extremely difficult conditions for hop farmers throughout the year.

2.1 Weather data (monthly means or monthly totals) for 2010 compared with 10- and 50-year means

Month		Temp. 2 m above ground Mean (°C)	Min.Ø (°C)	Max.Ø (°C)	Relat. humid. (%)	Precipi-tation (mm)	Days with precipitn. >0.2 mm	Sun-shine (h)
January	2010	-3.1	-5.9	-1.0	89.3	23.7	13.0	36,2
Ø	10-yr.	-0.8	-4.4	3.0	88.2	53.5	11.4	76,3
	50-yr.	-2.4	-5.1	1.0	85.7	51.7	13.7	44,5
February	2010	-0.8	-4.2	3.3	84.6	45.0	15.0	66,0
Ø	10-yr.	0.7	-3.7	5.7	84.7	43.0	12.6	97,3
	50-yr.	-1.2	-5.1	2.9	82.8	48.4	12.8	68,7
March	2010	3.7	-1.4	9.8	74.9	50.1	11.0	169,8
Ø	10-yr.	4.0	-0.9	9.5	81.3	79.5	14.3	138,2
	50-yr.	2.7	-2.3	8.2	78.8	43.5	11.3	134,4
April	2010	8.5	1.3	16.0	66.8	14.4	6.0	224,9
Ø	10-yr.	9.2	3.0	15.9	73.6	61.0	11.3	197,2
	50-yr.	7.4	1.8	13.3	75.9	55.9	12.4	165,0
May	2010	11.4	7.4	15.8	81.1	155.8	21.0	112,3
Ø	10-yr.	14.1	7.7	20.7	73.7	97.8	13.8	224,9
	50-yr.	11.9	5.7	17.8	75.1	86.1	14.0	207,4
June	2010	16.7	11.4	22.2	77.5	140.5	15.0	201,8
Ø	10-yr.	17.3	10.5	24.0	73.2	88.5	13.8	247,5
	50-yr.	15.3	8.9	21.2	75.6	106.1	14.2	220,0
July	2010	19.9	12.9	27.2	73.2	104.8	10.0	309,8
Ø	10-yr.	18.0	11.8	24.9	76.2	104.2	15.9	233,1
	50-yr.	16.9	10.6	23.1	76.3	108.4	13.9	240,3
August	2010	16.7	11.4	23.3	85.0	198.1	18.0	168,0
Ø	10-yr.	17.6	11.6	24.7	78.9	95.0	12.7	217,2
	50-yr.	16.0	10.2	22.5	79.4	94.9	13.3	218,4
September	2010	11.6	6.0	18.2	86.0	66.0	9.0	167,0
Ø	10-yr.	13.2	7.8	19.7	83.5	70.0	11.4	163,7
	50-yr.	12.8	7.4	19.4	81.5	65.9	11.4	174,5
October	2010	7.3	2.9	12.9	89.4	24.5	9.0	119,6
Ø	10-yr.	9.0	4.6	14.5	88.3	65.0	12.3	113,8
	50-yr.	7.5	2.8	13.0	84.8	60.0	10.4	112,9
November	2010	4.7	1.3	8.2	92.4	66.2	18.0	67,7
Ø	10-yr.	3.9	0.4	7.7	91.4	63.4	12.8	63,9
	50-yr.	3.2	-0.2	6.4	87.5	58.8	12.6	42,8
December	2010	-3.4	-7.2	-0.4	95.5	125.1	16.0	34,9
Ø	10-yr.	0.2	-2.8	3.3	91.1	49.0	13.9	58,5
	50-yr.	-0.9	-4.4	1.6	88.1	49.1	13.3	34,3
Ø 2010		7,8	3.0	13.0	83.0	1014.2	161.0	1678.0
10 – year mean		8,9	3.8	14.5	82.0	869.9	156.2	1831.5
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 2000 through 2009.

3 Statistical data on hop production

LD Johann Porter, Dipl. Ing. agr.

3.1 Production data

3.1.1 Pattern of hop farming

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

Year	No. of farms	Hop acreage per farm in ha	Year	No. of farms	Hop acreage per farm in ha
1974	8 120	2.48	1994	3 282	6.69
1975	7 654	2.64	1995	3 122	7.01
1976	7 063	2.79	1996	2 950	7.39
1977	6 617	2.90	1997	2 790	7.66
1978	5 979	2.94	1998	2 547	7.73
1979	5 772	2.99	1999	2 324	7.87
1980	5 716	3.14	2000	2 197	8.47
1981	5 649	3.40	2001	2 126	8.95
1982	5 580	3.58	2002	1 943	9.45
1983	5 408	3.66	2003	1 788	9.82
1984	5 206	3.77	2004	1 698	10.29
1985	5 044	3.89	2005	1 611	10.66
1986	4 847	4.05	2006	1 555	11.04
1987	4 613	4.18	2007	1 511	11.70
1988	4 488	4.41	2008	1 497	12.49
1989	4 298	4.64	2009	1 473	12.54
1990	4 183	5.35	2010	1 435	12.81
1991	3 957	5.70			

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

Hop-growing region	Hop acreages				Hop farms				Hop acreage per farm in ha	
	in ha		Increase + / Decrease -				Increase + / Decrease -			
	2009	2010	2010 to 2009		2009	2010	2010 to 2009		2009	2010
			ha	%			Farms	%		
Hallertau	15 473	15 387	- 86	-0.6	1 196	1164	- 32	- 2.7	12.94	13.22
Spalt	373	376	+ 3	+ 0.1	78	75	- 3	- 4.9	4.78	5.01
Tettnang	1 221	1 226	+ 4	+ 3.6	168	165	- 3	- 2.3	7.27	7.43
Baden and Bitburg	19	20	+ 1	+ 5.3	2	2	± 0	± 0	9.50	10.00
Elbe-Saale	1 387	1 379	- 8	- 0.6	29	29	± 0	± 0	47.81	47.54
Deutschland	**18 473**	**18 386**	**- 86**	**- 0.5**	**1 473**	**1 435**	**- 38**	**- 2.6**	**12.54**	**12.81**

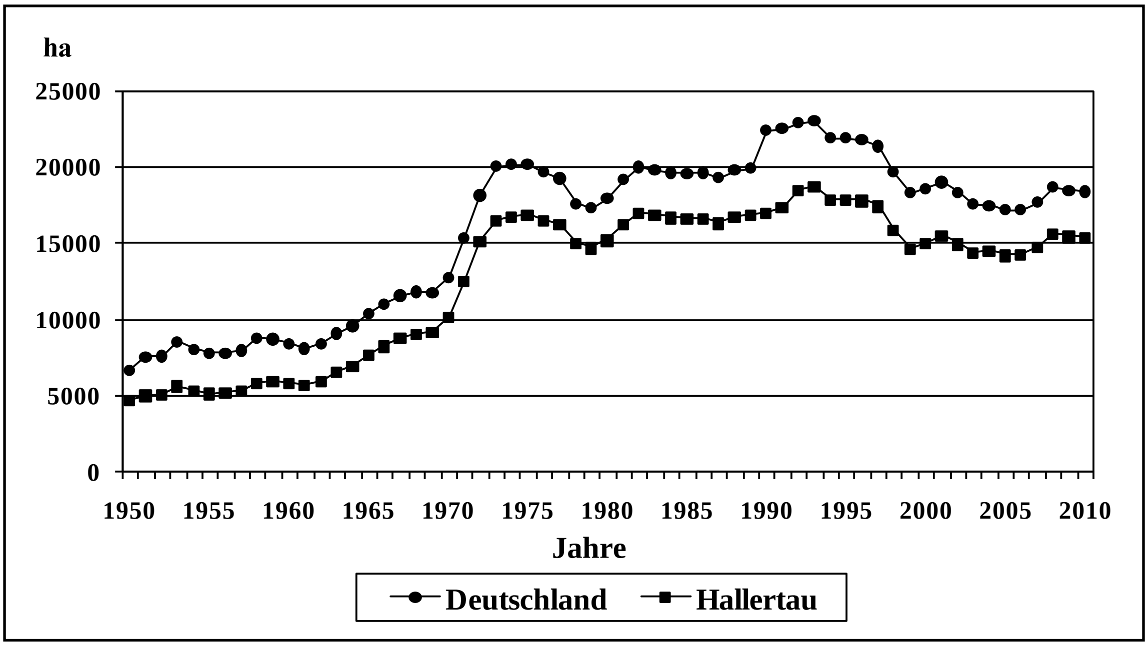

Fig. 3.1: Hop acreages in Germany and in the Hallertau

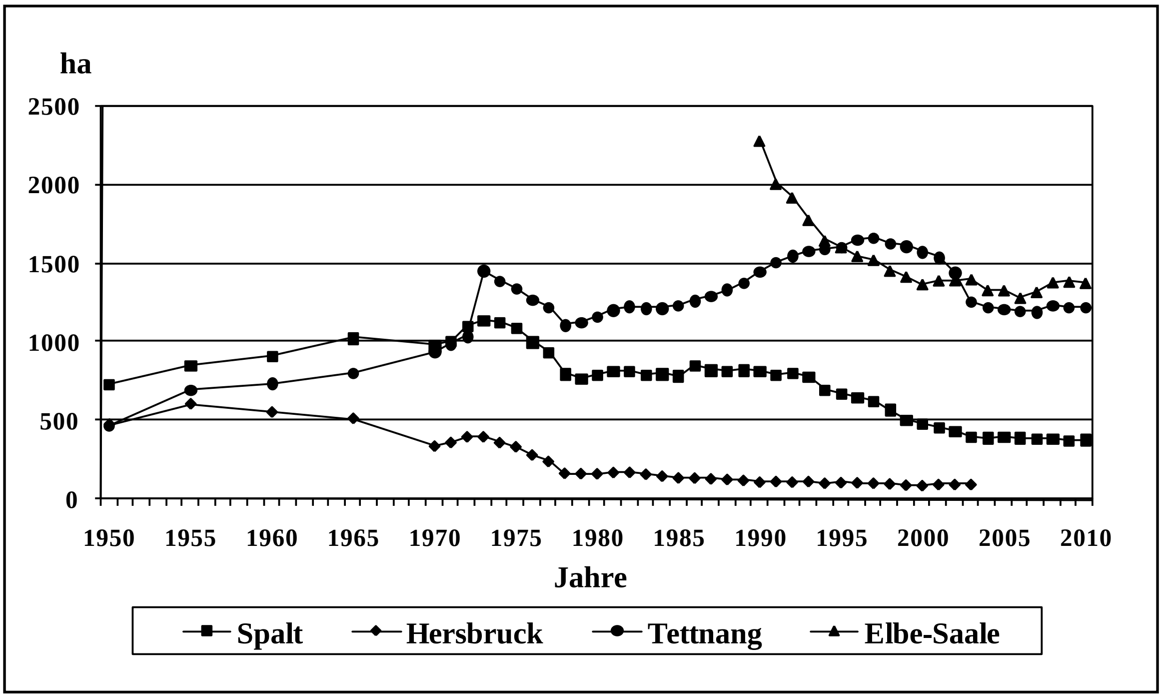

Fig. 3.2: Hop acreages in the Spalt, Hersbruck, Tettnang and Elbe-Saale regions

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

3.1.2 Hop varieties

The production shift away from aroma varieties towards bitter varieties, as observed in the preceding years, came to a halt in 2010, with slight reductions in the acreages of both aroma and bitter varieties being recorded. Aroma varieties now account for 53.3 % (- 0.1 %) of the total acreage under hop production, and bitter varieties for 46.7 %.

In 2010, the area under hop production in Germany declined by 86 ha, to 18 386 ha, as a result of the saturated market. Of the aroma varieties, Hallertauer, Hersbrucker, Spalter Select and Opal saw complete clearance of some of the areas previously under cultivation. Perle and Hallertauer Tradition, for their part, witnessed small increases in area of 23 and 19 ha respectively, whereas the new Hüll aroma varieties Saphir (+ 11 ha) and Smaragd (+ 3 ha) posted only very slight increases. Altogther, the acreage planted with aroma varieties decreased by 61 ha in 2010. The acreage planted with bitter varieties also decreased in 2010, by 25 ha, reversing the trend of the previous years. Only Herkules ran contrary to the trend, with a renewed increase in acreage of 154 ha.

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

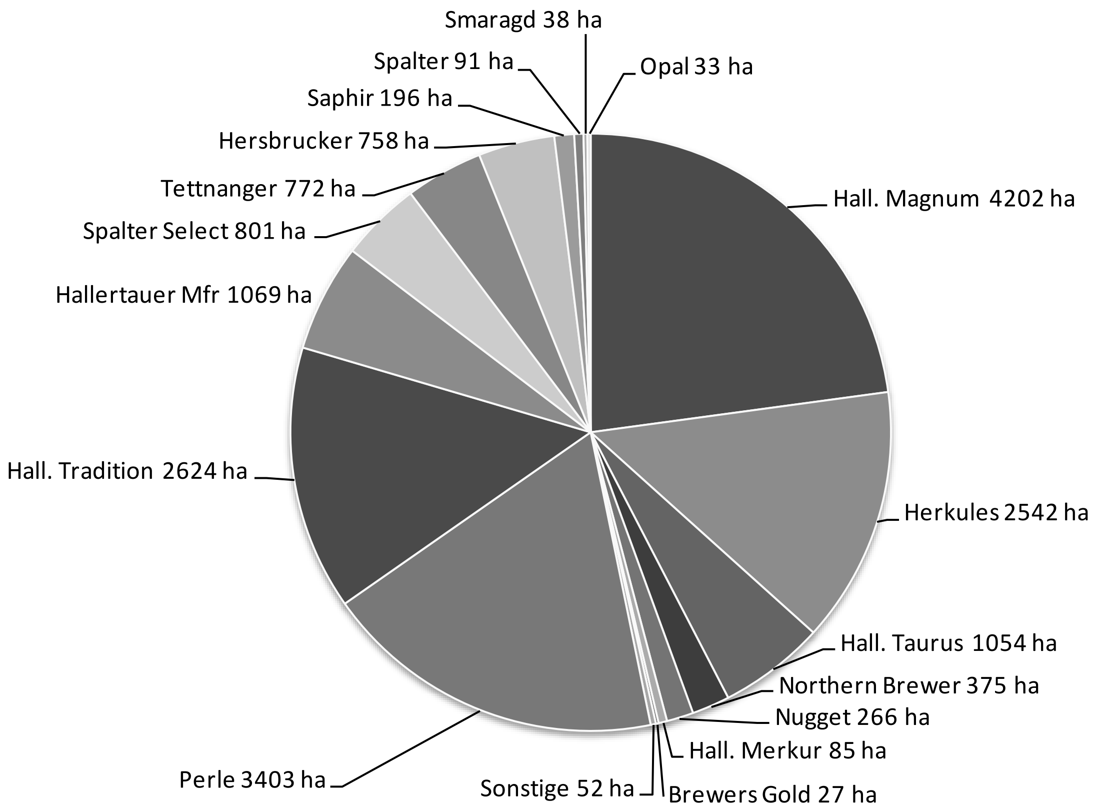

Fig. 3.3: Distribution of hop varieties in Germany in 2010

Tab. 3.3: Hop varieties by German hop-growing region in ha in 2010
Aroma varieties

Region	Total acreage	HA	SP	TE	HE	PE	SE	HT	SR	OL	SD	Other	Aroma varieties	
													ha	%
Hallertau	15,387	704			755	3,139	690	2,513	195	33	34	8	8,070	52.4
Spalt	376	80	91		3	26	104	30	2				336	89.3
Tettnang	1226	284		772		78	4	48			5		1,191	97.1
Baden, Bitburg and Rhine. Pal.	20	1				8	2	5					16	80.4
Elbe-Saale	1379					152		28				8	188	13.6
Germany	**18,386**	**1,069**	**91**	**772**	**758**	**3,403**	**801**	**2,624**	**196**	**33**	**38**	**16**	**9,800**	**53.3**
% acreage by variety		5.8	0.5	4.2	4.1	18.5	4.4	14.3	1.1	0.2	0.2	0.1		

Variety changes in Germany

2009 ha	18,473	1,150	85	765	768	3,380	836	2,605	185	35	36	15	9,861	53.4
2010 ha	18,386	1,069	91	772	758	3,403	801	2,624	196	33	38	16	9,800	53.3
Change in ha	- 86	- 81	+ 6	+ 8	- 11	+ 23	- 36	+19	+ 11	- 2	+ 3	+ 1	- 61	- 0.1

Tab. 3.4: Hop varieties by German hop-growing region in ha in 2010
Bitter varieties

Region	NB	BG	NU	TA	HM	TU	MR	HS	Other	Bitter varieties	
										ha	%
Hallertau	248	27	236	3	3,340	1,025	63	2,350	25	7,317	47.6
Spalt					4		9	27		40	10.7
Tettnang						6		29	1	35	2.9
Baden, Bitburg and Rhine-Pal.					3			1		4	19.6
Elbe-Saale	127		30		854	23	13	136	8	1,191	86.4
Germany	**375**	**27**	**266**	**3**	**4,202**	**1,054**	**85**	**2,542**	**34**	**8,586**	**46.7**
% acreage by variety	2.0	0.1	1.4	0.0	22.9	5.7	0.5	13.8	0.2		

Variety changes in Germany

2009 ha	401	27	279	10	4,267	1,106	96	2,388	39	8,611	46.6
2010 ha	375	27	266	3	4,202	1,054	85	2,542	34	8,586	46.7
Change in ha	- 26	0	- 13	- 7	- 65	- 53	- 11	+ 154	- 5	- 25	+ 0.1

3.2 Yields in 2010

Approximately 34,233,810 kg (= 684,676 cwt.) hops were harvested in Germany in 2010, compared with 31,343,670 kg (= 626,873 cwt.) in 2009. In volume terms, the yield was thus about 2,890,140 kg (= 57,803 cwt.) higher than in the previous year, an increase of around 9 %.

With a mean per-hectare yield of 1,862 kg, the yield is a good average. If estimated crop losses of one million kg caused by widespread hail in the central Hallertau region are taken into account, the yield can be classed as above average. Alpha content was also above average in 2010.

Tab. 3.5: Per-hectare yields and relative figures in Germany

	2005	2006	2007	2008	2009	2010
Yield kg/ha and (cwt./ha)	2006 kg (40.1 cwt.)	1660 kg (33.2 cwt.)	1819 kg (36.4 cwt.)	2122 kg (42.4 cwt.)	1697 kg (33.9 cwt.)	1862 kg (37.2 cwt.)
					(severe hail damage)	(hail damage)
Acreage in ha	17.179	17 170	17.671	18.695	18.473	18.386
Total yield in kg and cwt.	34 466 770 kg = 689 335 cwt.	28 508 250 kg = 570 165 cwt.	32 138 870 kg = 642 777 cwt.	39 676 470 kg = 793 529 cwt.	31 343 670 kg = 626 873 cwt.	34 233 810 kg = 684 676 cwt.

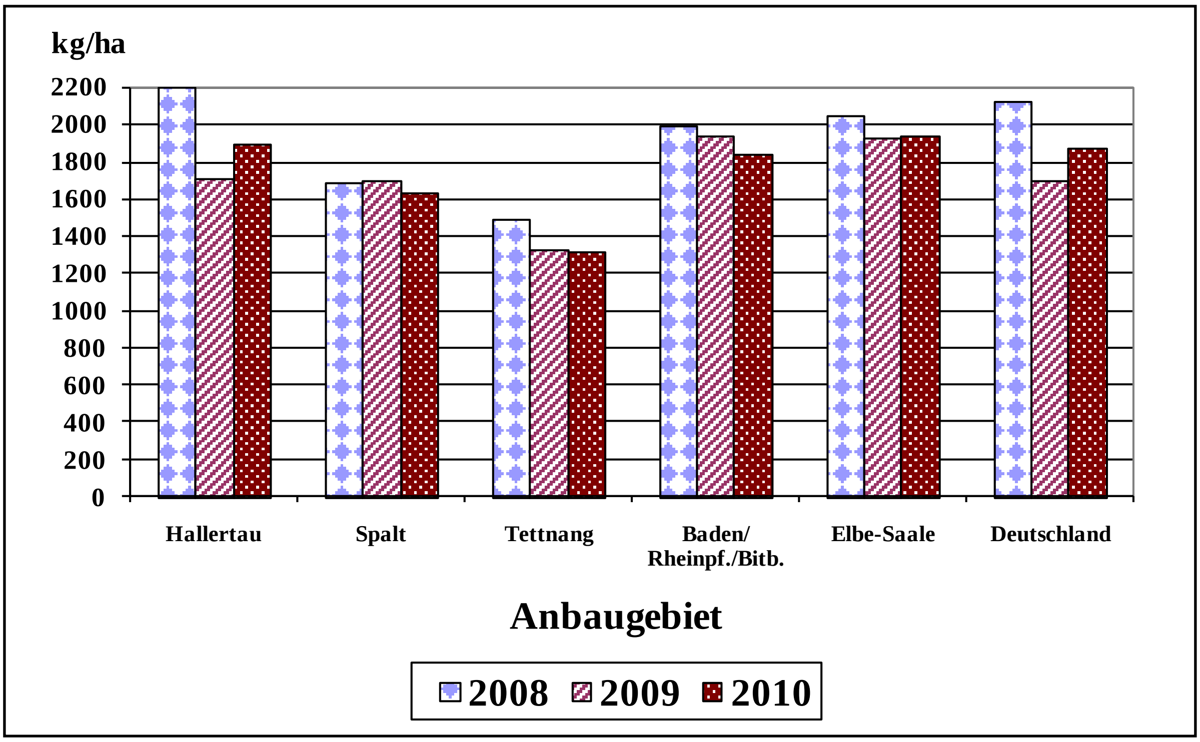

Fig. 3.4: Average yields by hop-growing region in kg

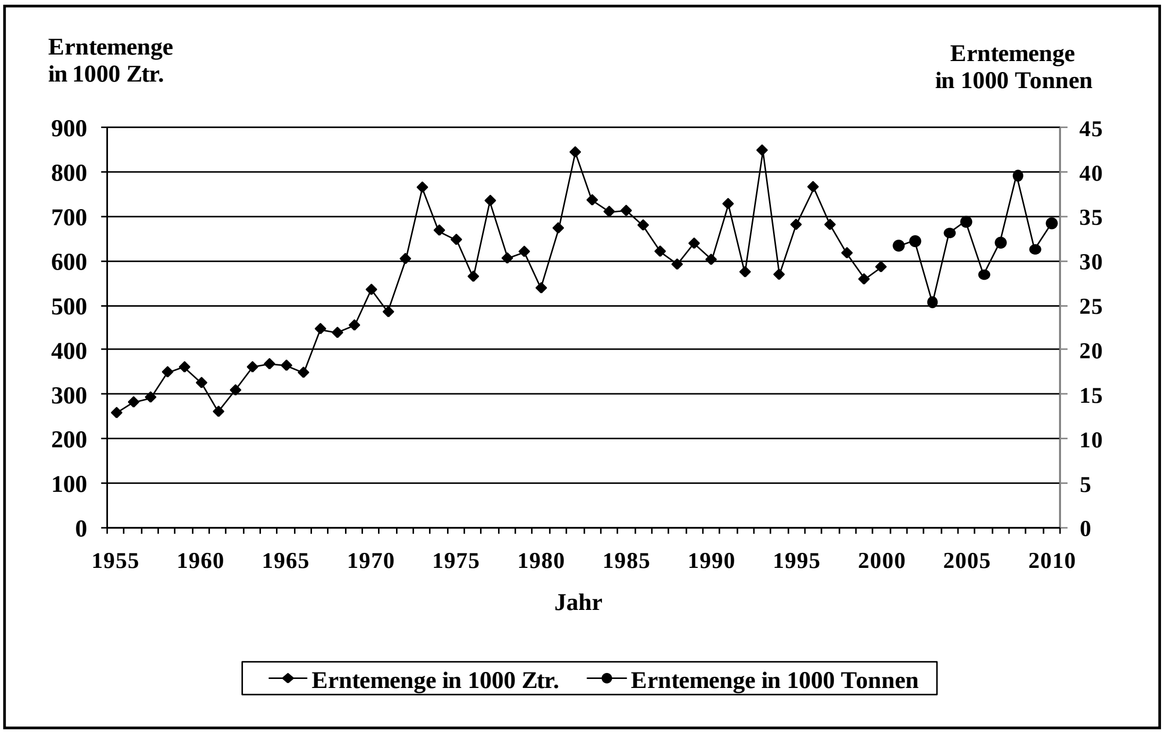

Fig. 3.5: Yields by volume in Germany

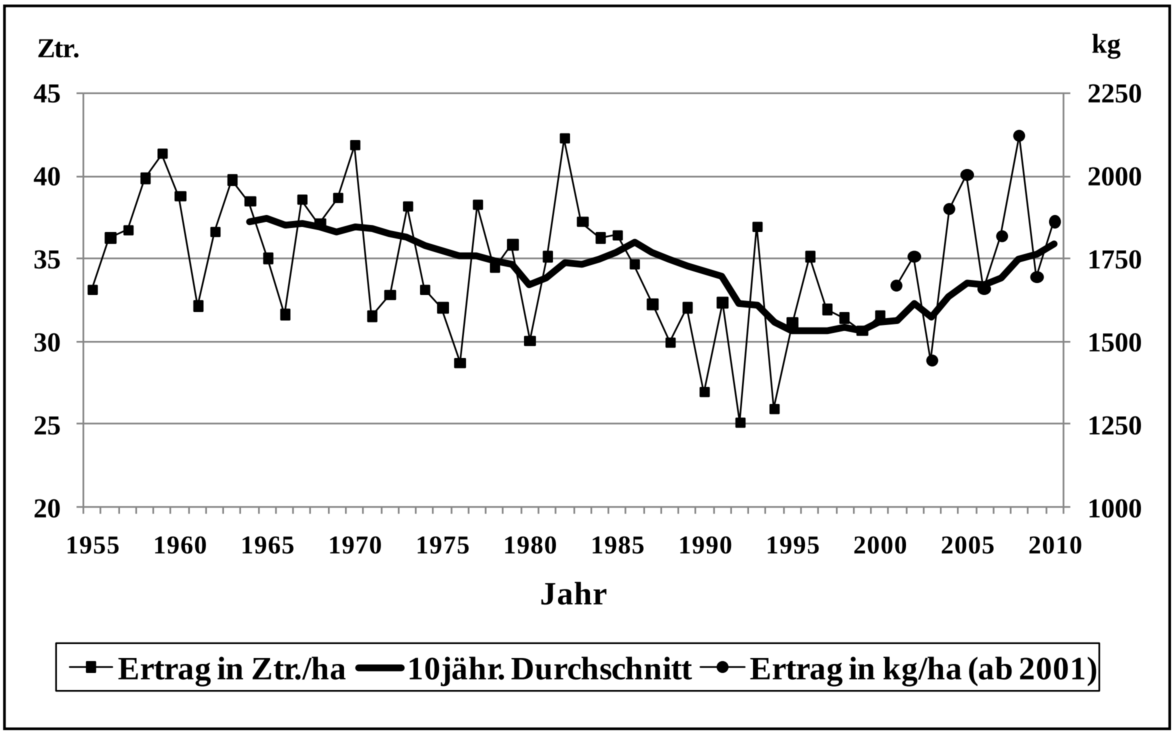

Fig. 3.6: Average yields (cwt. and kg/ha) in Germany

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

	Yields in kg/ha total acreage								
Region	2002	2003	2004	2005	2006	2007	2008	2009	2010
Hallertau	1825	1462	1946	2084	1701	1844	2190	1706	1893
Spalt	1464	1131	1400	1518	1300	1532	1680	1691	1625
Hersbruck	1306	983	- *	- *	-*	- *	- *	- *	- *
Tettnang	1360	1216	1525	1405	1187	1353	1489	1320	1315
Baden./Rhine -Pal	1763	1936	1889	1881	1818	2029	1988	1937	1839
Bitburg									
Elbe-Saale	1576	1555	1895	1867	1754	2043	2046	1920	1931
Ø Yield / ha **Germany**	**1758 kg**	**1444 kg**	**1900 kg**	**2006 kg**	**1660 kg**	**1819 kg**	**2122 kg**	**1697 kg**	**1862 kg**
Total crop Germany (t and cwt.)	32 271 t 645 419	25 356 t 507 124	33 208 t 664 160	34 467 t 689 335	28 508 t 570 165	32 139 t 642 777	39 676 t 793 529	31 344 t 626 873	34 234 t 684 676
Acreage Germany	18 352	17 563	17 476	17 179	17 170	17 671	18 695	18 473	18 386

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

Tab. 3.7: Alpha-acid values for the various hop varieties

Region/Variety	2001	2002	2003	2004	2005	2006	2007	2008	2009	**2010**	Ø 5 years	Ø 10 years
Hallertau Hallertauer	4.6	4.6	3.1	4.3	4.4	2.4	3.9	4.4	4.2	**3.8**	**3.7**	**4.0**
Hallertau Hersbrucker	3.0	3.2	2.1	3.0	3.5	2.2	2.6	2.9	3.4	**3.5**	**2.9**	**2.9**
Hallertau Hall. Saphir				3.4	4.1	3.2	4.6	5.1	4.5	**4.5**	**4.4**	
Hallertau Opal							7.4	9.4	9.0	**8.6**		
Hallertau Smaragd							6.1	6.7	6.4	**7.4**		
Hallertau Perle	7.0	8.6	3.9	6.4	7.8	6.2	7.9	8.5	9.2	**7.5**	**7.9**	**7.3**
Hallertau Spalter Select	4.8	6.0	3.2	4.9	5.2	4.3	4.7	5.4	5.7	**5.7**	**5.2**	**5.0**
Hallertau Hall. Tradition	6.3	7.2	4.1	6.3	6.3	4.8	6.0	7.5	6.8	**6.5**	**6.3**	**6.2**
Hallertau North. Brewer	9.6	10.1	6.0	9.8	9.8	6.4	9.1	10.5	10.4	**9.7**	**9.2**	**9.1**
Hallertau Hall. Magnum	13.9	14.6	11.7	14.8	13.8	12.8	12.6	15.7	14.6	**13.3**	**13.8**	**13.8**
Hallertau Nugget	11.9	12.4	8.5	10.6	11.3	10.2	10.7	12.0	12.8	**11.5**	**11.4**	**11.2**
Hallertau Hall. Taurus	15.7	16.5	12.3	16.5	16.2	15.1	16.1	17.9	17.1	**16.3**	**16.5**	**16.0**
Hallertau Hall. Merkur				13.5	13.3	10.3	13.0	15.0	14.8	**12.6**	**13.1**	
Hallertau Herkules							16.1	17.3	17.3	**16.1**		
Tettnang Tettnanger	4.4	4.6	2.6	4.7	4.5	2.2	4.0	4.2	4.2	**4.0**	**3.7**	**3.9**
Tettnang Hallertauer	4.5	4.8	3.1	5.0	4.8	2.6	4.3	4.7	4.5	**4.2**	**4.1**	**4.3**
Spalt Spalter	4.4	4.6	3.1	4.4	4.3	2.8	4.6	4.1	4.4	**3.7**	**3.9**	**4.0**
Elbe-S. Hall. Magnum	13.9	13.9	10.2	14.0	14.4	12.4	13.3	12.2	13.7	**13.1**	**12.9**	**13.1**

Source: Working Group of Hop Analysis (AHA)

4 Hop breeding research

RDin Dr. Elisabeth Seigner, Dipl. Biol.

4.1 Classical breeding

By breeding new hop cultivars, the Work Group for Hop Breeding Research in Hüll seeks to remain constantly at the cutting edge of developments. Improved resistance mechanisms against major diseases and pests continue to be the main criterion for the selection of new seedlings. German hop growers will thus be able to harvest future top-quality, higher-performance cultivars even more cost efficiently yet with even less impact on the environment. Breeding activities in Hüll encompass the entire hop spectrum, from the most delicate aroma hops through to super-high-alpha varieties. Biotechnological methods have been used for years to support classical cross-breeding. Virus-free planting stock, for example, can only be produced by way of meristem culture. Use is also made of molecular markers, e.g., when selecting for disease resistance.

4.1.1 Crosses in 2010

A total of 82 crosses were carried out during 2010. Tab. 4.1 shows the number of crosses performed for each breeding goal.

Tab. 4.1 Cross-breeding goals in 2010

Breeding direction combined with resistance / tolerance to various hop diseases	Further requirements	Number of crosses
Aroma type	Exceptional aroma	15
	New powdery mildew (PM)-resistance qualities from wild hops	19
	Aphid resistance	3
	High beta-acid content	1
	Suitability for low trellis systems	6
High-alpha-acid type	None	18
	Aphid resistance	2
	High xanthohumol content	2
	High beta-acid content	7
	Suitability for low trellis systems	9

4.1.2 Breeding of dwarf hops for low trellis systems

Objective

The aim of this research project, funded by Germany’s Federal Agency for Agriculture and Food, is to breed hop cultivars which, by virtue of their shorter height, broad disease resistance and excellent brewing qualities, are particularly suitable for profitable and ecologically sustainable cultivation on low trellis systems.

Results

2010 seedlings

The preliminary selection of seedlings from the 21 crosses (8 aroma- and 13 bitter-type) performed in 2009 began early in March. A total of 25,000 greenhouse seedlings in seed dishes were inoculated with four PM (*Podosphaera macularis*) races typical of the Hallertau region. Seedlings not visibly infected with PM were transferred from the seed dishes into individual pots. They were kept in the greenhouse under conditions conducive to PM infection and monitored for PM until mid-April. The PM-resistant seedlings and also seedlings that had not been pre-selected as PM-resistant were then tested for tolerance towards downy mildew (*Pseudoperonospora humuli*). In mid-May, these seedlings, pre-selected for disease resistance/tolerance, were planted out in the vegetation hall, where their growth vigour and, once again, their resistance towards fungal attack were monitored under natural conditions until autumn. The plants were also classified as male or female on the basis of the flowers that formed as from July. A DNA marker was used to sex any seedlings that had not produced any flowers by autumn. Any plants that showed considerable deficiencies, such as severe aphid infestation, mildew or root rot, or were of unsuitable growth type were dug up by autumn.

In spring 2011, the female and male seedlings were planted out in the high-trellis breeding yards in Hüll and Freising respectively, where their growth vigour on 7-metre trellises, their resistance towards downy mildew and powdery mildew under natural infection conditions and, for the first time, their resistance to *Verticllium* wilt will be monitored over the next 2 to 3 years. Testing for resistance to *Verticillium* wilt requires a plant's root system to be fully developed, which means that it will not be possible to transplant the most promising breeding lines to the low-trellis yards until the seedlings are at least two-to-three years old. To obtain seedlings with broad fungal resistance, field data are supplemented at this stage by laboratory leaf tests for resistance to non-endemic PM races.

Crosses in 2010

The goal of 15 additional crosses (6 aroma- and 9 bitter-type) performed in July, 2010 was to breed hops suitable for low-trellis systems. Seeds were obtained from all the crosses in autumn.

Cultivation on the two low-trellis systems in Starzhausen and Pfaffenhofen

English dwarf varieties, low-growth breeding lines from other breeding programmes and, for comparison purposes, traditional high-trellis Hüll cultivars have been grown on the low-trellis systems since 1993 to gain insights into hop cultivation on 3-metre trellis systems.

Cultivation in the low-trellis yard at the Mauermeier hop farm in Starzhausen

2010 was the first year in which seedlings obtained from the crosses performed specifically for this dwarf-hops project were grown on the 3-m trellis systems and monitored. However, these young hop plants (plants in their first year of cultivation) do not allow any conclusive and reliable estimates as to crop yields, resistance qualities or components, and thus cannot be assessed in terms of brewing quality.

Tab. 4.2 : LT Starzhausen – breeding line yields in 2010

Breeding line / Cultivar	Direc -tion	Yield[3] in kg/ha	α-acids in %	β-acids in %	Cohumulone in %	Aroma 1-30
Herald[1]	A	971	13.9	4.9	29.8	21
Pioneer[1]	A	1,582	11.0	4.1	30.7	22
Perle[2]	A	1,160	10.2	5.3	26.4	25
Hall. Magnum[2]	B	1,304	18.1	6.8	25.9	20
Hall. Taurus[2]	B	1,587	17.4	5.7	23.2	21
Herkules[2]	B	1,925	16.4	5.3	39.1	20
99/097/702	B	1,202	7.4	4.3	25.4	23
99/097/706	B	1,473	6.7	4.9	37.3	24
99/097/725	B	1,243	15.0	6.0	32.0	23
2000/102/004	B	1,389	6.6	3.2	24.1	22
2000/102/005	B	1,660	13.1	5.3	26.5	23
2000/102/012	B	1,512	10.2	4.3	29.8	24
2000/102/019	B	1,734	14.4	4.4	26.5	23
2000/102/032	B	1,876	15.0	6.1	31.5	23
2000/102/043	B	1,288	12.7	5.0	25.5	22
2000/102/054	B	1,892	14.2	4.6	29.0	23
2000/102/074	B	1,144	11.8	3.8	25.7	20
2000/102/791	B	2,185	16.1	5.7	29.6	22
2001/040/002	A	833	9.3	4.8	23.8	25
2001/045/702	A	1,056	7.2	5.0	24.2	26
2003/039/022	B	2,217	13.3	6.3	33.2	25
2004/098/010	A	1,437	11.4	5.1	28.0	20
2004/107/719	B	2,083	13.4	5.9	29.9	21
2004/107/736	B	1,386	5.5	3.9	31.2	21
2005/098/005	B	1,596	11.8	5.3	26.1	24
2005/098/744	B	1,628	12.3	4.7	29.2	21
2005/100/718	B	2,059	16.1	5.4	27.2	22
2005/101/001	B	1,384	6.7	3.9	34.1	24
2005/102/009	B	1,862	6.5	3.2	33.2	22
2005/102/028	B	1,414	11.3	5.4	32.3	22
2005/102/710	B	1,525	12.6	5.7	26.8	23
2006/048/720	B	1,374	13.2	4.6	25.3	21
2006/047/735	B	2,051	10.8	5.3	30.7	23
2006/047/768	B	1,568	6.6	8.7	20.5	18
2007/074/702	B	2,309	14.4	5.7	30.7	20
2007/074/709	B	2,139	13.6	5.8	30.7	22
2007/074/724	B	2,159	10.8	5.2	31.2	20
2007/074/736	B	1,910	15.4	5.8	30.0	23
2007/080/007	B	1,814	14.2	5.4	31.3	22
2007/080/015	B	1,864	10.1	7.1	29.4	18

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

Cultivation in the low-trellis yard at the Schrag hop farm in Pfaffenhofen

Tab.4.3 : LT Pfaffenhofen – breeding line yields in 2010

Breeding line	**Direc-tion**	**Yield in kg/ha**	**α-acids in %**	**β-acids in %**	**Cohumulone in %**	**Aroma 1-30**
2000/102/005	B	930	15.9	5.6	28.7	21
2000/102/008	B	1,298	9.9	5.1	25.8	21
2000/102/019	B	1,057	15.1	4.2	28.5	22
2000/102/032	B	1,317	14.7	5.6	33.7	22
2000/102/791	B	1,212	16.3	5.6	30.0	20

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

Severe downy-mildew infection in the crop grown on the heavy clay soil in Pfaffenhofen caused problems that could only be controlled through use of plant protectives. The extreme weather conditions exacerbated the situation, leading to severe drought damage and also moisture damage and hence very poor yields (Tab.4.3). By contrast, very good yields were obtained at the Starzhausen location, where alpha-acid values alone were below average – a result of the cool and cloudy summer in 2010 (Tab. 4.2).

Comparison of different cultivation systems

The rows (75 cm within-row spacing) in the two low-trellis yards were all cultivated in the conventional manner, with bine training up galvanized wires. A further two rows of each of two promising breeding lines had been planted at both the Pfaffenhofen and Starzhausen locations in order to compare different methods of cultivation: “conventional – non-cultivation” and “training wires – netting”. The entire trial stand was harvested on September 21st and 22nd 2010, this being the second time that harvest yields could be compared in terms of cultivation methods employed.

Tab. 4.4 : LT Pfaffenhofen – 2010 yields in terms of cultivation methods employed

Breeding line	**Cultivation method**	**Yield in kg/ha**	**α-acids in %**	**kg α-acids/ha**	**β-acids in %**
2000/102/008	Conventional, wire	1,211	9.3	113	4.6
2000/102/008	Conventional, netting	1,329	9.1	121	4.6
2000/102/008	Non-cultivation, wire	1,008	9.0	91	4.4
2000/102/791	Conventional, wire	904	16.6	150	5.3
2000/102/791	Non-cultivation, wire	801	16.2	130	5.3

Tab. 4.5 : LT Starzhausen – 2010 yields in terms of cultivation methods employed

Breeding line	**Cultivation method**	**Yield in kg/ha**	**α-acids in %**	**kg α-acids/ha**	**β-acids in %**
2000/102/008	Conventional, wire	2,053	10.4	213	5.0
2000/102/008	Conventional, netting	2,180	12.0	261	5.8
2000/102/008	Non-cultivation, wire	1,997	11.5	230	5.7
2000/102/791	Conventional, wire	2,567	15.1	387	4.4
2000/102/791	Non-cultivation, wire	2,176	15.8	343	5.6

Three-metre trellis systems are expected to have major labour-related advantages, particularly as far as hop cultivation and husbandry are concerned. The aim is therefore to clarify, using our own short-stature breeding lines, the extent to which the conventional, distinctly more labour-intensive cultivation method can be replaced by what is called the “non-cultivation” method. Two training methods, with wire or with netting, were also compared. The following trend became apparent following the second crop year: at both locations, the yields obtained with the less labour-intensive, non-cultivation method and wire bine-training were lower than with the conventional method involving pruning and wire bine-training. A comparison of single-wire bine training and netting appears to indicate that higher yields are obtained with netting; netting also provides a better hold for the bines, which accordingly require less training assistance.

It is important to mention that the picking performance of the mobile picking machine (Fig. 4.1, left) had been substantially improved for the 2010 harvest. Losses of harvested hop cones around the posts (Fig. 4.1, right) was substantially reduced, in particular by a better, more flexible termination at the bottom of the picking machine. As the yields for cultivation with netting show (Tab. 4.4 and Tab. 4.5), cone-picking performance is good even when the bines are densely intertwined with the netting.

Fig. 4.1. : The mobile picking machine harvesting hops (left). Losses of harvested hop cones around the posts (right) were substantially reduced in 2010 thanks to a number of improvements to the mobile picker.

Current outlook:

Despite promising breeding lines, alpha-acid levels as high as 16 % and yields of around 2 t, all the lines selected so far show relatively high susceptibility to downy mildew and red spider mite, a problem that is currently leading to high costs for plant protectives and is not conducive to profitable, environmentally sound cultivation.

All our hopes are pinned on the pertinent seedlings obtained from special crosses performed for this project and selected to meet the specific requirements. They were first cultivated on low-trellis systems in 2010. Reliable information on yield, resistance and components will not be available until the end of 2011, after the second year of cultivation on 3-m trellis systems.

4.1.3 Breeding of PM-resistant hops – current situation

Objective

Hop powdery mildew (*Podosphaera macularis*) poses a serious threat to hop cultivation in Europe and the USA. Drastically increased prices for plant protectives are having to be paid in order to produce high-quality hops with acceptable crop yields. Resistance breeding thus has top priority in the battle against powdery mildew, and has for years played a major role at the Hüll Hop Research Centre. Below (see also Tab. 4.6), we describe the various efforts undertaken since 2003 in the fields of classical breeding, genome analysis and biotechnology in order to develop high-quality PM-resistant cultivars for the hop and brewing industries. Using our resistance-testing systems, all assays were conducted both in the greenhouse and in the lab (detached leaf assay) with the various PM isolates so as to permit highly targeted selection of breeding lines, wild hops and cultivars for their PM-resistance.

Results

Greenhouse testing in 2010 for PM resistance in breeding stock (long-term task)

As from early March each year, around 100,000 seedlings (obtained from approx. 100 crosses from the previous year) were greenhouse-tested in seed dishes for their PM resistance (mass screening; see Fig. 4.2). Four different PM isolates with virulence levels (v1, v3, v4, v6, vB) widespread throughout the Hallertau region were used in all cases as inoculation material.

Fig. 4.2 Greenhouse resistance test with seed dishes and, interspersed among them, severely PM-infected inoculator plants

Highly susceptible hop varieties with a dense fungal mycelium on their leaves were used as inoculator plants. They were placed among the seed dishes to create a condition of continuous, very high infection pressure in the greenhouse.

After about two weeks, seedlings not infected with PM were monitored further in the greenhouse, as individual plants, for their ability to resist the fungal virulences used. Altogether 1,864 plants were monitored individually from 2003 to 2010. It should be noted in the context of this figure that every promising breeding line is monitored for its PM resistance over a period of three years in the greenhouse. The same applies to wild hops. In addition, 44 foreign varieties and two Hüll cultivars were monitored in the greenhouse as individual plants.

Laboratory leaf testing at EpiLogic for PM resistance in breeding stock (long-term task)

As from the second year of monitoring, hop plants assessed as resistant during the first year in the greenhouse were brought into contact with an English (v1,v2, v3, v5, vB) and with a Hallertau PM isolate (v3, v4, v6, vWH18, vB) in detached-leaf resistance tests (Fig. 4.3). A total of 11 cultivars, 1,237 breeding lines and 902 promising wild hops were tested at EpiLogic between 2003 and 2010.

Fig. 4.3 : Leaf resistance test on young leaves following inoculation with a specific PM isolate. Hop plants whose leaves show no sign of infection are classified as resistant to this PM race.

Field testing for PM resistance (long-term task)

Seedlings assessed in the greenhouse and laboratory tests as resistant were monitored each year under field cultivation and natural infection conditions, and without the use of fungicides, for their PM-resistance properties.

Only plants shown to be PM-resistant in all tests are used for breeding purposes.

52 breeding lines and 45 wild hops demonstrating the desired broad resistance to all PM virulences are currently available.52 breeding lines and 45 wild hops demonstrating the desired broad resistance to all PM virulences are currently available.

Assessment of the virulence situation in the hop-growing region and leaf-test evaluation of resistance sources (long-term task)

Extensive leaf-test monitoring of the efficacy of the various hop resistance genes in different hop-growing regions has revealed for years that only a few of the known resistance genes provide protection against powdery mildew (Seigner et al., 2002; 2006). Until a few years ago, only the *R2* PM resistance gene of the English variety "Wye Target" was bred into the Hüll breeding stock. “Hallertauer Merkur” (introduced for commercial planting in 2001) is still fully PM-resistant and thus bears witness to the success of this resistance strategy. In the USA and in England, however, the protective effect of this *R2* gene has already been overcome by various powdery mildew populations, all of which have the v2 virulence gene. Continuous monitoring of the current virulence spectrum of PM populations in the Hallertau region and of global virulence trends is therefore essential. To this end, the reaction of eleven hops from what is known as the set of differential varieties (hops with characteristic resistance genes, such as R1-R6, Rb, RWH18, RJapC) to all the available PM races is tested annually at EpiLogic by detached-leaf assay. This is the only way to ascertain which resistances have already been overcome and which can still be used in breeding programmes to improve resistance qualities. The resistance of Wye Target (R2 resistance) is still fully effective in the Hallertau region, whereas the R1, R3, R4, R5, R6, RJapC and RB resistance genes no longer protect against PM infection. WH18, a wild hop from Germany's Eifel region, also showed considerable resistance until 2008. As of 2008, however, the detached-leaf tests showed that the resistance of “Herkules” (R1) and the wild hop WH18 (R WH18) from the Eifel region had been overcome.

Wild hops – new genetic resource for the breeding of PM-resistant hops

Between 2003 and 2010, some 25,000 wild hop plants from 195 origins in Europe, Asia, Australia and North America were greenhouse-tested for PM resistance. After mass screening followed by greenhouse testing of 1,118 pre-selected wild hops as individual plants, 902 non-infected plants were tested at the EpiLogic laboratory by means of the detached-leaf assay for their reaction to the various virulent strains of PM (see details, Seigner et al., 2006). With PM resistance in the WH18 wild hop variety from the Eifel region and in JapC, a hop of Japanese/Chinese origin, having been overcome as of summer 2008, the search for a new source of resistance to a broad range of PM races was re-commenced in February 2009. By 2010, 45 wild hops – from the USA, Turkey, Japan, New Zealand, the Netherlands, Austria and Germany – had been identified, these plants having shown no signs of PM pustules after several years of greenhouse and leaf testing for PM.

Microscopic investigations to identify the various resistance mechanisms

In the context of a doctoral thesis, work has been underway since 2008 to clarify the various resistance mechanisms in 12 PM-resistant cultivars and in wild hop varieties using special microscopic investigation techniques. These investigations confirmed that different resistance mechanisms, such as apoptosis and cell-wall apposition, can be reliably identified with existing methods, as illustrated by the PM resistance of a wild hop variety from the USA, which was shown to be due primarily to hypersensitive hop cells that react by undergoing apoptosis. Only a few interactions here were found to involve cell-wall apposition (Oberhollenzer et al., 2009). In future cross-breeding work, all the findings from this project will be used to selectively combine different resistance mechanisms with mutually complementary effects.

Use of the detached-leaf assay and special PM isolates in the development of molecular resistance markers

The range of PM isolates established by EpiLogic has been used very successfully since 2003 to obtain reliable assessment data for resistant and susceptible seedlings from mapping populations in order to develop molecular selection markers. Only with this detached-leaf assay, combined with PM races of defined virulence, is it possible to test the action of specific resistance genes. Altogether 3,125 hop plants from 21 mapping populations have been tested by detached-leaf assay at EpiLogic since 2003, enabling molecular markers to be developed for almost all the available resistance genes (R2, R4, R6, R WH18, R JapC) (Seefelder et al., 2006; Seefelder et al., 2009). All the resistance mechanisms except that based on the R2 gene have meanwhile unfortunately become ineffective.

The great advantage of DNA-based resistance markers is that they can be used not only to identify resistant hop seedlings fast and reliably but also to furnish evidence of double resistance mechanisms, obviating the need for years of tedious, time-consuming inheritance studies. Multiple resistance mechanisms are crucial to effective long-term resistance qualities.

Since 2007, gene expression analyses based on differential display techniques have been conducted in order to identify genes, and thus also markers, which are directly involved in the resistance reactions. Building on the findings of Godwin (1987), which clearly prove that the resistance response of the PM-resistant English cultivar “Wye Target” is not triggered until fungal infection occurs, the pattern of active, inactive and newly activated genes was compared in resistant and susceptible hop plants that had been inoculated with PM spores. Genes that first become active after PM contact are very probably involved in the plant’s defence response, which leads, inter alia, to cell-wall apposition in the hop leaves. The function of newly activated genes and their possible role in resisting the fungus or recognizing the pathogen can be clarified on the basis of their expression kinetics and their similarities with known resistance genes in other crops.

In two projects, what are known as cDNA-AFLP markers and very probably describe genes that play a role in recognizing or resisting the fungus were identified in the resistance response of “Wye Target" and of a wild hop (Seidenberger et al., 2007). Sequence similarities with mlo proteins found in PM-resistant barley were also discovered (Seigner, Seefelder et al., 2009). Lack of funding prevented continuation of this promising work.

Functional analysis of PM-defence-related genes

Work is also underway to characterise the function of genes possibly involved in the defence reaction against hop PM. To this end, individual leaf cells of PM-resistant or PM-susceptible hop varieties are transformed with a reporter gene and the test gene. The behaviour of these transformed (genetically modified) cells following contact with the PM fungus (specified PM races from EpiLogic are used) is expected to provide information about the function of these genes in the hop/hop powdery mildew interaction. Studies are being conducted on hop-specific and universal resistance genes from barley and *Arabidopsis* (Oberhollenzer et al, 2009). Hop-specific sequences verified as having a PM-defence-related function will then be used as highly reliable molecular selection markers for conventional resistance breeding.

Testing of transgenic hops for PM resistance

In addition to the above work, transgenic hops, too, were tested for PM resistance by detached-leaf assay in Petri dishes. In a project aimed at improving fungal resistance via gene transfer, transformed hops carrying a presumed resistance gene were bred in 2006 and 2007. From 2006 to 2010, a total of 30 hop plants with genomes containing a hop-specific or bacterial chitinase gene introduced by gene transfer were tested at EpiLogic by detached-leaf assay. None of the transgenic hops showed distinctly improved PM resistance. The system of detached-leaf assaying provides a means of testing transgenic hops for PM resistance in the laboratory, obviating the need for field trials.

Development of the PM forecasting system

Basic data on the biology and epidemiology of the fungus were collected in laboratory and field tests using PM isolates. In addition, a preliminary forecasting model was modified as required. The revised and optimised system was introduced for routine use in 2009 (Engelhard und Schlagenhaufer, 2009).

Tab. 4.6 : Overview of PM-resistance breeding from 2003 to 2010

2003-2010	Greenhouse testing		Laboratory leaf testing	
	Plants	**Assessments**	**Plants**	**Assays**
Seedlings from 761 crosses	Approx. 800,000 mass screened, thousands tested as individual plants		-	-
Breeding lines	1,864	7,490	1,237	5,775
Cultivars	44	220	37	126
Wild hops: mass screening individual screening	25,000 1,118	4,900	902	5,120
PM virulence situation			9-14 / yr.	3,375
21 mapping populations for DNA marker development			3,125	11,090
Transgenic plants	-	-	30	140
PM forecasting studies			(approx. 1,100 assays)	
Studies on various resistance mechanisms		Greenhouse and detached-leaf testing of 12 wild hops and cultivars, followed by microscopic studies.		
Gene expression studies to develop markers and clarify gene function		Approx. 40 different trials to investigate specific patterns in active PM-defence-related genes		

Mass screening = screening in seed dishes; individual screening = screening as individual plants in pots

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4.1.4 Hop quality assurance: monitoring for virus and viroid diseases

Objective

Top brewing quality and reliable supplies can only be ensured with healthy hops. Diseases caused by viruses and viroids often go unnoticed for a long time, enabling them to spread during this latent phase. Their destructive potential with regard to yield and alpha-acid content is revealed during stressful weather conditions – often years after initial infection – in the form of losses of 40 - 75 %. For effective management of these diseases, which cannot be controlled with plant protectives, it is first necessary to clarify the prevailing infection situation in the German hop-growing regions. Only then can decisions be made as to whether and where phytosanitary measures need to be implemented. Although commercial hop growers are supposed to use tested planting stock only, annual agricultural surveys in Bavaria revealed in 2009 that the current viral-infection situation on hop farms gives grounds for concern.

RT-PCR-based monitoring for HSVd infection in hops continued in 2010. Tests were conducted on 377 leaf samples from hop farms, the Society of Hop Research's propagation facilities, the various breeding yards in Hüll, Rohrbach, Freising und Schrittenlohe, and the Hüll cultivar yard. Tab. 4.7 summarizes the figures for hop samples tested from 2008 - 2010. No HSVd was detected in any of the tested leaf samples from hop farms in the Hallertau, Tettnang and Elbe-Saale hop-growing regions. All 66 plants tested for the Eickelmann propagation facility were likewise confirmed HSVd-free.

In 2010, however, we discovered Hop stunt viroid for the first time ever among the 275 tested plants from our breeding yards, namely in the US "Horizon” variety growing in our Hüll cultivar yard. This variety had come from the USA in 2001 and been planted in our Hüll cultivar yard. HSVd infection was identified by RT-PCR testing in all five plants of this variety. The plants showed none of the typical symptoms of hop stunt disease, such as stunted growth, curled-up leaves, small cones and chlorisis. Following this discovery, all the in-row plants growing in the vicinity of “Horizon,” as well those in the two plots to the left and right of the row, were tested systematically. No HSVd was detected in any of the plants growing to the right and left of the row containing four of the HSVd-infected “Horizon” plants. The infection was only identified in three immediately adjacent in-row hop plants, a finding which may be attributed to mechanical spreading of infectious sap in the pruning direction. By contrast, all directly adjacent plants growing in the contra-pruning direction (US variety “Sterling”), which had come to us from the USA at the same time, were HSVd-free. HSVd was also detected at one other location in the cultivar yard, in a plant directly adjacent to the fifth HSVd-infected “Horizon” plant, which had been growing on its own. The infected plant was again located in pruning direction, whereas all the other surrounding hop plants were infection-free.

In accordance with the phytosanitary measures recommended by our US colleague Dr. K. Eastwell, all 9 HSVd-infected plants (bine and rootstock) were immediately killed by glyphosate injection, the bines and rootstocks burnt and the area around the rootstock locations treated several times with glyphosate, so as to eradicate all HSVd-infected components. The area was immediately cordoned off and will not be planted next year, either.

This finding strengthens us in our resolve to continue monitoring for Hop stunt viroid. It is clear that the high cost of RT-PCR testing will make 100 % screening for HSVd infections impossible. However, our findings to date confirm our suspicion that breeding stock and varieties originating from regions previously or currently affected by HSVd, such as Japan, China and the USA, may harbour a potential risk. It is therefore especially necessary to test for this viroid in all foreign varieties grown on hop farms, as well as in imported breeding material, including wild hops, and in plants received at Hüll for variety registration testing. Furthermore, care should be taken to ensure that all mother plants in the GfH’s propagation facility are tested for HSVd, since the best form of protection, until reliable curative methods are available for HSVd-infected hops, is to monitor for the disease constantly and as closely as possible.

Tab. 4.7 : Hop samples examined between 2008 – 2010 and HSVd results

Origin and nature of the sample material	**Number of hop samples**	**RT-PCR HSVd negative**	**RT-PCR HSVd positive**	**Not evaluable due to absence of an internal control band**
Hüll, Rohrbach and Freising breeding yards: cultivars, male and female breeding lines, and Hüll cultivar yard	254	224	9 (5 Horizon)	5+16*
Schrittenlohe breeding yard: wild hops from all over the world	21	20	0	1
GfH Hallertau propagation facilities: mother plants	63	61	0	2
Elbe-Saale field crop: cultivars	8	6	0	2
Hallertau field crops: cultivars	125	120	0	5
Tettnang experimental station and field crops: cultivars	30	23	0	7
Foreign cultivars	155	155	0	0
Total	**656**	**609**	**9!**	**22+16***

Absence of the typical HSVd band (300 base pairs) on the gel image following electrophoretic separation of the reaction products confirms the HSVd-free status of a hop sample. A hop-mRNA-based internal control was also run for every sample to ensure that the missing HSVd band was not the result of a non-functioning RT-PCR. As in preceding years, it was found that the PCR test often did not work – as shown by the missing internal control band – with samples taken very late in the season from old, phenol-rich hop leaves. *Late sample, taken on August 4th, 2010

This quality offensive, promoted by the HVG Hop Processing Cooperative via its funding of HSVd monitoring activities in 2009 and 2010, will be continued in 2011 with the financial support of the Scientific Station for Brewing in Munich. The LfL's pathogen diagnostics laboratory in Freising will not only test the hops for HSVd infections but also screen for five different hop viruses known to impair hop quality and yield. Besides the established ELISA (enzyme linked immunosorbent assay) method, PCR-based methods will be established and implemented for the first time to detect hop viruses.

4.2 Biotechnology

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

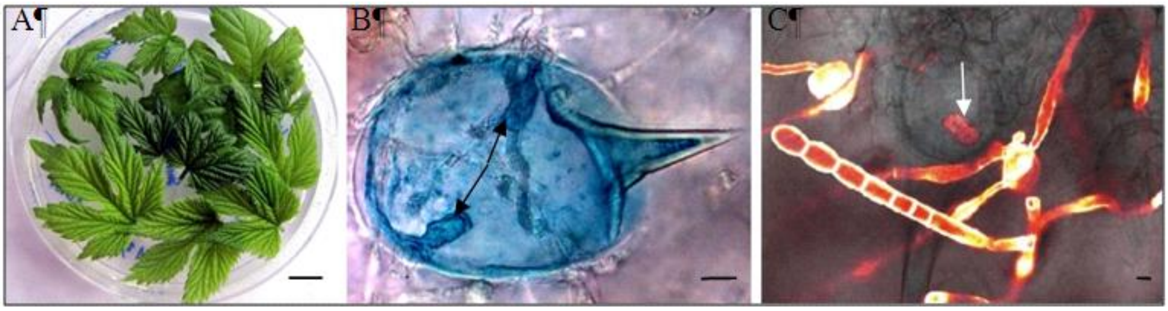


*Fig.4.4 : Images from individual project stages **A)**, Inoculated leaves for microscopic investigation. **B)**, Two haustoria (arrow) of the PM fungus in a hair cell, stained blue by the GUS reporter system. **C)**, Sporulation of the PM fungus following infection of a single hair cell. Arrow: haustorium in hair cell. Scale: A: 1 cm; B,C: 10 µm*

Objective

Hop powdery mildew, caused by *Podosphaera macularis*, has been a problem in international hop production for decades. The aim of this research project is to characterise the hop/hop powdery mildew interaction in various wild hop varieties intended for use as new resistance carriers for breeding. These studies are performed microscopically.

Another component of this project supports resistance breeding via a molecular biological approach in which the functions of genes involved in defence responses are characterised. This involves the use of what is known as a transient transformation assay system. Transient knock-down (i.e. making specific genes ineffective), and/or overexpression at single-cell level, are expected to provide information about the function of these genes.

Method

PM resistance is assessed microscopically by inoculating various hop varieties with PM and stopping the infection at various points in time after inoculation. A number of staining techniques were developed to visualize the fungus and cell-level defence responses.

Various hop ESTs *(expressed sequence tags)* were selected as candidate genes for the transient assay. To obtain more information about these genes, gene expression, i.e. gene activity, following PM infection was examined in susceptible and resistant varieties. A functional analysis was performed on individual candidate genes via transient transformation of hair cells by particle bombardment.

Results

A number of wild hop varieties from the USA, Japan, Turkey and Germany are currently being investigated. Fig. 4.5 A serves to illustrate the results of microscopic investigations of various wild hops (WH1-WH6) 24 hours after inoculation with the PM fungus. Apoptosis is the main form of defence in all wild hops. The fungus was able to establish haustoria in Northern Brewer, the susceptible control variety, and also in one wild hop variety (see Fig. 4.5 A, “susceptible cells”). Cell-wall apposition seems to be of little importance in these wild hops.

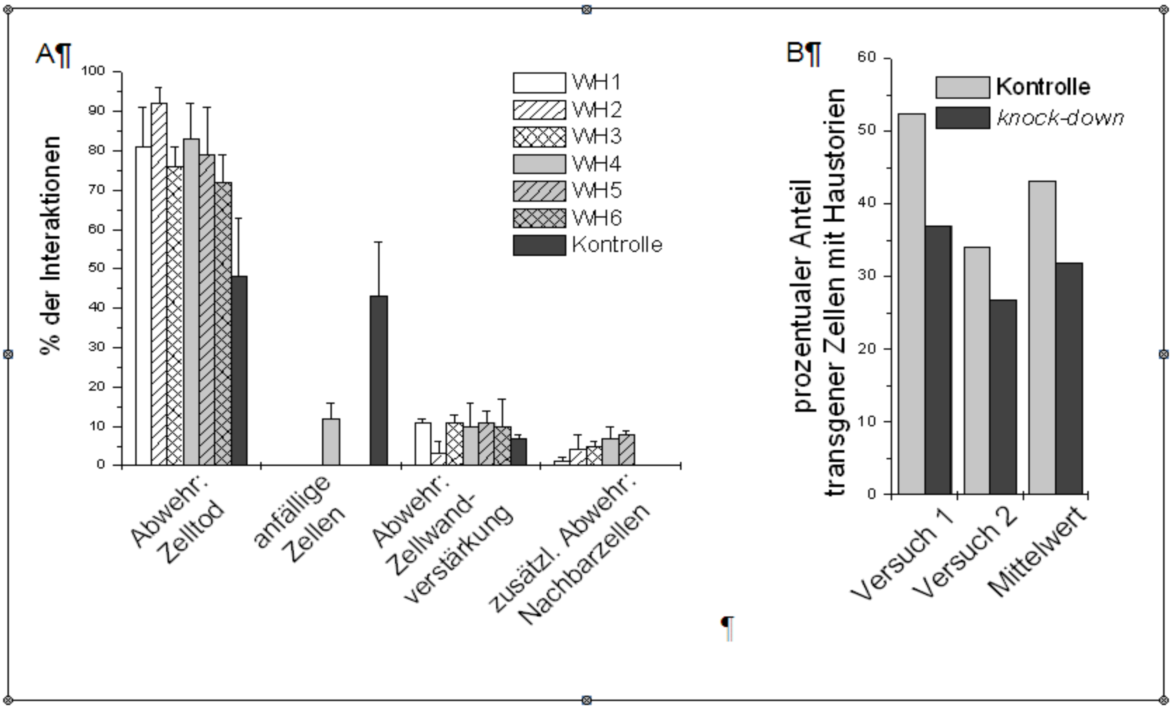


*Fig. 4.5 : **A)**, Assessment of the microscopic investigation of six wild hop varieties, WH1 – WH6, 24 hours post inoculation. Apoptosis is the main form of defence in all wild hops. Cell-wall apposition is of little importance. Susceptible cells were detected in Northern Brewer, the PM-susceptible control variety, and also in one wild hop variety (pale grey). **B)**, Transient transformation assay: Cells in which the Mlo gene had been silenced by transient knock-down contained fewer haustoria and are therefore less susceptible. The chart shows the results of two independent assays, and the mean of the two assays.*

Surprisingly, it was found that even the hair cells of hops with macroscopically resistant genotypes are susceptible, with the PM fungus being able to sporulate once it has infected individual hair cells (seeFig.4.4 : B,C).

Once the transient assay system had been established, functional analysis of resistance-associated genes was commenced.

Fig. 4.5 B shows the preliminary results of two knock-down experiments in which an Mlo gene was silenced in the susceptible Northern Brewer variety. Cells in which the susceptibility gene had undergone transient kniock-down contained fewer haustoria than the control. In other words, silencing the gene makes the cells less susceptible.

Outlook

Now that effective methods of characterising different resistance mechanisms have been established, microscopic investigation of various resistant wild hop varieties will be concluded. This will involve describing the hop/hop powdery mildew interaction in terms of time and characterising the PM resistance of different cell types.

Transient transformation assays will be used to assess other candidate genes.

4.3 Genome analysis

4.3.1 Investigation of *Verticillium* infections in the Hallertau district

Objective

Fig. 4.6: Hop yard severely affected by wilt

Exceptionally high incidence levels of hop wilt, caused by the *Verticillium* fungus, have been responsible for massive yield reductions in isolated regions of the Hallertau since 2005 Previously wilt-tolerant cultivars such as Northern Brewer are now also affected, not only highly susceptible varieties such as Hallertauer Mittelfrüher. To assess the potential risk to the Hallertau, it is above all important to investigate the race spectrum of this fungal pathogen. In the case of hop wilt, in particular, a distinction has always been made between mild strains and very aggressive, lethal strains. The latter severely affected hop cultivation in England in the past (1944), and this has also been the case in Slovenia since 1995. In addition to genetic analyses for comparing known mild and lethal foreign references with the predominant German races, artificial *Verticillium* infection tests are being used to accurately determine the virulence of isolated *Verticillium* races. At the same time, special field trials are being conducted on leased hop yards seriously affected by wilt. The aim is to clarify whether crop husbandry measures, such as excessive nitrogen fertilisation or the spreading of inadequately decontaminated bine choppings, are causing the problem. The focus of the investigation is on establishing a fast diagnostic system for hop farmers and testing the effectiveness of bioantagonists, bacterial adversaries of *Verticllium* used to protect hop plants from infection.

Method

At the start of the project, severely wilt-affected hop plants were collected and, to cultivate the *Verticillium* fungus, approx. 2 cm^2 bine sections prepared under sterile conditions, transferred to solidified plum-agar medium in Petri dishes (Fig. 4.7, left), and incubated at 25 °C for approx. 2 weeks in the dark. Once the *Verticillium* species had been clearly identified (via PCR and under the microscope), single-spore mycelia obtained from every Petri dish via dilution series were plated on fresh solidified medium. Optimum genetic differentiation and classification of the newly obtained *Verticillium* samples is only possible via these single-spore isolates. One-cm^2 pieces were cut out of the resultant single-spore mycelia and transferred to conical flasks containing 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. The fungal material was freeze-dried, ground in a ball mill, and the DNA isolated according to the modified Doyle and Doyle protocol (1990) for subsequent PCR assays. At the same time, work was underway to establish a fast laboratory test involving the use of a homogenizer (Fig. 4.7, right) and a commercial DNA isolation kit and allowing *Verticillium* DNA to be obtained directly from hop bines for subsequent investigations.

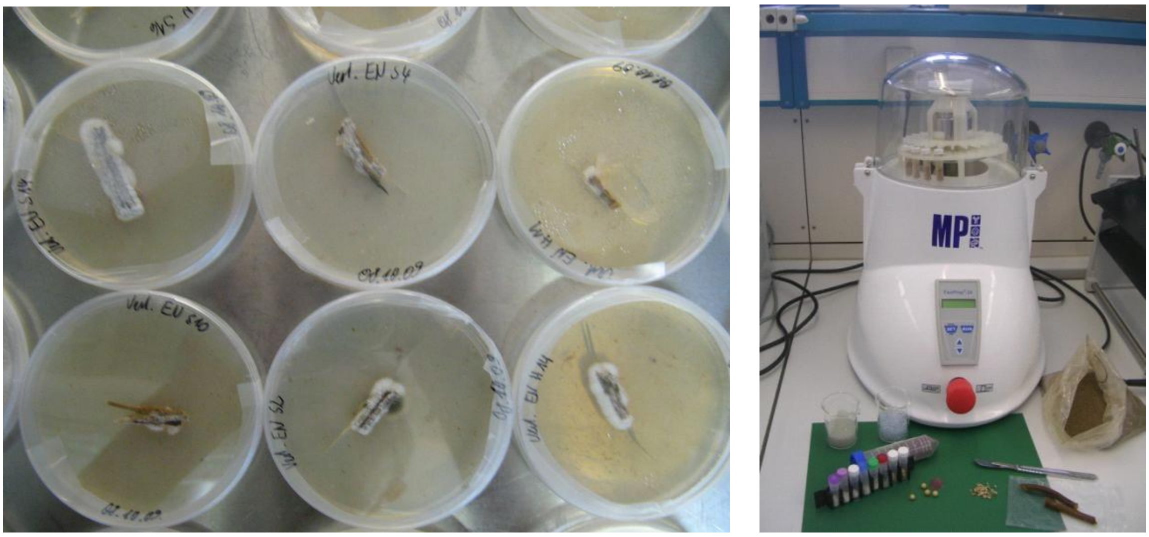


Fig. 4.7 : Establishing a bank of Verticillium isolates (left); homogenizer for breaking up bines (right)

Result

To assess the potential risk to the Hallertau hop-growing region, the Verticillium isolates were first differentiated genetically and compared directly with foreign reference isolates. Building on these genetic differences, we then tested the newly obtained isolates for their virulence. AFLP screening showed approx. 60 single-spore isolates of Verticillium from 19 Hallertau origins to contain specific DNA fragments (Fig. 4.8) found only in lethal English and lethal Slovenian reference isolates. These DNA bands were absent in the mild English and Slovenian isolates and in Hallertau isolates from regions little affected by wilt. The virulence of isolated Hallertau Verticillium isolates was determined in an artificial Verticillium infection test carried out in Slovenia. Besides the Slovenian reference isolates (mild and lethal), Hallertau isolates from slightly affected and seriously affected hop yards were used in this test. In this infection test, these isolates and the references were used on the following hop cultivars: Celeja, Perle, Hallertauer Tradition, Northern Brewer, Hallertauer Magnum and Wye Target. The cultivars were inoculated with the fungal isolates and the proportion of infected foliage measured (in %) after 30, 44 and 58 days. One noteworthy finding in this infection test, which was carried out by our cooperation partner, Dr. Radisek, was that the levels of virulence of Hallertau isolates from less severely affected hop yards resembled those of the mild foreign references and the more aggressive Hallertau isolates those of the lethal references (Fig. 4.9).

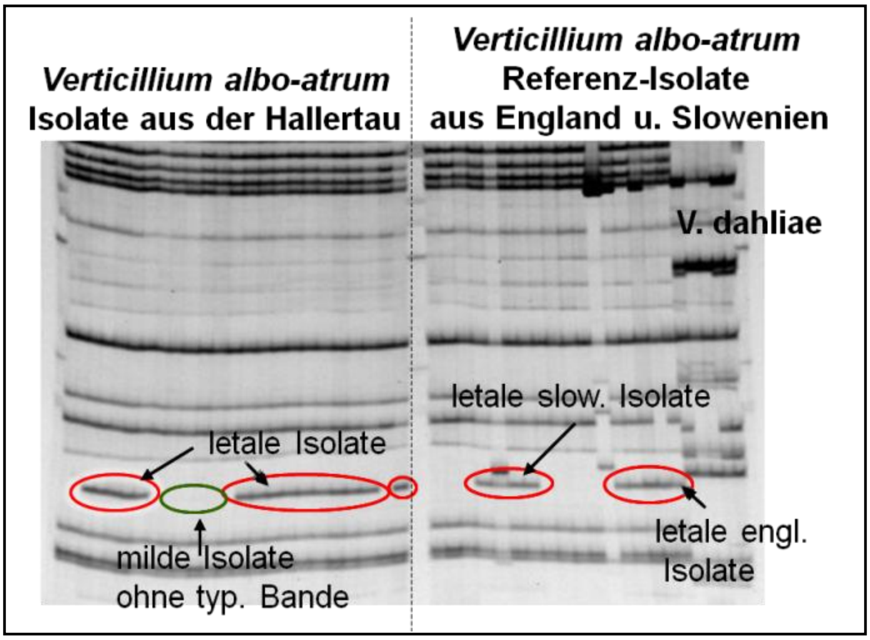


Fig. 4.8 : Section of an AFLP pattern of various Verticillium races (Hallertau isolates compared with references)

	Isolat	Tage nach Inok.	Sorte						Mittel-wert
			CEL	PER	HT	NB	MAG	WT	
Mildere Hallertauer Isolate →	P83	38	2	1	1	0	0	0	0,8
		52	3	1	2	0	0	0	1,2
		66	3	1	3	1	1	0	1,8
→	P55	38	1	0	0	0	1	0	0,4
		52	2	0	1	0	1	0	0,8
		66	3	1	2	1	1	0	1,6
Aggressivere Hallertauer Isolate →	P10	38	3	2	2	1	0	0	1,6
		52	4	3	2	1	1	0	2,2
		66	5	3	4	3	1	1	3,4
→	P15	38	4	1	1	1	1	0	1,6
		52	5	2	3	1	1	0	2,4
		66	5	3	5	3	2	1	3,8
Mildes slowen. Isolat →	Zup	38	0	0	1	0	0	0	0,2
		52	2	0	1	0	0	0	0,6
		66	2	1	2	1	0	0	1,2
Letales slowen. Isolat →	T6	38	1	2	3	0	1	0	1,4
		52	3	3	4	1	2	1	2,8
		66	5	4	5	2	2	1	3,8
Letales engl. Isolat →	11055	38	3	1	1	1	0	0	1,2
		52	4	3	3	1	1	1	2,6
		66	5	3	4	3	1	1	3,4

Fig. 4.9 : Result of an artificial infection test with defined Verticillium isolates. The 1-5 scale indicates the wilt-infected percentage of the test plant's foliage. 1= 0-20 %; 2 = 20-40 %; 3 = 40-60 %; 4= 60-80 %; 5 = 80-100 %

Outlook

Centre-stage besides the performance of further virulence assays will be the development of specific SCAR markers to be used for fast, PCR-based differentiation between mild and lethal races. In addition, we have already commenced testing of specific bacterial strains that could be used as bioantagonists to protect young hop plants from *Verticillium* attack in severely wilt-infected hop yards. Another focus will be on potential resistance selection in wild hops and Hüll breeding lines planted in 2010 on seriously *Verticillium*-contaminated leased land.

5 Hop cultivation and production techniques

LD Johann Portner, Dipl. Ing. agr.

5.1 N_{min} test in 2010

The N_{min} nitrogen fertiliser recommendation system has been in place for some time and has become an integral part of fertiliser planning on hop farms. In 2010, 3610 hop yards in Bavaria were tested for their N_{min} levels and the recommended amount of fertiliser calculated.

Tab 5.1 tracks the numbers of samples tested annually for N_{min} since 1983. Average N_{min} levels in Bavarian hop yards were around 86 kg/ha in 2010, the same as in 2009. Compared with the last 10 years, they were average.

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

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

Year	Number of samples	N_{min} kg N/ha	Fertiliser recommendation kg N/ha
1983	66	131	
1984	86	151	
1985	281	275	
1986	602	152	
1987	620	93	
1988	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
2009	3338	85	148
2010	3610	86	148

Tab. 5.2 shows 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 2010.

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

Tab. 5.2: Number, average N_{min} levels and fertiliser recommendations for hop yards by administrative district and region in Bavaria in 2010

District / Region	**Number of samples**	**N_{min} kg N/ha**	**Fertiliser recommendation kg N/ha**
Spalt (minus Kinding)	95	96	129
Pfaffenhofen	1169	94	144
Eichstätt (plus Kinding)	267	90	147
Hersbruck	54	88	129
Kelheim	1439	84	150
Freising	404	77	154
Landshut	182	69	157
Bavaria	**3610**	**86**	**148**

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

Tab. 5.3: Number, average N_{min} levels and fertiliser recommendation in 2010 for various hop varieties in Bavaria

Variety	**Number of samples**	**Nmin kg N/ha**	**Fertiliser recommendation kg N/ha**
Herkules	480	81	167
Nugget	54	74	164
Brewers Gold	5	71	161
Hall. Magnum	696	79	155
Hall. Merkur	10	72	155
Smaragd	7	68	154
Hall. Taurus	305	90	147
Saphir	42	84	146
Perle	685	87	145
Spalter Select	185	89	144
Opal	8	87	141
Hall. Tradition	607	97	140
Hallertauer Mfr.	248	77	139
Hersbrucker Spät	173	95	139
Northern Brewer	57	100	134
Spalter	42	113	113
Other	6	62	162
Bavaria	**3610**	**86**	**148**

5.2 Studies to investigate the structural design of hop trellis systems

5.2.1 Objective

In Germany, hops are grown predominantly on 7-8 m trellis systems. The advantage of high trellises is that current land races and cultivars have adapted to this height. They have long internodes, which means that maximum potential yields can be obtained on high trellises. In low-trellis trials with Hallertau cultivars, yields were 30-50 % lower than on high-trellis systems. The disadvantage of high trellises, however, is that they are costly and structurally challenging, and consequently at risk of collapsing during storms. This risk has, moreover, increased even further with the advent of new, higher-yield varieties with greater bine weights.

The aim of the studies is to investigate the various trellis designs in the different growing areas for weaknesses and identify possible structural improvements.

5.2.2 Method

The studies were carried out by civil engineering students from Regensburg University of Applied Sciences within the framework of a project. They were assisted by a civil engineer who comes from a hop farm and has experience in structural engineering. The project was funded by the HVG hop producer group. Following an extensive review of the literature and discussions with hop consultants and trellis builders, the students undertook excursions to the Hallertau, Tettnang and Elbe-Saale hop-growing regions in order to familiarize themselves with and document the various trellis designs on site. Their task was to work out the pros and cons of the various trellis designs on the basis of structural analyses and propose improvements.

The Cultivation/Production Techniques work group (IPZ 5a) provided the technical background and liaised with experts and contact persons in the other hop-growing regions.

5.2.3 Results

The results of the literature review, descriptions of the various trellis designs, assumptions underlying the structural analyses and their results, together with the proposed improvements, are summarized in a 110-page catalogue available for download at www.lfl.bayern.de/ipz/hopfen (homepage of the LfL, Hops Department). A number of typical findings are presented below.

Under wind load, the greatest compressive forces in the corner poles occur in the Hallertau trellis, a result mainly of the steep angle of the poles and guy lines. The use of concrete instead of wooden poles, or more and flatter guy lines, might resolve the problem at the corners. The distance between screw anchors should be at least 1 m.

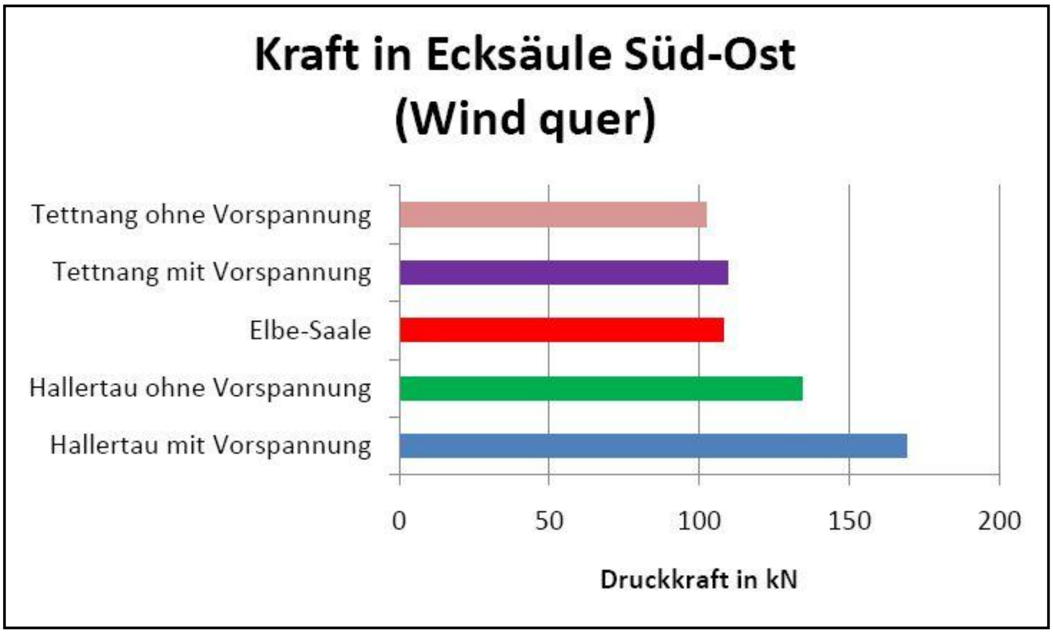


Fig. 5.1 : Compressive forces in the SE corner pole of various trellis designs

Sagging of the central cross-cable was greatest in the Elbe-Saale trellis design due to the large span width and the lack of lateral pre-tensioning. Thanks to overhead pre-tensioning, the Tettnang trellis design showed the least tendency to sag.

The proposed improvements included the following:

Since the highest forces occur at the edges, and above all at the corners of the yard, increasing the tilt of the guy cables greatly reduces the forces in the guy cables and poles. For example, reducing the angle of inclination from 76° to 45° will halve the compressive forces in the poles. Strong pre-tensioning, as is typical of the Hallertau trellis system in particular, puts an additional load on all trellis components. Overhead pre-tensioning of the kind used in Tettnang is therefore a much more effective way to prevent cable sagging.

Economic aspects were not taken into account in the calculations and deliberations nor did they play a role in the resulting proposals for improvements.

5.3 Measuring the weight of wet and dry hop bines

5.3.1 Initial situation and objective

Hop bines are trained up a 1.2-1.4-mm iron wire hooked into a 7-m high, barbed trellis wire. The training wire is expected to support a load of up to 45 kg without tearing. The wire must bear weight of the bines themselves plus any adhering rainwater, and withstand tensile forces caused by the wind. The weight of hop bines under wet and dry conditions must be known in order to obtain realistic assumptions on which calculations of the structural loads on trellis systems (research project “Studies to investigate the structural design of hop trellis systems”) can be based.

5.3.2 Method

In each of two hop yards planted with different varieties (Fig. 5.2 : Herkules and Fig. 5.3 : Hall. Taurus), the dry and wet weights of a row of five adjacent hop plants in the stand was determined shortly before harvesting. A 7-m high platform was used for this purpose and the training wire with the bines detached from the barbed wire and hooked into a scale hung from the latter in order to weigh the suspended bines. This method also allows wet bines to be weighed without loss of the rainwater adhering to them. The dry measurements were conducted on September 8th, 2010 (temperature 16 °C, no wind). Weighing of the hops when wet necessitated waiting for a sufficiently rainy day to ensure that the hops were thoroughly wet. This was the case on 13th September 2010 (temp. 13 °C, 11 mm rain in the preceding 10 h), when the same bines were weighed once again.

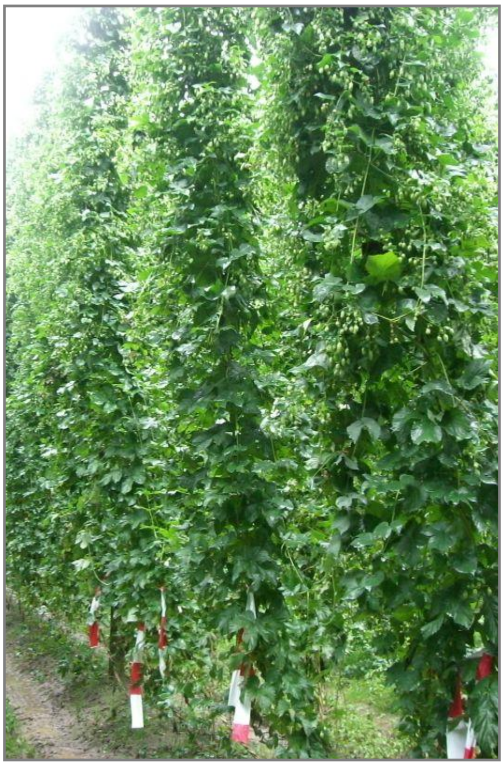


Fig. 5.2: Labelled Herkules plants for weighing

Fig. 5.3: Labelled Hall. Taurus plants for weighing

5.3.3 Results and discussion

The following table gives the weights of the dry and wet bines, the differences between the dry and wet weights, and the average values.

Tab. 5.4 : Weight of hop bines (Rohrbach, Herkules variety)

Training wire No.	Weight in kg dry bines (08.09.2010)	Weight in kg wet bines (13.09.2010)	Weight difference in kg (wet – dry)
1	9.2	11.9	2.7
2	9.2	12.0	2.8
3	10.2	13.1	2.9
4	8.9	13.5	4.6
5	7.7	9.0	1.3
Average	**9.04**	**11.90**	**2.86**

Tab. 5.5 : Weight of hop bines (Kreithof, Hall. Taurus variety)

Training wire No.	Weight in kg dry bines (08.09.2010)	Weight in kg wet bines (13.09.2010)	Weight difference in kg (wet – dry)
1	5.1	5.4	0.3
2	6.5	7.0	0.5
3	6.1	6.8	0.7
4	6.4	6.8	0.4
5	7.7	7.9	0.2
Average	**6.36**	**6.78**	**0.42**

The weights of the five adjacent plants show considerable differences from training wire to training wire. Comparison of the two varieties reveals even more pronounced differences. The Hallertauer Taurus bines were less advanced and, when dry, weighed only about 2/3 as much as the heavy Hercules bines. The weight difference was even greater when the hops were wet. There was much more water adhering to the Herkules plants, with their large leaf surface area and numerous small cones, than to the compact Taurus plants, which have less foliage. The fact that the dry-wet weight difference is so much lower for Taurus (0.42 kg) than for Herkules (2.86 kg) is, however, surprising, especially as the weight difference between the two varieties is relatively small in dry conditions.

With an average of just under 12 kg, the weight of the Herkules plant when wet is still well below the training wire's 45-kg failure limit. The fact that, in practice, many training wires nevertheless tear during rainy and stormy weather points to general wear on the wire, accompanied by a reduction in its tear strength during the vegetation period, or to the huge influence of wind forces.

Approx. 4,000 training wires are hung per ha hop yard. Based on the above measurements, this means that a one-hectare hop trellis for varieties with less vigorous growth (e.g. Taurus, Northern Brewer or Perle) has to support a total weight of around 25 t in dry conditions and 27 t in wet conditions. The weight per ha of varieties characterised by very vigorous growth, such as Herkules, can increase to 36 t (dry) – 48 t (wet). Bearing in mind that wind will cause the weight to increase further before individual plants are torn down, it is clear that the hop trellis must withstand much higher weights to prevent collapse.

5.4 Measurement of wind-velocity variation in hop yards

5.4.1 Initial situation and objective

Wind is an important factor to be taken into account in the research project “Studies to investigate the structural design of hop trellis systems”. Wind hitting a hop yard head-on or from the side tautens the hop bines, increasing the weight on the training wires and the structural load on the hop trellis by several times the hop bines’ own weight. For the purpose of structural calculations, it is important to know the force with which and the angle at which the wind hits the wall of hops, and the degree to which wind velocity decreases as the wind penetrates the stand.

5.4.2 Method

On a gusty day (wind force 4-6) with the prevailing wind coming from the SW, wind measurements were made on the windward side of two hop yards facing in different directions. The measurements were made at three different heights (1.5 m, 4.0 m and 7.0 m) and three different depths of penetration into the hop stand (edge = 0 m, 3rd row = approx. 9 m and 6th row = approx. 18 m). To rule out chance occurrences and achieve comparable results, the measurements were carried out simultaneously with three hand wind sensors, at a specified height and three different depths of penetration, to determine the extent to which the velocity of the wind decreases as it penetrates the hop yard. To this end, the wind sensors were mounted in holding devices attached to metal rods at the same height. The wind sensors were switched on at the word “go” and left on for two minutes. The maximum and average wind velocities recorded during this time were then read off. Each measurement was repeated twice.

5.4.3 Results and discussion

Tab. 5.6 and Tab. 5.7 give the measured wind velocities (maximum value and two-minute average) at different heights and depths of penetration for two hop yards facing in different directions relative to the wind.

Tab. 5.6: Wind velocities (km/h) in the hop stand with rows facing the wind (Kreithof, Saphir variety, 30.08.2010)

(Rows: 20°N – 200°S, wind direction: 240 °SW)

Penetration depth		**0 m**		**8.6 m**		**18.4 m**	
Height		**Max. value**	**Ø**	**Max. value**	**Ø**	**Max. value**	**Ø**
7.0 m	**Measmt. 1**	44.0	19.0	35.6	9.0	15.6	5.2
	Measmt. 2	32.0	17.2	29.0	9.8	12.2	4.2
4.0 m	**Measmt. 1**	40.0	22.0	26.0	12.3	12.5	4.5
	Measmt. 2	38.0	15.0	21.0	7.4	9.1	3.0
1.5 m	**Measmt. 1**	21.0	9.6	13.4	7.0	11.0	5.2
	Measmt. 2	33.0	17.2	28.0	13.8	11.0	5.8

Tab. 5.7 : Wind velocities (km/h) in the hop stand exposed to wind from the side (Rohrbach, Hall. Magnum variety, 30.08.2010)

(*Rows: 110°O – 290°W, wind direction: 240 °SW*)

Penetration depth		**0 m**		**9.2 m**		**18.6 m**	
Height		**Max. value**	**Ø**	**Max. value**	**Ø**	**Max. value**	**Ø**
7.0 m	**Measmt. 1**	41.0	22.0	25.0	11.6	21.0	6.5
	Measmt. 2	38.0	23.0	27.0	14.0	20.0	8.2
4.0 m	**Measmt. 1**	36.0	25.0	12.0	5.5	12.6	4.2
	Measmt. 2	40.0	24.0	22.0	6.7	7.6	3.2
1.5 m	**Measmt. 1**	41.0	24.0	30.0	10.5	33.1	14.4
	Measmt. 2	46.0	28.0	35.0	11.2	27.7	9.7

It became clear from all measurements that wind is slowed down on hitting a hop yard and that wind velocity decreases with increasing depth of penetration into the stand. However, the pattern according to which the wind decreases and the extent of trhe decrease depends on wind direction, measuring height and penetration depth.

Where the rows face the wind, (Thalmaier, Kreithof), wind force within the stand was higher and the decrease tended to be more linear (Fig. 5.4 and Fig. 5.5) than where the wind came from the side (Fig. 5.6 und Fig. 5.7). The highest wind velocities were measured at a trellis height of 7 m, followed by heights of 1.5 m and 4 m. The higher air velocities at 1.5 m are due to the fact that the wind can penetrate the stand better at ground level, where the bines are defoliated, and is slowed down less near the ground than in the middle section of the bines.

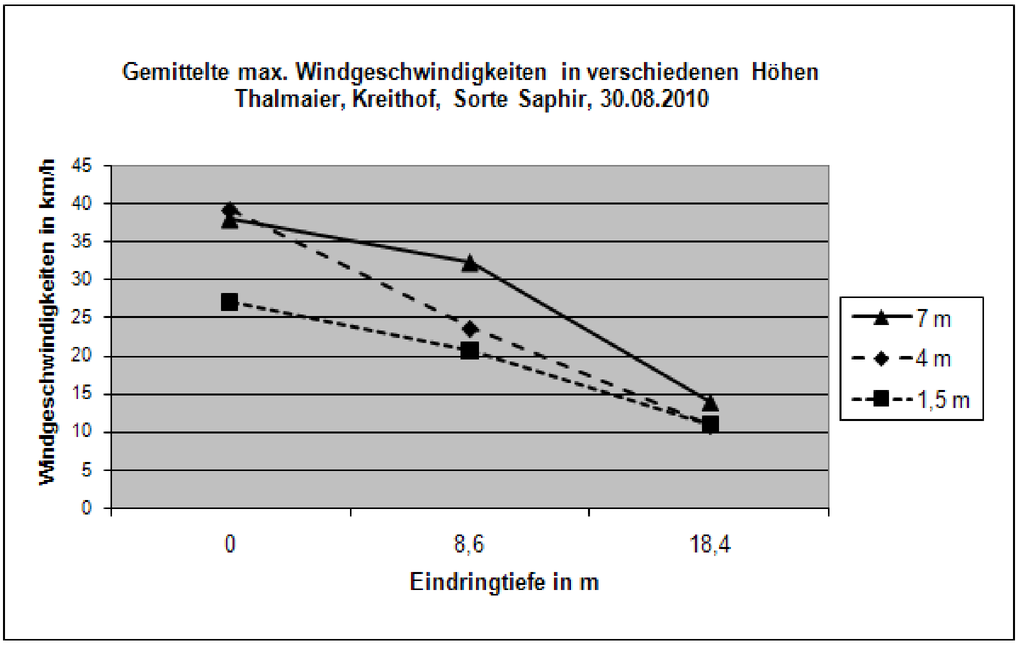


Fig. 5.4 : Mean maximum wind velocity - Saphir

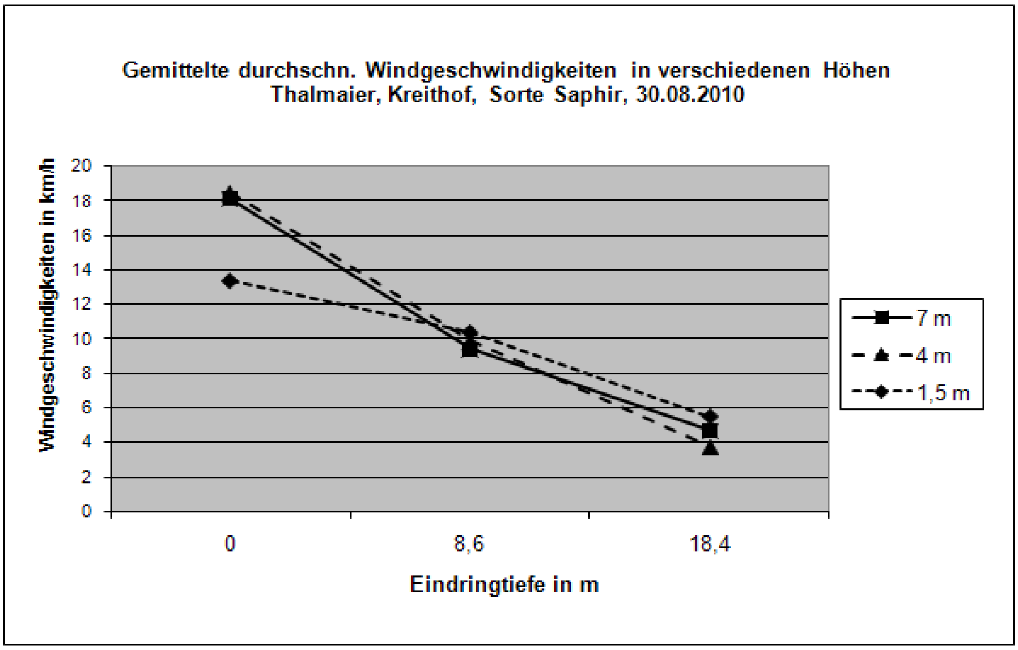


Fig. 5.5 : Mean average wind velocity - Saphir

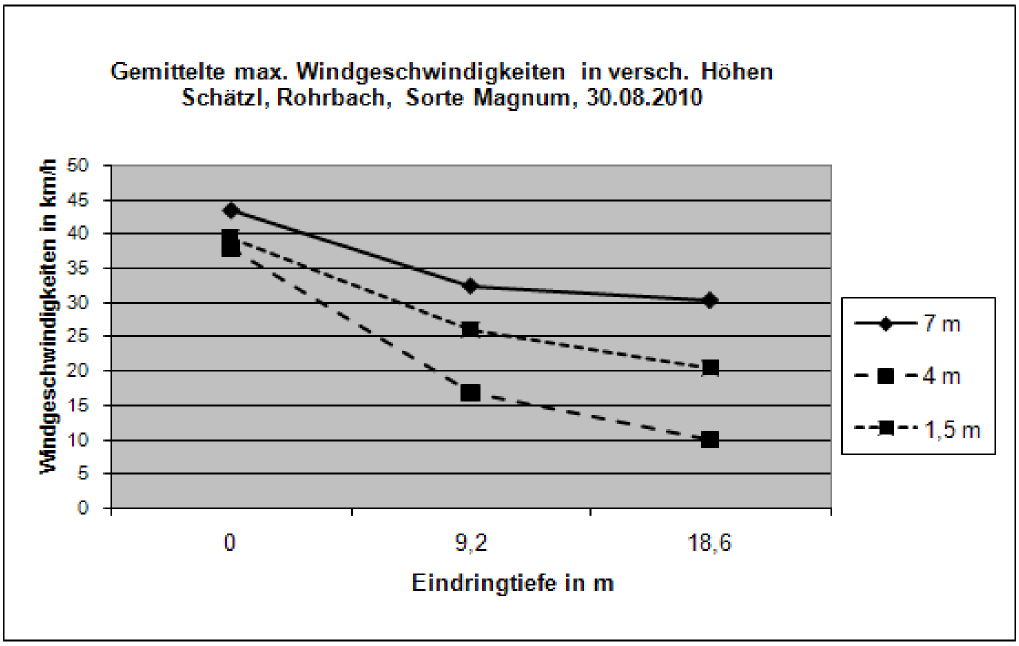


Fig. 5.6 : Mean maximum wind velocity - Magnum

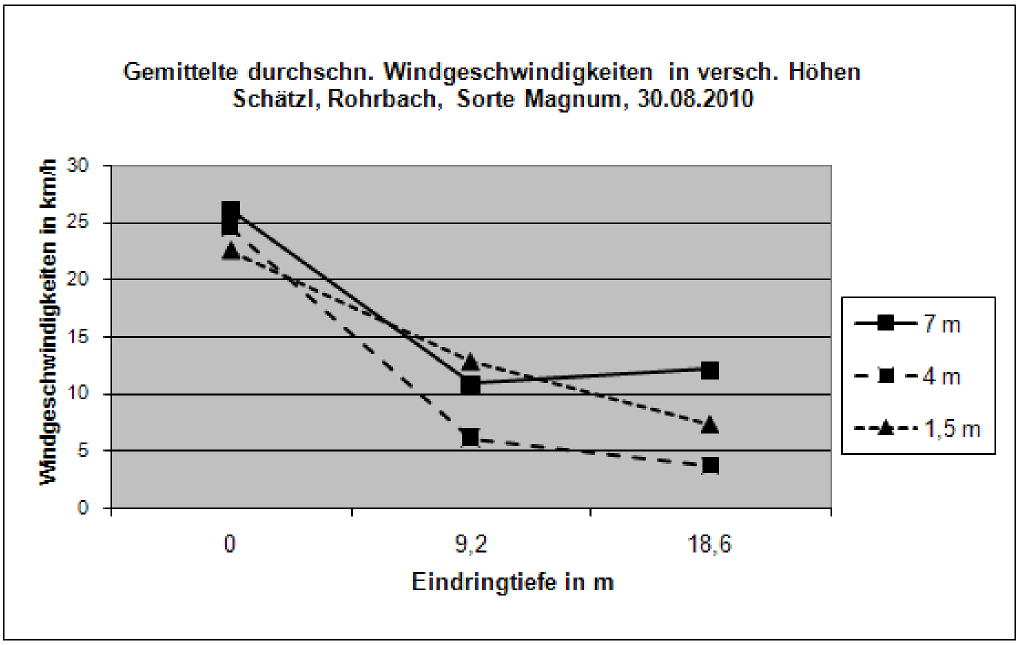


Fig. 5.7 : Mean average wind velocity - Magnum

5.5 Investigations to determine the influence of strobilurins on yield, alpha acids and disease infestation using "Ortiva" (active agent: azoxystrobin) as an example

5.5.1 Objective

Treating plants, especially cereals, with strobilurins intensifies the green colour of the leaves, an effect referred to as "greening". It is due largely to the fact that plants treated with strobilurins are less susceptible to fungal damage or do not need to invest as much energy in fungal defence. In cereal cultivation trials conducted by manufacturers of plant protectives, strobilurins have also been found to enhance yields. This trial set-up was intended to test whether these positive effects can be detected in hops.

A four-year trial involving the Hallertauer Magnum cultivar was conducted in a conventionally farmed hop yard to investigate the influence of strobilurin use on yield, alpha-acid formation and cone health.

5.5.2 Method

The approx. 0.8 ha hop yard was divided into four plots of equal size, each with twice replicated randomized trial blocks earmarked for harvesting. Each trial block consisted of 20 hop plants in a row.

No strobilurins were applied to the plots labelled "conventional" during the four-year trial.

By agreement with Syngenta, the first Ortiva treatment (1.6 l/ha) in the strobilurin variant was scheduled to take place approx. 8-10 days prior to main flowering. This date naturally varies from year to year, and was chosen according to the hop plants' stage of development. The earliest date was July 11th 2008 and the latest July 20th 2010.

The second treatment with 1.6 l/ha Ortiva was applied 10 – 14 days after the first treatment, again as per Syngenta's instructions.

In the conventional plots, Forum (active agent: dimethomorph) was applied each time as the reference preparation, at a dose rate of 4.0 l/ha.

Yield and alpha-acid content were measured for the harvested trial blocks, and the alpha-acid content extrapolated to alpha-acid yield/ha. A cone sample was also collected from each plot, and 500 cones from each sample examined individually for disease. The disease level was broken down into zero, slight, medium and severe, and a weighted mean disease level calculated. An index of 1.0 to 4.0 is indicative of the disease level; according to experience, NQF (Neutral Quality Assessment Procedure) price reductions must be expected as from an index of 1.0.

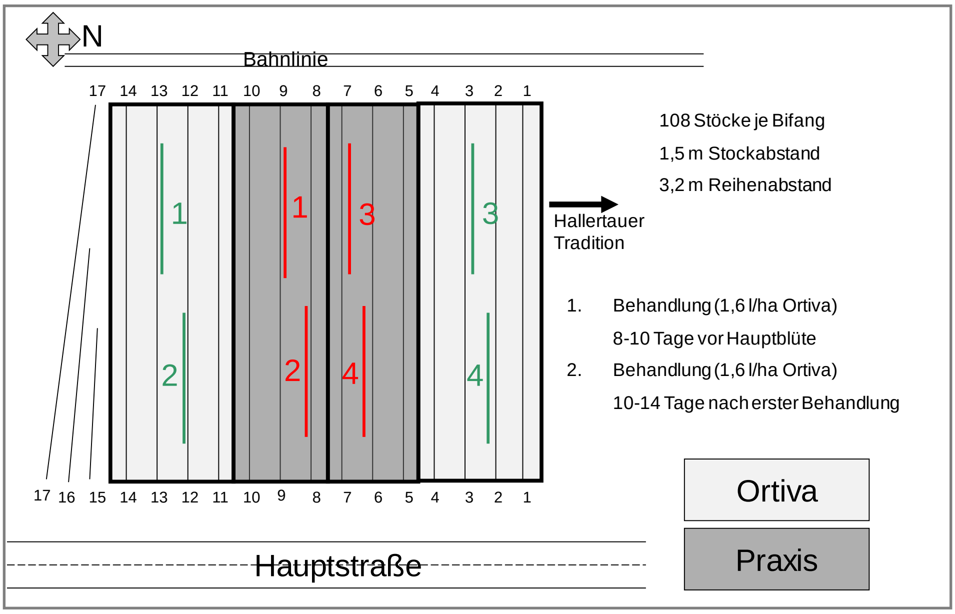


Fig. 5.8 : Rohrbach trial location

5.5.3 Results

Assessment of the plots treated with Ortiva showed no evidence of a greening effect in any of the trial years. Leaves from the Ortiva trial plots were no greener, either shortly after treatment or at harvesting time. Cone assessment, by contrast, furnished evidence of a slight reduction in downy mildew infestation and a positive side effect on powdery mildew and botrytis.

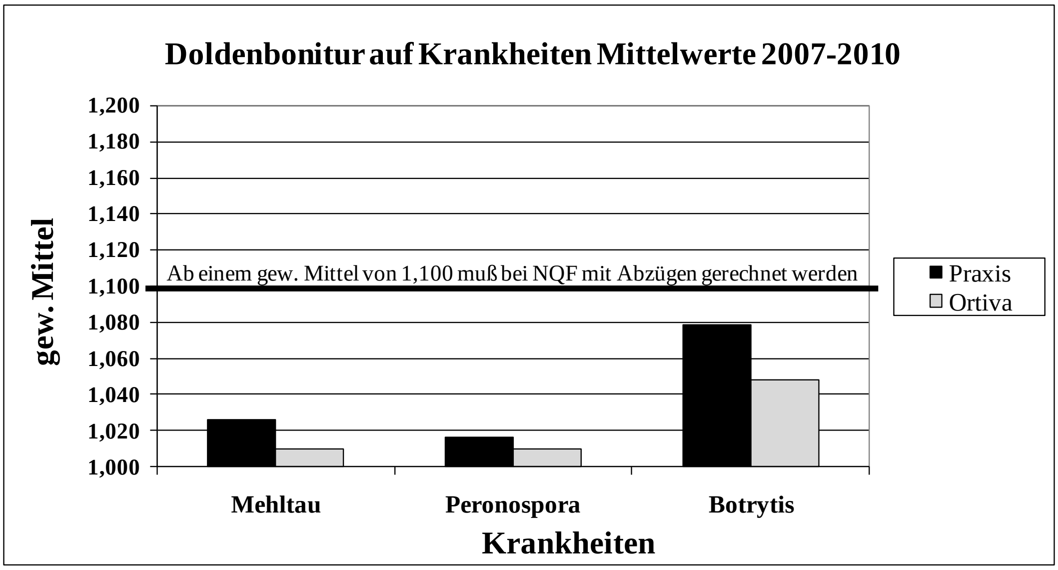


Fig. 5.9 : Mean disease level in 500 cones (NQF price reductions must be expected as from a weighted mean of 1.000)

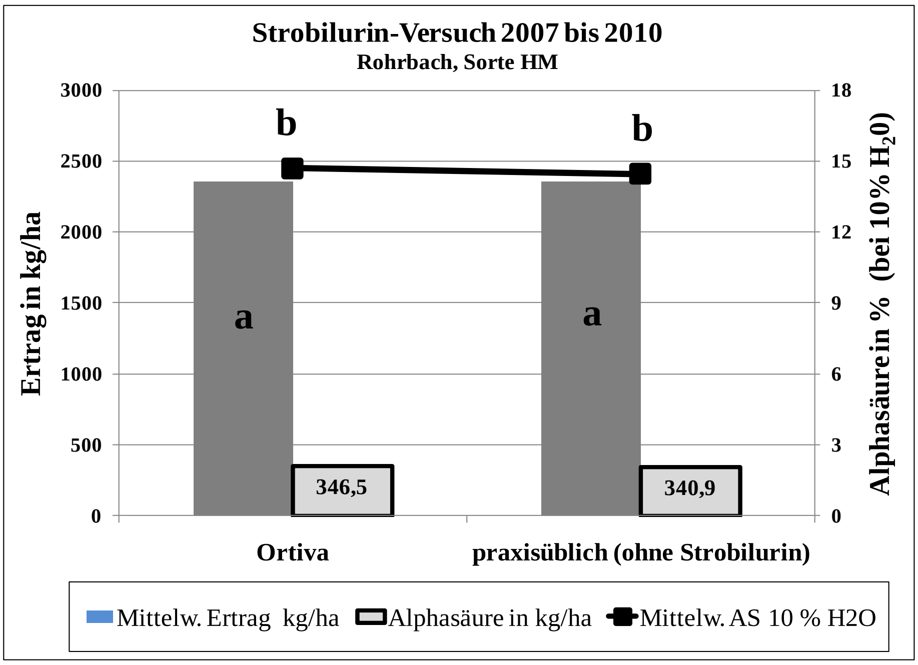


Fig. 5.10 : Influence of Ortiva on yield and alpha acids

The use of Ortiva did not lead to significantly higher yields (averaged over the four trial years). The slightly higher alpha-acid values obtained with the strobilurin variant are not statistically significant. The enhanced yield and components performance obtained in other crops with the strobilurin Ortiva was not confirmed for hops.

5.6 Influence of “Pentakeep super” leaf fertiliser on hop yield and alpha-acid content

Objective

In addition to various primary nutrients and micronutrients, Pentakeep super leaf fertiliser contains the compound aminolevulin acid, which is said to have a plant-strengthening and stress-compensating effect and to increase chlorophyll content. Increases in yield and/or alpha-acid content have already been demonstrated in other crops and in a number of trials involving hops. The aim of this three-year trial in the Hallertau was to investigate the effect of the relatively expensive leaf fertiliser on different cultivars at various locations.

Method

From 2008-2010, the leaf fertiliser was tested on the aroma variety Perle and the bitter variety Hallertauer Magnum in two commercial hop yards. Pentakeep super was applied by spraying (the conventionally managed control plot remaining unsprayed) according to two different regimens specified by the manufacturer. One regimen involved spraying 6 times, each time with a leaf fertiliser solution of 0.5 kg/ha in 1,000 l/ha water. The other was combined with conventional plant-protection measures and involved 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.

Results

At the Oberulrain location (Danube basin, mild climate, slightly loamy sand), which was planted with Perle, significantly higher yields (averaged over the three trial years) were obtained in the treated plots than in the untreated control plot. The yield obtained in variant 2 (six treatments) was even higher than in variant 3 (three treatments). There were no significant differences in % alpha-acid content.

At the Kirchdorf location (tertiary hill country, rugged hilltop, silty clay), which was planted with Hallertauer Magnum, the yield obtained in variant 2 (six treatments) was significantly lower than in the control plot. The yield in variant 3 (three treatments) was the same as in the control plot. In neither variant 2 nor 3 did the % alpha-acid content differ significantly from that of the control plot. For the sake of completeness, alpha-acid contents were calculated in kg/ha and included in the following chart:

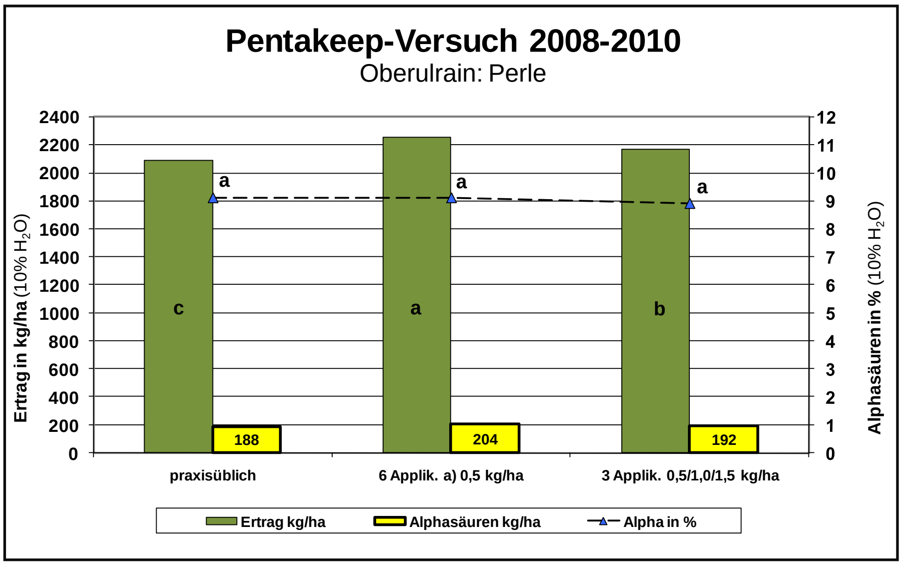


Fig. 5.11 : Yield, alpha-acid content and alpha-acid yield/ha in Pentakeep trials with Perle

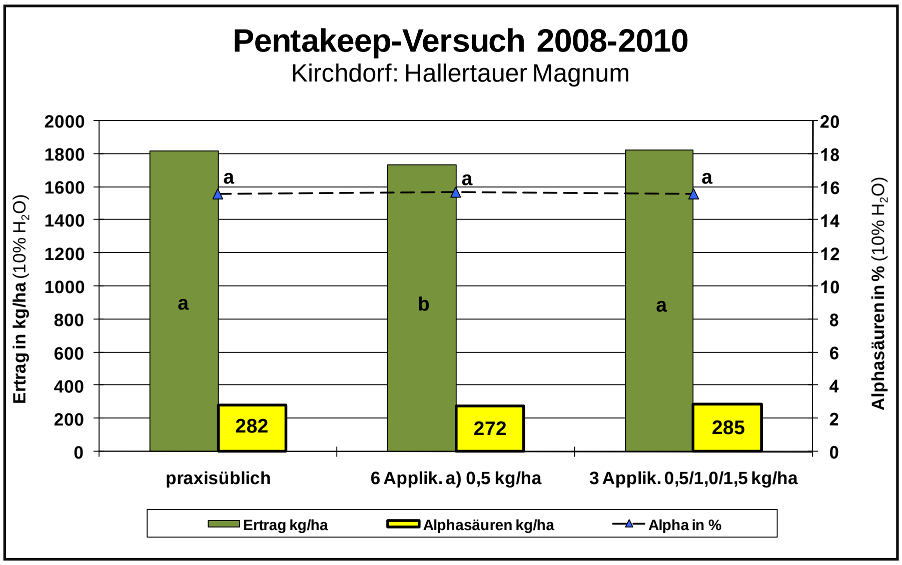


Fig. 5.12 : Yield, alpha-acid content and alpha-acid yield/ha for Pentakeep-treated Hall. Magnum

Six applications of Pentakeep resulted in a significant yield increase (+ 169 kg/ha) at one trial location (Perle) and in a significant yield decrease (- 83 kg/ha) at the other location (Hall. Magnum). As no uniform trend can be identified, other variables (e.g. location, variety, etc.) seem to have had a greater influence on yield than the use of Pentakeep. In light of the results, it makes no economic sense to recommend the use of Pentakeep super, especially as three kg of the leaf fertiliser currently cost over € 500 and supplementary costs exceeding 100 €/ha for six applications (= 3 additional sprayings) must be reckoned with.

5.7 Testing coir string as an alternative training material to iron wire

5.7.1 Initial situation

Alternative training materials to conventional iron wire have been under test for many years on account of the problems caused by metal spikes when bine choppings are returned to the soil. Apart from eliminating the wire spikes, the advantages of non-ferrous training materials include less wear on cutting tools and a longer service life for the barbed wires. Degradable material would furthermore be suitable for fermentation in biogas plants together with bine choppings.

Acceptance of alternative training materials depends not only on economic considerations but also, and in particular, on labour-related aspects. It is also essential that the string does not break, sag, or rot in the soil-air transition zone.

5.7.2 Material and methods

On March 27th, 2010, fifty coir strings from Bon Terra were hung in a commercial hop yard (Rohrbach, HM variety, loamy sand) for comparison with 1.3 mm iron wire. The coir strings were attached to the overhead barbed wire by means of a simple knot. The wires and coir strings were then embedded in the rootstock region by means of an insertion and anchoring device. Differences in labour input, twining behaviour of the hop bines and any material changes were recorded.

5.7.3 Observations and findings

<u>Time needed to hang the strings</u>

Provided the strings are hanging freely from the bundle on the platform, the time needed to knot them to the barbed wire is comparable to that needed to attach wire. Handling the bulky material on the hop platform proved difficult, as it is awkward to accommodate and, due to its rough surface, does not slip out of the bundle easily. This was a strenuous and time-consuming task.

Fig. 5.13.: Coir strings attached with a simple knot

<u>Embedding the string:</u>

Embedding coir strings requires more strength than is needed for wire, and embedding them in the centre of the rootstock region is difficult if not impossible. It is, moreover, impossible to embed two strings simultaneously because the strings are too thick for two of them to fit into the groove in the insertion device. It is important to embed the strings very soon after they have been suspended because otherwise, under windy conditions, there is a risk of their being blown upwards and becoming entangled in the barbed wire.

When there was no wind, an hourly embedding rate of 200 strings was achieved, which translates into 20 h/ha. One disadvantage of coir training string compared to wire is that, once embedded, coir string cannot be re-tensioned if it slackens.

Fig. 5.14 : Coir string anchored in the ground

Observations during the growing season

The coir strings proved to be extremely tear-resistant. Of the 50 test strings, not a single one broke. The hops were found to twine equally well around coir strings as around iron wire, a fact attributable to the rough surface of coir string. As none of the bines came down, there was no need for re-training or re-hanging during the season. None of the bines were observed to slip down or sag, either. The material also proved to be sufficiently strong at the soil-air transition zone, with none of the strings rotting at the base. Other seasonal maintenance work was also carried out in the “string plot” without any problems.

Fig. 5.15 : Bine-clad coir string

Fig. 5.16 : Test hop yard: coir strings left; iron wires right

Harvesting observations:

Machine harvesting was as successful as for the wire-strung row and there was no difference in cone-picking performance, with coir-strung bines being chopped up just as well as wire-strung bines.

5.7.4 Discussion

Bulkiness proved to be the major disadvantage of coir; it is difficult to store on the elevated platform and does not slip smoothly out of the bundle after having been tied to the barbed wire. The tying technique employed in other hop-growing regions where coir string is already in use should be adopted here.

No tests were performed with regard to tear strength. As none of the bines collapsed, the question of whether thinner strings would suffice should be investigated. This would reduce bulk and make the alternative training material cheaper – an important aspect in light of the fact that coir string is about twice the price of iron wire according to the manufacturer's quote and is therefore economically unviable.

5.8 Initial trials to optimise belt driers

Objective

In trials to optimise hop drying in floor kilns, drying performance was substantially increased and energy input optimised. Optimised operation is achieved via the correct ratio between drying parameters – drying temperature, air speed and cone depth or weight. This necessitates a measuring technique with which the most important drying parameters are not only recorded but also charted, thus helping to explain the drying processes and make them controllable. During the 2010 harvest, the findings from long-term trials in floor kilns were used for the first time to optimise drying in a belt drier. The idea was to determine the conditions under which drying performance is best via daily documentation of important drying parameters and routine settings.

Method

All relevant settings and measurements were documented in a drying protocol in order to determine the current status. The belt drier on the commercial hop farm had three drying belts one above the other, each with a drying surface area of 18 m^2. Different belt speeds resulted in a cone depth of 18-20 cm on the uppermost belt and of 20-27 cm on the two belts below. The drying temperature on entry of the cones into the bottom of the drier was 65-68 °C, and the openings in the lateral air-supply ducts were adjusted in such a way that the drying temperature above was still 60-62 °C. Air was sucked out of the belt drier via two waste-air flues. The volume of air suctioned off can be controlled manually. According to the hop farmer's past experience, drying performance is best if the relative humidity in the first waste-air flue does not exceed 50 %. This ensures that the water extracted from the cones is removed as quickly as possible. The relative humidity in the second waste-air flue should not fall below 38 %, as otherwise heating oil consumption is too high. The average temperature measured with these settings was 42 °C at the first air extractor and 45 °C at the second air extractor. The moisture level specified for the dried hops was set by measuring the conductivity of the hops on the bottom belt and adjusting the belt speed accordingly.

During the course of a harvesting day, air speed in m/s was measured several times as a function of oil consumption and temperature difference between drying air and intake air. This method of determining the air speed was described in the 2007 Annual Report.

The dried hops were transported on conveyor belts from the belt drier to two conditioning chambers. Filling time and duration were documented for each chamber in a drying protocol. The conditioned hops were weighed on baling. This permitted drying performance as kg dry hops/m^2 drying area/h drying time to be determined for defined drying periods. This figure was charted as a function of the air speed measured for the same period in order to establish a relationship between air speed and drying performance.

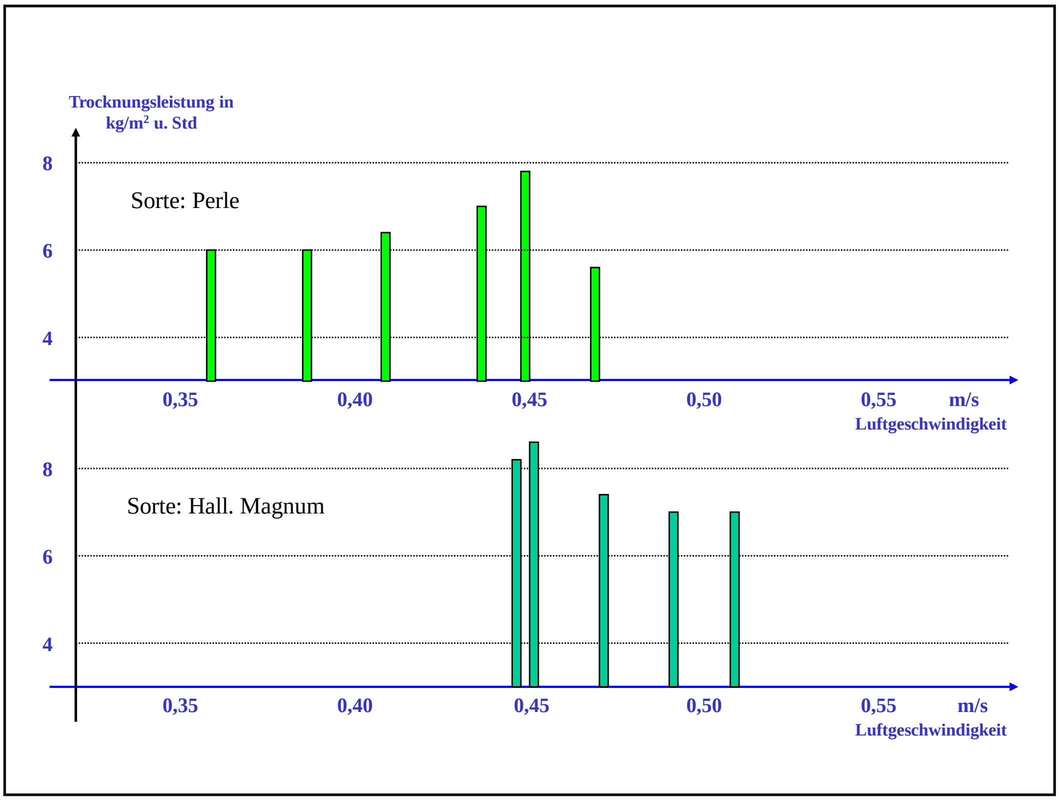


Fig. 5.17: Drying performance of Perle and Hall. Magnum as a function of air speed

Results

Constant changes in air speed (in m/s) in the belt dryer were observed for the same cone depth and the same fan-intake-port setting. This is because the cone weight of green hops also varies. Within one and the same variety, cone weight will vary according to ripening time, growing conditions and moisture content. Cone weight naturally differs from variety to variety.

The above chart shows the influence of optimal air speed on drying performance. The highest drying performance was obtained for both Perle and Hall. Magnum at an air speed of 0.45 m/s. The intervarietal difference in drying behaviour is also interesting. For the same cone depth, air speeds were on the low side for Perle and too high for Hall. Magnum. Thus, simply by adjusting cone depth, the air speed in belt driers could be controlled such as to ensure that drying performance is always optimal.

5.9 LfL projects within the Production and Quality Initiative

As part of a production and quality offensive on behalf of agriculture in Bavaria, the Bavarian State Research Center for Agriculture has launched a programme to collect, record and evaluate representative yield and quality data for selected agricultural crops from 2009 to 2013. For the Hops Department of the Institute for Crop Science and Plant Breeding, this work is being undertaken by its advisory service partner Hallertau Hop Producers' Ring. The aims of the hop projects are described briefly below, and the 2010 results summarized.

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

"Alpha-Express"

During the 2010 harvest, 604 freshly harvested hop samples were analysed on the day of harvesting for alpha-acid content. These daily measurements provide insight into harvest maturities of the various hop cultivars, allowing recommendations to be made concerning optimum harvesting times.

Neutral Quality Assessment Procedure (NQF) results

Quality data collected within the framework of the NQF provide valuable information on the hop quality of the year in question and point to production-related errors or incorrect treatment of harvested hops. In 2010, for example, a high proportion of cones were again found to be tainted.

Assessment of diseases and pests and assignment into infection categories reveal cultivar-specific differences in resistance and regional differences in infestation levels, and also enable the effectiveness of plant protectives to be judged. The 2010 results showed infestation levels that were much lower than in preceding years, pointing to a modified assessment key and putting limitations on a comparison with earlier years.

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

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

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

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

The preliminary index thresholds (Adcon model), which had prompted more frequent spray warnings in the past, were raised in 2010, with a distinction being made between "before flowering" and "after flowering".

The 2010 figures showed that the number of treatments recommended for susceptible varieties in the Hallertau region by the previous early-warning model was substantially lower at the Aiglsbach trial location than the number of treatments according to the Adcon model, despite the index threshold for the latter having been raised. At the Hirnkirchen location, by contrast, the Adcon model did not respond during the wet month of May, although infection risk was very high.

Cone samples from the comparative plots at the scientific-test locations were examined for downy-mildew infestation after harvesting. In Speikern (Hersbruck), a clearly higher proportion of downy-mildew-infected cones of the susceptible variety Hersbrucker Spät was detected in the Adcon plot than in the LfL plot!

5.10 Advisory and training activities

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

The group's training and advisory activities in 2010 are summarized below:

5.10.1 Written information

- The 2010 "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. 2445 copies were distributed by the LfL to the national offices for food, agriculture and forestry (ÄELF) and research facilities, and by the Hallertau Hop Producers' Ring to hop growers.
- 34 of the 56 faxes sent in 2010 by the Hop Producers' Ring to 1035 recipients contained up-to-the-minute information from the work group on hop cultivation and spray warnings.
- Updated information was likewise made available at irregular intervals for the German Weather Service's weather data fax.
- 3338 soil-test results obtained within the context of the N_{min} nitrogen fertilisation recommendation system were checked for plausibility and approved for issue to hop-growers.
- Advice and specialist articles for hop-growers were published in two circulars issued by the Hop Producers' Ring and in seven monthly issues of the magazine "Hopfen Rundschau".
- 345 field records on the 2010 hop harvest were evaluated by three working groups with the "HSK" recording and evaluation program and returned to farmers in written form.

5.10.2 Internet and Intranet

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

5.10.3 Telephone advice and message services

- The downy-mildew warning service, prepared jointly by the WG Hop Cultivation/Production Techniques (Wolnzach) and the WG Plant Protection in Hop Growing (Hüll) and updated 77 times during the period from 11.05.2009 to 01.09.2010, was available via the answerphone (Tel. 08442/9257-60 and 61) or via the internet.
- The message service for hop-growing tips, formerly available via the answerphone in Wolnzach, was terminated in 2010 because comprehensive fax and internet information is now available nationwide.
- Consultants from the WG Hop Cultivation/Production Techniques answered around 3,000 special questions by telephone or provided advice in one-to-one consultations, some of them on site.

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

- 7 training sessions for consultants from the Hop Producers' Ring
- Weekly note swapping with the Ring experts during the vegetation period
- 9 meetings on hop cultivation, organised jointly with the offices for food, agriculture and forestry (ÄELF)
- 56 talks
- Poster exhibition on "Hop Drying" information day in Wolnzach and at the HopFa tradeshow held during the Gallimarkt fair in Mainburg.
- 21 guided tours through trial facilities for hop growers and the hop industry
- 14 conferences, trade events and seminars

5.10.5 Basic and advanced training

- Setting of a Master's examination topic and assessment of 3 work projects for the examination
- 6 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 and examination of agricultural trainees focusing on hop cultivation (2 districts)
- 6 meetings with the "Business Management for Hop Growers" working group

6 Plant protection in hops

LLD Bernhard Engelhard, Dipl. Ing. agr.

6.1 Pests and diseases in hops

6.1.1 Aphids

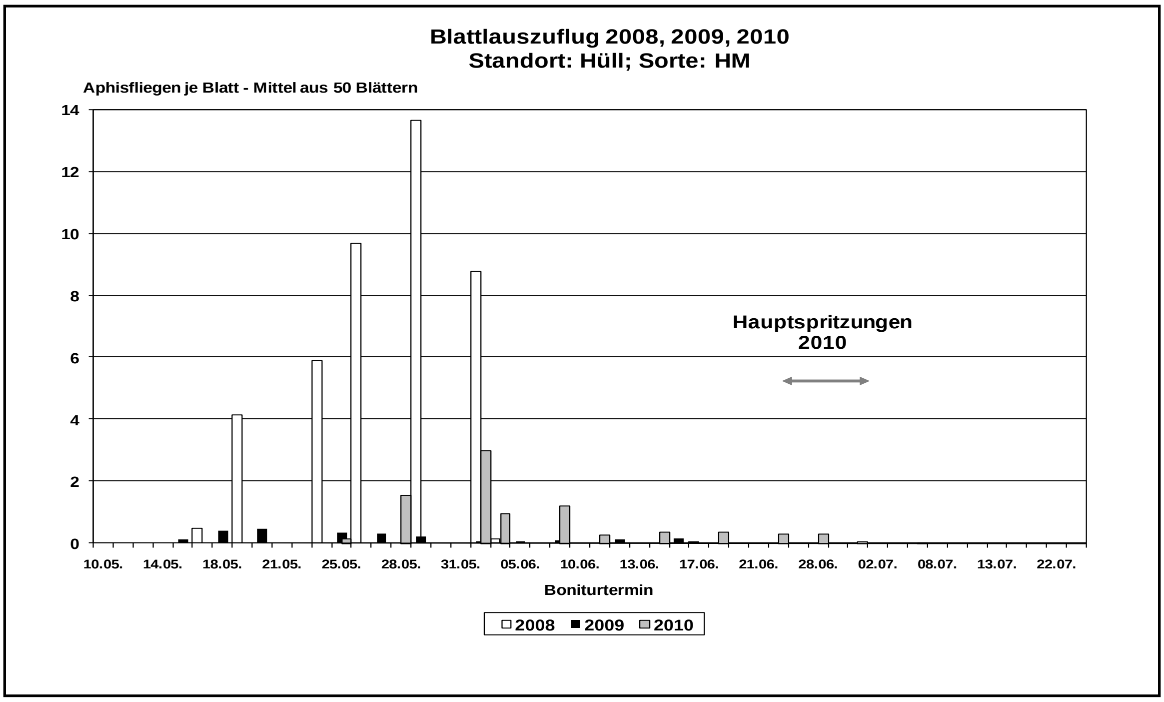


Fig. 6.7: Aphid migration

Whereas flea beetle outbreaks immediately after bud break right up to training are becoming more and more of a problem, there were altogether fewer problems with hop aphids and common spider mites. In many cases what is known 'precautionary spraying' was performed to avoid all risks.

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

Date	Aphids per leaf			Spider mites per leaf		
	Ø	min.	max.	Ø	min.	max.
25.05.	0.16	0.00	0.88	0.01	0.00	0.13
31.05.	1.71	0.00	16.70	0.01	0.00	0.23
07.06.	4.98	0.02	46.50	0.02	0.00	0.90
14.06.	11.,60	0.00*	70.60	0.90	0.00	10.30
21.06.	14.60	0.04*	70.40	1.30	0.00	17.30
28.06.	26.60	0.00*	71.40	1.10	0.00	13.70
05.07.	9.00	0.00	88.90	1.10*	0.00**	18.30
12.07.	1.00	0.00	4.66	0.20	0.00	3.40
	Main spraying dates 02. - 09.07. * Cultivar SE			Main spraying dates 02. - 09.07. *Control threshold exceeded at 7 locations ** 19 locations		

6.1.2 Downy mildew

Tab. 6.2 : Downy and powdery mildew warning service

Fax No.	Date	Primary downy mildew	Spray warnings			Powdery mildew
			Susceptible cultivars	All cultivars	Late cultivars	
13	08.04.	xxx				
17	07.05.	xxx				
19	20.05.	x				
20	25.05.	x	x			
21	27.05.			x		Susceptible
23	02.06.	xxx Eng.				
24	04.06.					All
25	07.06.			x		
27	16.06.	xx				
09.-28.06.		x	"Spike" warning in DM warning service			
28	21.06.	xx				All
30	29.06.	x	x			
37	30.07.		Warning re increase in zoosporangia			
38	02.08.			x		
40	10.08.		x			Susceptible
41	17.08.			x		
43	24.08.			x		
46	01.09.				x	
No. of spray warnings			3 + 5	5	+1	2 + 2

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

Problem and objective

The larvae of click beetles (Elateridae), commonly referred to as wireworms, have caused more and more damage to hops (especially to young plants) over the last few years. This is illustrated, among other things, by the issue of a temporary emergency permit as per Sec. 11 PflSchG (Plant Protection Act) in spring 2010 for use of the insecticide 'Actara' (agent: thiamethoxam) against wireworms. The actual biology of this pest is, admittedly, still largely unknown and insight gained so far into the period of larval development, for instance, stems solely from studies conducted several decades ago on the striped click beetle, *Agriotes lineatus*. Other species, such as *Agriotes sordidus*, which invaded Germany only recently and is currently spreading, have much shorter periods of larval development, which must be taken into consideration, of course, if measures to combat this pest are to be effective. The actual range of click beetles currently found in hops has not been ascertained to date.

Within the framework of a nation-wide, multi-year joint project aimed at remedying this situation and launched on the initiative of the German Phytomedical Society/Julius Kühn Institute (WG Cereal Pests), Syngenta Agro GmbH and Göttingen University, click-beetle monitoring was also performed in the Hallertau in 2010 for the first time.

Methods

Two locations were selected whose altitudes were as close as possible to the two ends of the range in the Hallertau to enable even microclimatic effects at as widely differing locations as possible to be gathered right from the start. One location, on the lower terrace of the Donau Valley (Oberulrain, Kelheim District, soil type: sand) is at 370 m a.s.l., the other (Rudertshausen, Freising District, soil: sandy, silty loam) lies in the tertiary hill country at 510-520 m a.s.l.. At each location, five pheromone traps (Fig. 6.2) were installed at the edge of the hop yard and approx. 50 m apart; the lures used in the traps varied in their degree of species specificity in each case. The traps were first installed on 16th April 2010 and were emptied every Friday from then on up to 30th July, i.e. for 16 weeks. The pheromone dispensers in the traps were renewed every five to six weeks (21st May, 25th June). Identification of the trapped beetles with the help of the standard literature (Freude, Harde & Lohse Vol. 6, 1979, Vol. 13, 1992) generally took place immediately after the traps were emptied.

Fig. 6.8: Pheromone trap for catching click beetles. Rudertshausen, Freising District, 23.04.2010

Results and discussion

Within the 16-week period, a total of 565 adult click beetles were caught in the ten traps and identified (Oberulrain: 347 beetles, Rudertshausen: 218 beetles). The total catch was distributed over 13 species, of which the six *Agriotes* species are classed as agricultural pests causing varying degrees of damage (Tab. 6.3). The striped click beetle, *A. lineatus*, dusky click beetle, *A. obscurus,* and common click beetle, *A. sputator,* were the main species found at both locations, with *A. lineatus* predominating in Oberulrain and *A. obscurus* predominating in Rudertshausen (60 %) (Tab. 6.3). These three species were found regularly in the traps from April to mid-July. A mere 12 specimens of the *A. ustulatus* species, which also causes considerable damage, were trapped at the two locations, on 9th and 16th July only.

Overall, a wider diversity of species than expected was trapped, with *A. lineatus* and *A. obscurus,* the most common click-beetle species, also predominating. One pleasing aspect is the fact that the thermophilic *A. sordidus*, a dangerous pest currently spreading in central Europe from the south along the large rivers (e.g. Rhine Graben), does not appear to have reached the Hallertau region yet. The fact that the incidence of *A. ustulatus* was low and of very limited duration is a further positive aspect. It should, however, be kept in mind that the catches of adult beetles in the pheromone traps merely provide a rough indication of the noxious click-beetle species actually occurring as wireworms in hops, as the adult beetles may equally well come from areas adjacent to the hop yards such as grassland or other crops.

Tab. 6.3 : Relative occurrence of click-beetle species (Elateridae) in pheromone traps in two hop yards in the Hallertau region in 2010

		Oberulrain (n=347)	Rudertshausen (n=218)	Schad-potential
Adrastus pallens	Zwergschnellkäfer	0,6 %		
Agriotes acuminatus			6,9 %	!
Agriotes gallicus		1,2 %	3,7 %	!
Agriotes lineatus	Saatschnellkäfer	55,0 %	12,4 %	!!!
Agriotes obscurus	Düsterer Humusschnellkäfer	21,9 %	60,1 %	!!!
Agriotes sputator	Garten-Humusschnellkäfer	18,4 %	11,5 %	!!
Agriotes ustulatus	Rauchiger Schnellkäfer	0,6 %	4,6 %	!!!
Agrypnus murina		0,6 %		
Athous subfuscus	Bräunlicher Schnellkäfer		0,5 %	
Cidnopus aeruginosus		0,6 %		
Dalopius marginatus	Gestreifter Forstschnellkäfer	0,8 %		
Ectinus aterrimus	Wald-Humusschnellkäfer	0,2 %		
Limonius aeneoniger			0,5 %	

6.3 Research project "Sustainable optimisation of aphid control (*Phorodon humuli*) in hops (*Humulus lupulus*) through control thresholds and breeding of aphid-tolerant hop varieties"

Objective

The hop aphid, *Phorodon humuli*, is the most serious pest with which hop farmers have to contend. In the absence of well-substantiated experimental findings, a preventive requirement stipulating that plants must be free of aphids at cone formation in order to avoid yield and quality impairment has been in force for decades. As isolated aphids can normally still be found at this stage, insecticides are usually applied, although this is probably unnecessary in some cases. Until now, no multi-year test results or publications on this topic have been available.

The first, more extensive part of the project will involve investigating whether and, if yes, under what conditions (e.g. variety, growth stage, time until harvest) a certain number of aphids per leaf/cone can be tolerated without their being qualitatively and quantitatively detrimental to the harvested cones.

Methods

Test setup: All tests were field tests performed on 27 conventionally managed hop farms. The individual hop yards were selected according to four varieties: the aroma varieties Hallertauer Tradition (HT) and Spalter Select (SE) and the high-alpha varieties Hallertauer Magnum (HM) and Herkules (HS).

A total of 15 yards per year and variety were set aside for use as trial areas. In each of the 60 original trial yards, three plots of approx. 400 m² (6 rows wide, approx. 20 plants long) were marked out one behind the other, starting at the edge of the yard. No insecticides were scheduled for use in the first plot (P0) and in the second plot (P1) only one insecticide, to be applied prior to cone formation; the third plot was to be managed conventionally, i.e. in the same way as the rest of the yard (P2).

Assessments: After commencement of aphid migration, each trial yard was inspected every two weeks and aphid infestation measured in all three plots. All the trial yards had been assessed seven times by commencement of the harvest period. As of the start of cone formation in late July, a pooled sample of 100 hop cones was hand picked at every trial plot during the final assessment visit. At the Institute, each cone sample was immediately emptied into a modified Berlese funnel, via which all the arthropods in the cones were expelled into a bottle containing alcohol. The labelled bottle was then removed from the funnel and the dead athropods contained in it subsequently identified and counted.

Trial harvests: Large-scale trial harvests were conducted from 2008-2010 at 12 trial yards, three for each variety, and the yields of the individual plots compared; statistical significance was achieved through fourfold replication. Alpha-acid content was likewise measured in the laboratory for all plots (NIR or conductometer method). In addition, the total-oil content of pooled samples from each harvested plot was determined via gas chromatography in 2008, and the most important bitter substances (incl. xanthohumol) were measured annually (i.a. via UHPLC).

	2008		2009		2010	
	Ertrag	Alpha	Ertrag	Alpha	Ertrag	Alpha
HT	=	=	-	=	=	=
	=	=	-	-	=	=
	=	=	=	=	=	+
SE	=	=	=	=	=	=
	=	=	=	=	=	=
	+	=	=	=	=	=
HM	=	=	-	=	=	=
	=	=	-	=	=	=
	=	=	-	-	=	=
HS	=	=	-	-	=	=
	=	=	-	-	=	=
	+	=	-	=	=	=

- : signifikantes Minus in der unbehandelten Kontrolle

= : kein signifikanter Unterschied

+ : signifikantes Minus in der Praxis-Parzelle

Fig. 6.9 : Yield and alpha-acid content of 36 trial harvests from 2008-2010 involving four hop varieties (HT: Hallertauer Tradition, SE: Spalter Select, HM: Hallertauer Magnum, HS: Herkules): comparison between an untreated control plot and conventional yard management to ascertain the effect of aphid incidence and insecticide application (ANOVA, p≤0.05)

2008				2009				2010			
HM	HS	HT	SE	HM	HS	HT	SE	HM	HS	HT	SE
je 14/15 Gärten				je 15 Gärten				je 14/15 Gärten			
20 / 0	50 / 0			75 / 10	100 / 0	60 / 0		20 / 0	20 / 0	20 / 0	
20 / 0	20 / 0			60 / 0	75 / 10	50 / 0					
20 / 0				50 / 0	75 / 0	50 / 0					
				40 / 10	75 / 0	40 / 0					
				40 / 0	25 / 0						
				40 / 0	25 / 0						
				40 / 0							
				25 / 0							
				25 / 0							
3 / 0	2 / 0	0 / 0	0 / 0	9 / 2	6 / 1	4 / 0	0 / 0	1 / 0	1 / 0	1/ 0	0 / 0

75 / 10	Entschädigungszahlung [% eines Totalschadens] in der Kontrollparzelle (P0) / der einmal behandelten Parzelle (P1)
	Keine Entschäfigungszahlung im gesamten Garten

Fig. 6.10 : Compensation payments from 2008-2010 for 28/30 trial yards with four hop varieties (HT: Hallertauer Tradition, SE: Spalter Select, HM: Hallertauer Magnum, HS: Herkules). First value: control plot with no insecticide application, 2nd value: test plot with only one insecticide application

Results

In general, the entire project suffered from the fact that 2009 was the only one of the three test years for which evaluable results could be obtained, as the initially high aphid levels observed in the test plots in 2008 vanished completely within no time and in 2010 aphid levels were practically zero. This is also reflected in the trial-harvest yields in these three years (Fig. 6.9) and the compensation payments to farmers for losses in the test plots (Fig. 6.10). The data is therefore insufficient to allow well-founded conclusions to be drawn on a new control threshold and will be supplemented by further trial harvests in 2011, with greatly reduced assessment work. The data obtained so far nevertheless allow the following conclusions in brief:

- Routine annual insecticide application to control aphids in all hop yards is unnecessary and questionable from a scientific and economic perspective. The question of whether to use an insecticide or not should be decided from year to year, with differences in varieties being taken into account.
- Even high aphid levels early in the season (June) after massive aphid migration do not necessarily lead to yield or quality losses at harvest time, as such early levels, in particular, are generally regulated very quickly and naturally by beneficial organisms and entomopathogenic fungi. Immediate chemical control measures should, however, be taken if young leaves begin to curl up as the result of infestation and if there is a risk of growth arrest, above all in the 'Perle' cultivar.
- Aphid years characterised by low levels of migration taking place over a number of weeks (approx. 6-10) tend, on the other hand, to pose a risk. Continuous low aphid counts are unattractive for predators and the frequently premature use of an insecticide prior to the end of aphid migration in such years is almost pointless. In addition, the few aphids that are present migrate into the cones at an early stage and are hardly noticed

during foliage controls, resulting in a tendency towards retarded cone infestation in such years; this then involves a hygiene problem and also leads to significant yield and alpha-acid losses.

- Aphid treatment that is not effective enough (possible reasons: choice of insecticide, timing of treatment, weather conditions during treatment) should be followed by a further application as soon as possible, as the effect of inadequate treatment on yield is zero (Fig. 6.10).
- The prophylactic, unnecessary use of an insecticide or acaricide as a component of a tank mix with four or five mix partners (so-called 'July spraying') may lead to significant yield and alpha-acid losses of over 10 % (Fig. 6.10).
- In general, correlation between aphid infestation of foliage and that of cones is low. Bad-weather phases with low temperatures during cone formation lead to very rapid cone colonization.
- Aroma varieties are generally much less susceptible to aphids than high-alpha varieties. In the case of the aphid-tolerant variety Spalter Select, insecticide treatment for aphid control is completely unnecessary (Fig. 6.10).

Tab. 6.4 : Two examples of complete evaluation of a test yard in a project year with all assessments and trial harvest. Eschenhart 2008 (left) was a case in which unnecessary insecticide treatment led to significant yield losses of 13 %. Engelbrechtsmünster 2008 (right) is an example of two meaningful insecticide applications after an inital application that was inadequate.
Insecticide applications: i = imidacloprid, f = flonicamid.

Eschenhart 2008, Sorte: SE			
Blattbefall	**P0**	**P1**	**P2**
30.05.	24,3	23,3	23,8
		i	i
13.06.	56,0	0,3	0,5
27.06.	20,3	0,3	0,5
			f
09.07.	2,8	0,0	0,0
24.07.	1,5	0,0	0,0
04.08.	0,9	0,1	0,0
21.08.	0,2	0,0	0,0
12.09.	0,0	0,0	0,0
Doldenbefall grün [Blattläuse/100 Dolden]			
04.08.	0	1	0
21.08.	0	2	1
12.09. (Ernte)	7	14	7
Doldenbefall [%]	0,0	0,0	0,0
Gewogenes Mittel	1,000	1,000	1,000
Ertrag [dt/ha]	24,21	23,69	20,97
Alpha [%] (NIR)	5,81	6,28	5,73
Alpha/ha [kg]	140,7	148,7	120,1
Alpha [%] (UHPLC)	3,83	4,99	4,77
Beta [%]	4,04	5,08	5,60
Beta/Alpha	1,05	1,02	1,17
Cohumulon [%]	21,86	21,12	21,50
Xanthohumol [%]	0,35	0,41	0,41
Linalool	91	110	100
Humulen	172	185	185
Myrcen	9236	10368	6261
Farnesen	87	102	65

Engelbrechtsmünster 2008, Sorte: HM			
Blattbefall	**P0**	**P1**	**P2**
02.06.	49,2	52,8	51,0
11.06.	46,6	27,8	37,2
		i	i
24.06.	173,0	5,5	5,5
08.07.	113,3	7,0	7,0
			f
21.07.	2,3	1,5	0,0
05.08.	3,9	2,2	0,0
19.08.	4,6	4,1	0,0
09.09.	30,5	25,4	0,2
Doldenbefall grün [Blattläuse/100 Dolden]			
05.08.	102	82	0
19.08.	203	37	1
09.09. (Ernte)	952	1402	12
Doldenbefall [%]	81,7	85,0	7,0
Gewogenes Mittel	2,352	2,392	1,081
Ertrag [dt/ha]	22,95	21,63	24,69
Alpha [%] (KW)	15,30	14,64	15,52
Alpha/ha [kg]	351,0	316,4	383,2
Alpha [%] (UHPLC)	13,68	13,24	14,37
Beta [%]	6,05	6,25	6,94
Beta/Alpha	0,44	0,47	0,48
Cohumulon [%]	25,24	25,45	25,43
Xanthohumol [%]	0,40	0,42	0,43
Linalool	10	9	8
Humulen	280	283	282
Myrcen	8660	8002	7582

7 Hop quality and analytics

ORR Dr. Klaus Kammhuber, Dipl. Chemiker

7.1 General

Within the Hops Dept. (IPZ 5) of the Institute for Crop Science and Plant Breeding, the IPZ 5d team (WG Hop Quality/Hop Analytics) performs all analytical studies required to support the experimental work of the other work groups.

The hop plant has three groups of value-determining components: the bitter compounds, essential oils and polyphenols, ranked in order of importance. The bitter compounds consist of the alpha and beta acids. Alpha-acid content, as a measure of hop bittering potential, is by far the most economically important quality characteristic of hops. The alpha acids give beer its typical hop bitter taste and ensure both biological stability and good foaming stability. The antimicrobial characteristics of beta acids make them interesting for alternative fields of use, including use as preservatives in the food industry or for sugar and ethanol production. The essential oils are responsible for hop scent and aroma and their sedative properties can be exploited medicinally. Numerous publications attest to the positive health-giving properties of the polyphenols, which act as anti-oxidants and can scavenge free radicals. The hop plant is very rich in polyphenols. Xanthohumol, in particular, has attracted a lot of publicity in recent years because of its significant anti-carcinogenic potential, although the latest studies have shown that its bioavailability in the human organism is not especially high. 8-prenylnaringenin, trace amounts of which are found in hops, is regarded as one of the most potent phyto-oestrogens and is responsible for the slightly oestrogenic effect of hops. Currently the breweries face a huge glut of hops, making it very important to tap alternative uses; they can be found primarily in the food industry, as well as in the fields of medicine and wellness.

7.2 Component optimisation as a breeding goal

7.2.1 Requirements of the brewing industry

95 % of hop output is used in the brewing industry, which will remain by far the largest purchaser of hops in the future, too. As far as hopping is concerned, breweries follow two extremely different philosophies. The aim of the first approach is to obtain alpha-acids as cheaply as possible, with variety and growing region being irrelevant. The aim of the second approach is to cultivate beer diversity through a variety of hopping methods and products, with importance still being attached to varieties and regions and costs playing no role. Of course, a wide variety of approaches can be found between these two extremes.

The requirements of the brewing and hop industries regarding the composition of the hop components are of necessity also subject to changes based on recent scientific findings. All parties agree, however, that hop varieties with a maximum α-acid content that remains as constant as possible from year to year should be bred. A low cohumolone content has now become less important as a quality parameter. High-alpha varieties with a high cohumolone content are even in demand for downstream and beyond-brewing products.

The role of the essential oils in beer brewing is a never-ending story. The essential oils in hops consist of more than 300 different substances. The olfactory and aroma impression - and this applies not only to hops - must be seen as an integral, synergistic quality. Some substances are perceived more strongly, others blot each other out. The correct ratio of the substances to one another is crucial. Key substances must be defined, however, so that aroma quality can also be characterised analytically. Myrcene tends to be regarded as indicative of an unpleasant, resinous aroma and linalool of a pleasant, flowery aroma. The goal is to breed aroma cultivars with various combinations of hop oils in order to guarantee product diversity. Key substances for hop aroma include linalool, humulene, caryophyllene and myrcene. Craft brewers, in particular, are interested in hop cultivars with their own very distinct aroma. Exotic aromas such as tangerine, melon, mango and currant are also in demand.

Polyphenols contribute towards the bitter taste imparted by hops (harmony and quality of the bitterness) and also possess some functional health benefits. One of the goals of hop breeding will be to achieve higher levels of low-molecular polyphenols like xanthohumol, the prenylflavonoids and phenolic carboxylic acids.

7.2.2 Alternative uses

A mere 5 % of hops output is used for other purposes (Fig.7.1).

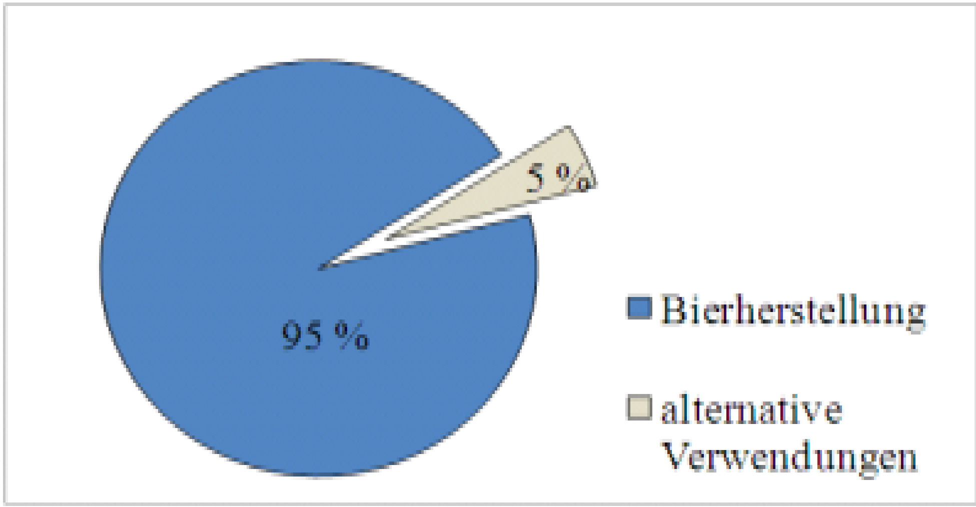


Fig.7.1 : Uses of hops

In theory, both the cones and the remainder of the plant can be used. The shives (woody core of the stem) are mechanically stable and have good insulating properties. Shive fibres can be used to make moulded parts such as automobile door panels or as filler material for composite thermal-insulation panels. As yet, no large-scale industrial applications exist, however.

As far as the cones are concerned, the antimicrobial properties of the bitter substances are especially suited to alternative uses. Even in catalytic amounts (0.001-0.1 wt. %), the bitter substances have antimicrobial and preservative properties in the following order of importance: iso-α-acids, α-acids and β-acids. They destroy the pH gradient at the cell membranes of bacteria, which can no longer absorb any nutrients and die. Iso-α-acids in beer even provide protection against *heliobacter pylori*, a bacterium that triggers stomach cancer. This property can be exploited by utilizing the bitter substances in hops as natural biocides wherever bacteria need to be kept under control. The sugar and ethanol industries, for example, have already begun replacing formalin with β-acids in some cases. Other potential applications exploiting the antimicrobial activity of hop β-acids include their use as preservatives in the food industry (fish, meat, milk products), the sanitation of biogenic waste (sewage sludge, compost), removal of mould, improvement of the smell and hygiene of pet litter, control of allergens, and use as an antibiotic in animal food. In future, a considerable demand for hops can be expected for use in such areas. Increased β-acid content is therefore one of the breeding goals in Hüll. Currently, the record is about 20 %, and there is even a breeding line that produces β-acids alone and no α-acids.

The hop plant boasts a wide variety of polyphenolic substances and is thus of great interest for the areas of health, wellness, dietary supplements and functional food. With an overall polyphenol content of up to 8 %, hops is very rich in these substances. Work is being done on increasing the xanthohumol content. A breeding line containing 1.7 % xanthohumol is already available. Other prenylated flavonoids, such as 8-prenylnaringenin, occur only in trace amounts in hops, but nevertheless produce strong physiological effects. The flavonoid quercetin, contained in hops in concentrations of up to 0.2 %, has very strong anti-oxidant potential. This substance is also deemed extremely beneficial to health. Aroma hops generally have a higher polyphenol content than bitter hops. If specific components are desired, Hüll can react at any time by selectively breeding for the required substances.

7.3 Development of analytical methods for hop polyphenols

About 80 % of the hop polyphenols are made up of higher molecular compounds such as the catechin tanning agents and the tannins (tannic acids). Approx. 20 % of hop polyphenols consist of monomeric substances such as the phenolic carboxylic acids and the flavonoids and their glycosides (Tab.7.1).

Tab.7.1 : 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 – 0.30 %
6) Proanthocyanidins	0.20 – 1.30 %
7) Xanthohumol	0.20 – 1.20 %
Higher molecular substances	
8) Catechin tanning agents and tannins	2.00 – 7.00 %

The polyphenols are becoming more and more important for both the brewing industry and areas of alternative use. There are, however, no official analytical methods for this substance group and the Working Group of Hops Analytics (AHA) has therefore set itself the task of designing reliable and standardized analytical methods.

7.3.1 Total polyphenols and total flavonoids

EBC analysis methods 9.11 and 9.12 can be used to determine total polyphenol and flavonoid concentrations in beer. In the case of hops, a hot-water extract is first prepared and methods 9.11 and 9.12 are then applied by analogy. Tab. 7.2 shows the statistical data of the most recent international ring test, in which a total of 16 laboratories participated.

Tab.7.2 : Statistical data from the ring test to determine total polyphenols and flavonoids

Sample	Mean	cvr	cvR	No. of laboratories
Pellet 1/Total polyphenols	2.64	2.46	15.61	16
Pellet 2/Total polyphenols	5.31	2.60	10.91	16
Pellet 3/Total polyphenols	5.71	3.17	15.16	16
Pellet 4/Total polyphenols	3.45	3.18	20.85	16
Pellet 1/Flavonoids	0.34	2.78	10.22	16
Pellet 2/Flavonoids	0.88	2.42	8.87	16
Pellet 3/Flavonoids	1.03	2.32	9.12	16
Pellet 4/Flavonoids	0.53	4.18	11.37	16

The inter-laboratory variation coefficients (cvr) are by no means poor, but the total variation coefficients (cvR) are very high, above all with respect to the total polyphenols, where they reach a figure of 20.85 %. The cvR for total flavonoids are only just acceptable. For a good analysis method, the cvR should not exceed 5 %. These methods require further improvement in order to be accepted as official methods.

7.3.2 Differentiating the world hop range with the help of low-molecular polyphenols

This project is being funded by the Bavarian State Ministry for Food, Agriculture and Forestry in the amount of € 20,000.

I. McMurrough and C. F. Sumere (Lit. 1,2) were the first scientists to analyse the low-molecular polyphenols in hops via HPLC and perform basic research on these substances.

Since mid-2008, a new UHPLC system has been available in Hüll. Both improved differentiation and shorter analysis times are possible with this system. Work first focussed on devising suitable methods of sample preparation and optimum HPLC differentiation. For sample preparation purposes, the hops are extracted using an acetone:water mixture (3:1) and the polar substances then shaken with hexane to remove them. The EC 125/2 NUCLEODURSphinx RP, 3 µm from Macherey and Nagel proved very suitable as a separation column. The following gradient system is used for UHPLC analysis:

Eluent A: add water to 100 ml methanol and 3 ml H_3PO_4 to make up 1 l solution

Eluent B: add water to 700 ml methanol and 3 ml H3PO_4 to make up 1 l solution

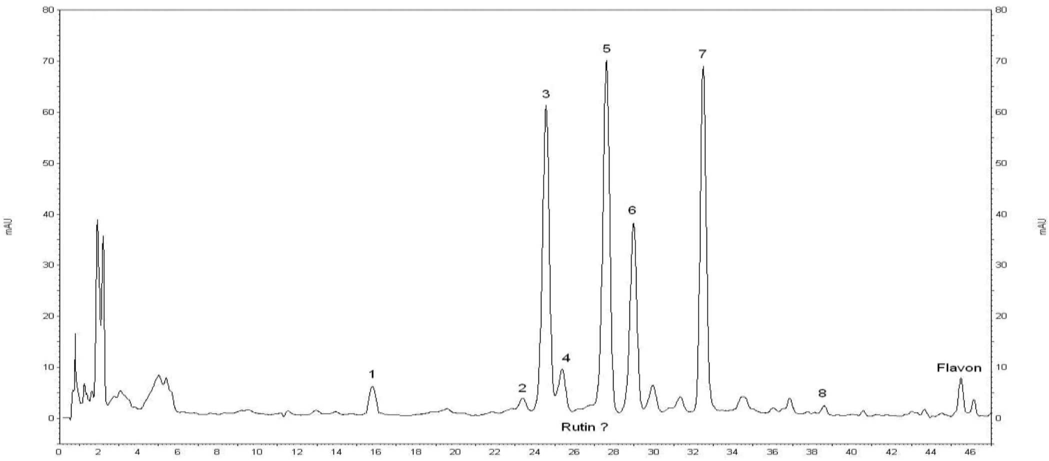
Eluent C: methanol

Gradient:	Detection wavelength:
0 min.: 100 % A	Benzoic acid derivatives: 250 nm
5 min.: 100 % A	Cinnamic acid derivatives: 280 nm
30 min.: 70 % A, 30 % B	Catechins: 280 nm
55 min.: 10 % A, 90 % B	Quercetin,
56 min.: 100 % C	Kaempferol glycosides: 350 nm
60 min.: 100 % C	Multifidol glucoside: 280 nm
61 min.: 100 % A	

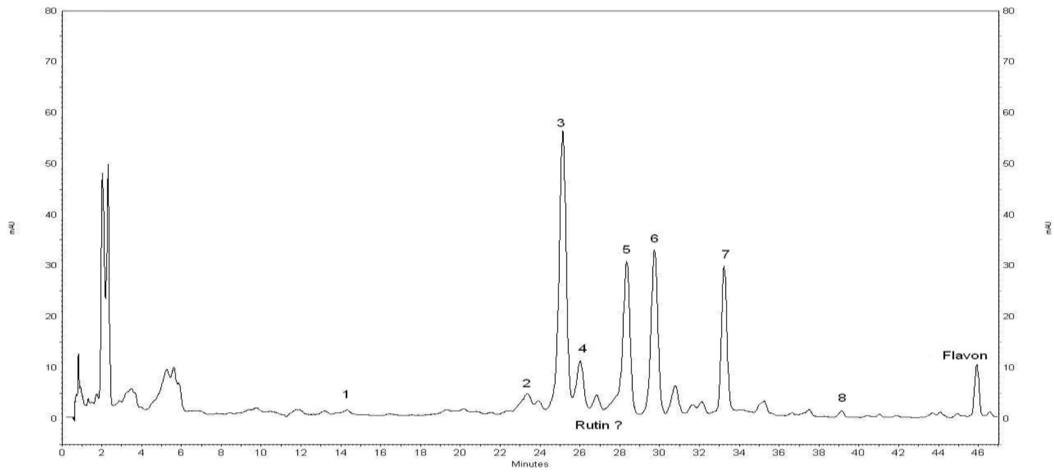
The most suitable polyphenols for cultivar differentiation are the quercetin and kaempferol glycosides; the other phenolic components are less cultivar specific. Figure 7.2 shows characteristic HPLC chromatograms obtained for three different cultivars.

Lit.: 1) McMurrough I., Hennigan, G., P., Loughrey, J.: "Quantitative Analysis of Hop Flavonols Using High Performance Liquid Chromatography", J. Agric. Food Chem. 1982, 10, 1102-1106

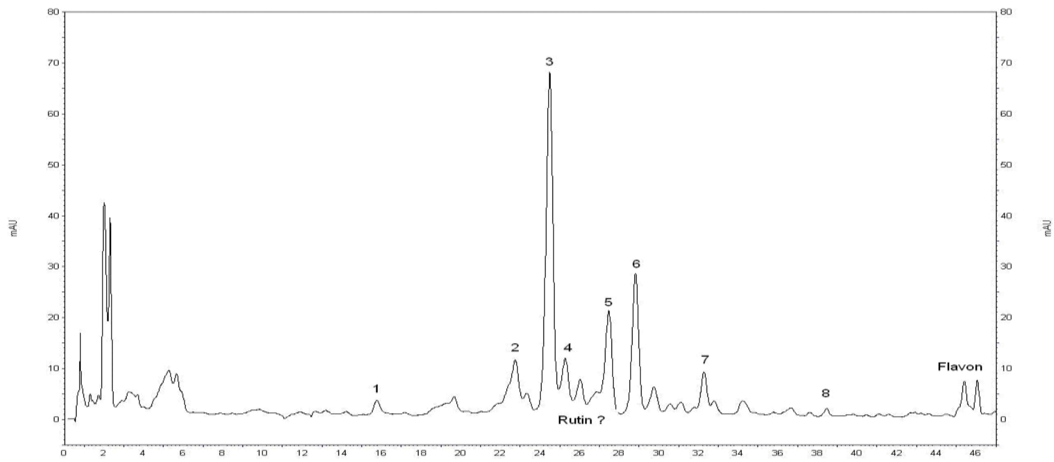
2) Van Sumere, C., F., Vande Casteele, K., Hutsebaut, M., Everaert, E., De Cooman, L., Meulemans, W.: "RP-HPLC Analysis of Flavonoids and the Biochemical Identification of Hop Cultivars", EBC-Monograph XIII, 146-175, 1987



Opal



Hersbrucker



Herkules

Fig. 7.2 : HPLC chromatograms of the flavonoid glycosides of Opal, Hersbrucker Spät and Herkules

The substance flavone (Fig. 7.3) is used as a reference, as flavone does not occur in hops and differentiates the polar from the non-polar substances. The non-polar bitter substances, xanthohumol and the prenylated naringenins are eluted only after flavone. The most interesting substances in this research work were those that exceeded flavone in polarity.

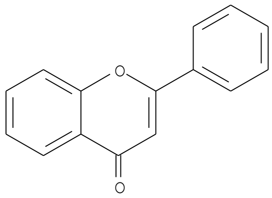


Fig. 7.3 : Chemical structure of flavone

Four substances can be clearly identified with the help of reference substances (see Fig. 7.2). 1= multifidol glucoside, 2 = quercetin-3-galactoside (hyperoside), 3 = quercetin-3-glucoside (isoquercit(r)in), 6 = kaempferol-3-glucoside (astragalin). The other substances will be identified at the Technical University of Munich in Weihenstephan with the help of a mass spectrometer. Multifidol glucoside takes its name from the tropical plant *Jatropha multifida*, of which it is the main component. Multifidol glucoside boasts anti-inflammatory properties and is therefore interesting from a pharmacological perspective. Multifidol glucoside was first described as a component of hops (up to 0.5 %) in a publication by G. Bohr (Lit. 3) (Fig. 7.4).

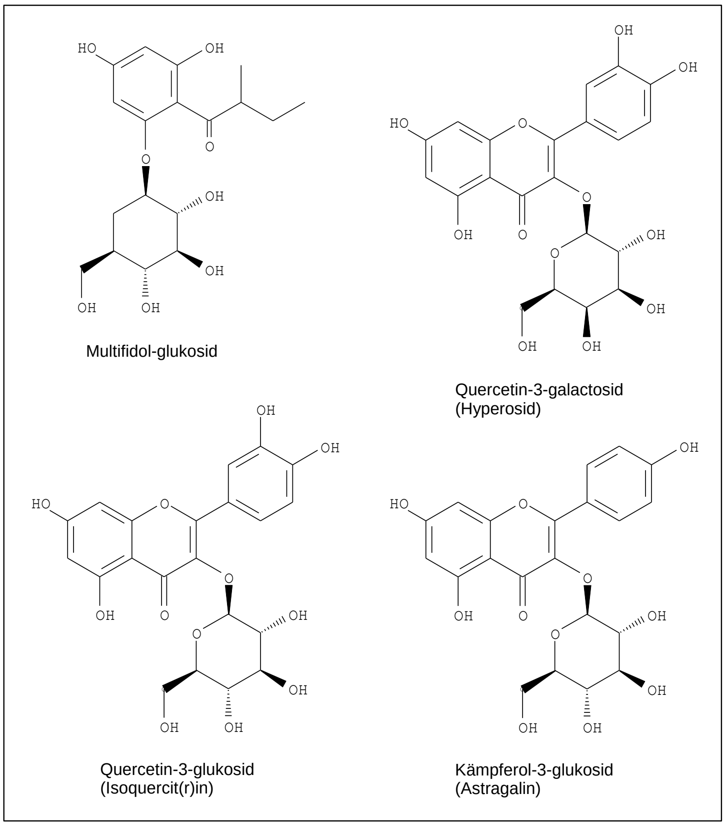
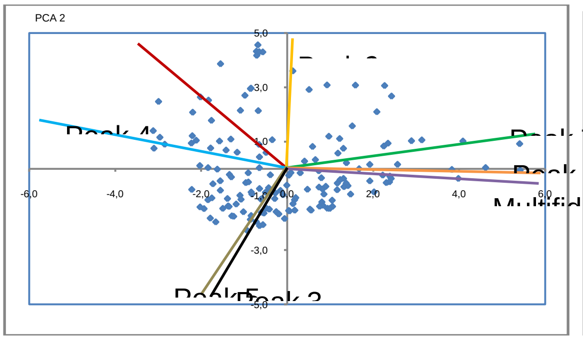


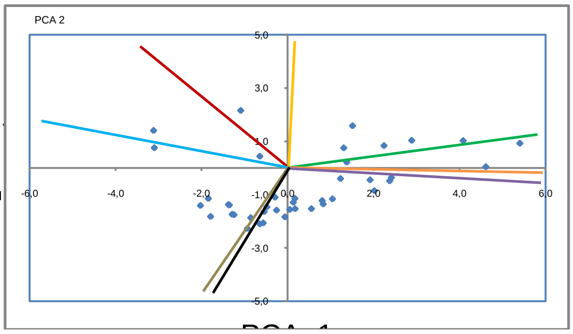
Fig. 7.4 : Chemical structures of multifidol glucoside and other flavonoid glycosides in hops

Lit.: 3) Bohr, G., Gerhäuser, Cl., Knauft, J., Zapp, J., Becker, H.: "Anti-inflammatory Acylphoroglucinol Derivatives from Hops (Humulus lupulus)", J. Nat. Prod. 2005, 68, 1545-1548

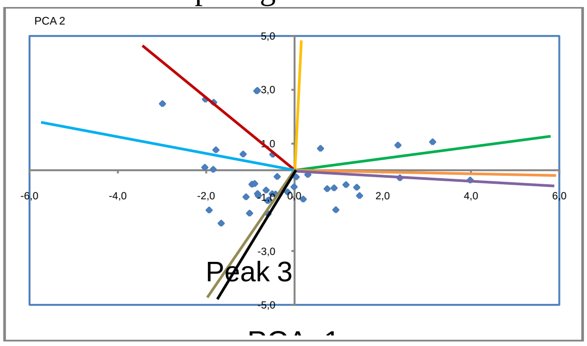
This method was used to analyse the total world hop range grown in Hüll (harvest year 2009, see 7.4). Many cultivars, above all the landrace cultivars, differ only very slightly, whereas other cultivars differ greatly in their flavonoid composition. On the basis of the eight substances identified (= peaks), a principal-component analysis of the total world hop range was performed (Fig.7.5 The plotted lines show the contribution of the individual characteristics to the principal-component analysis.



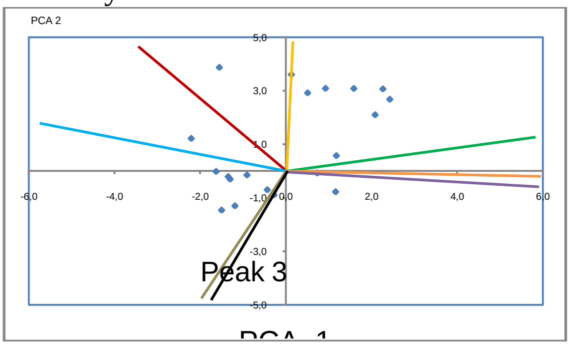
Total world hop range



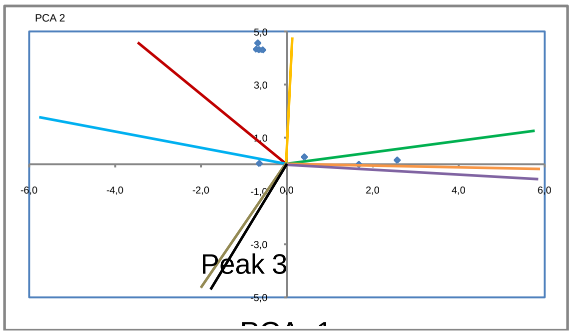
Germany



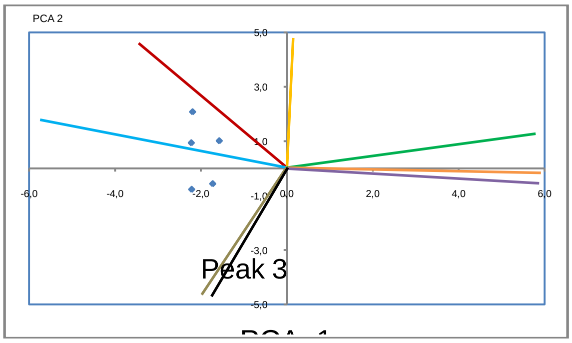
England



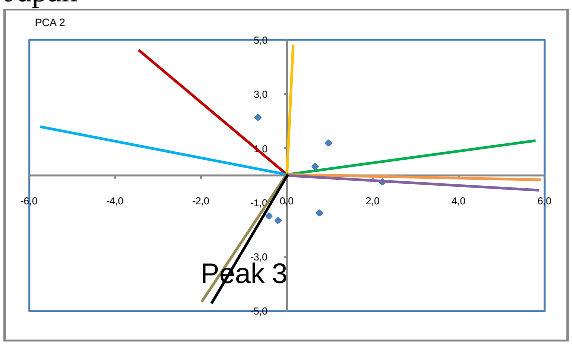
USA



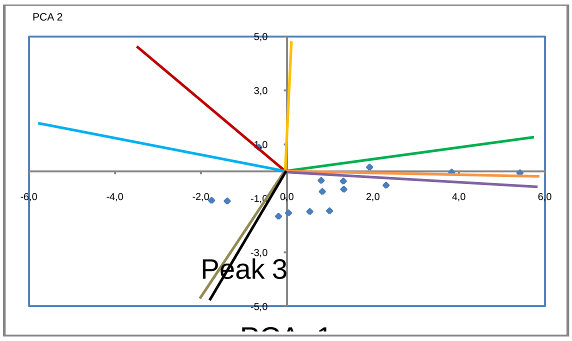
Japan



New Zealand



Slovenia



Czech Republic

Fig.7.5 : Principal-component analysis of the world range of hop varieties (sub-divided into countries) on the basis of the flavonoid glycosides.

Similarities and differences are clearly visible in the figure. Clusters cannot be observed, not even according to country. Crop years 2010 and 2011 will also be included in the analysis program.

7.4 World hop range (2009 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 they are grown under the conditions prevailing at Hüll. Tab. 7.3 shows the results for the 2009 harvest. It may be helpful in classifying unknown hop varieties. The oil analyses were performed via headspace gas chromatography. The individual oil components are quoted in relation to beta-caryophyllene.

Tab. 7.3 : World hop range, 2009

Variety	Myr-cene	2-M.-iso-butyrate	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendrene	Unde-canone	Humu-lene	Farne-sene	γ-Muu-rolene	ß-Seli-nene	α-Seli-nene	Cadi-nene	Seli-nadiene	Gera-niol	α-acids	ß-acids	ß/α	Cohu-mulone	Colu-pulone
Agnus	4607	62	1	6	8	1	3	123	0	3	5	5	12	0	0	11.2	6.2	0.55	36.2	59.7
Ahil	6188	345	20	5	16	4	7	170	84	6	9	8	13	0	1	9.8	4.1	0.42	29.0	57.4
Alliance	1007	52	1	2	15	0	5	274	7	3	4	3	17	0	1	6.1	3.3	0.54	29.0	54.0
Alpharoma	2503	232	25	12	14	0	8	277	17	9	4	2	17	0	2	9.1	2.8	0.31	26.5	59.7
Apolon	4112	36	21	8	23	0	4	192	52	5	6	4	14	0	2	7.1	4.6	0.65	29.2	50.3
Aquila	3882	65	3	105	25	18	11	18	0	7	63	73	11	78	2	5.4	4.0	0.74	49.4	71.8
Aromat	1724	15	1	4	25	0	11	301	19	8	9	5	21	3	2	5.2	4.7	0.90	27.2	48.2
Atlas	4011	372	15	6	17	2	3	158	58	5	7	5	12	0	2	8.0	4.2	0.53	33.5	58.3
Aurora	5987	89	3	43	36	0	15	254	38	6	3	2	14	0	1	10.2	4.6	0.45	21.3	48.3
Backa	1965	245	3	9	19	0	5	252	18	4	4	3	19	0	2	9.0	4.9	0.54	40.3	63.3
Belgisch Spalter	1832	72	1	7	15	3	4	160	0	4	26	28	15	44	1	6.0	4.2	0.70	26.3	48.2
Blisk	4873	216	21	7	25	0	3	197	86	7	7	6	15	0	1	8.8	4.4	0.50	31.9	54.4
Bobek	11821	169	11	118	54	0	13	236	52	5	5	3	14	0	2	7.6	6.3	0.83	24.7	46.7
Bor	3516	71	2	48	9	0	5	291	0	3	4	3	16	0	1	12.0	5.5	0.46	24.4	49.4
Bramling Cross	1418	109	9	5	34	0	9	273	0	8	8	4	22	4	3	5.0	4.3	0.86	33.8	50.6
Braustern	2572	78	2	36	7	0	4	241	0	3	3	2	15	0	1	10.2	5.8	0.57	26.0	47.8
Brewers Gold	1973	185	11	11	12	0	2	151	0	4	8	8	13	0	1	7.9	5.1	0.65	35.4	54.0
Brewers Stand	14654	496	34	38	48	17	16	57	0	28	74	75	94	99	3	8.6	4.5	0.52	25.4	49.4
Buket	4199	189	3	77	28	0	11	231	23	4	4	2	17	0	1	10.3	6.2	0.60	25.1	46.6
Bullion	2263	127	11	19	11	0	2	131	0	3	8	8	13	0	1	8.4	5.5	0.65	37.9	54.8
Cascade	4312	243	32	9	31	0	8	229	13	9	18	17	27	0	3	6.7	6.6	0.99	27.9	42.6
Chang bei 1	1532	6	3	3	36	0	13	226	11	9	21	21	19	25	2	4.9	4.3	0.88	22.5	43.5
Chang bei 2	1616	29	2	3	33	0	14	235	11	13	22	22	18	24	2	4.7	4.9	1.04	23.1	41.5
College Cluster	697	132	14	9	7	0	4	144	0	4	7	7	11	0	1	7.1	2.8	0.39	26.8	51.1

Table 7.3 (cont.)

Variety	Myr-cene	2-M.-iso-butyrate	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendrene	Unde-canone	Humu-lene	Farne-sene	γ-Muu-rolene	ß-Seli-nene	α-Seli-nene	Cadi-nene	Seli-nadiene	Gera-niol	α-acids	ß-acidsn	ß/α	Cohu-mulone	Colu-pulone
Columbus	4659	111	10	13	9	0	2	134	0	9	10	9	32	9	0	15.2	5.0	0.33	34.8	57.5
Comet	2250	61	5	35	11	0	3	7	0	2	36	44	4	10	0	8.8	4.4	0.50	31.3	52.8
Crystal	982	30	2	7	27	15	9	194	0	8	38	38	20	51	2	2.7	6.2	2.30	22.4	39.5
Density	1212	100	8	5	34	0	11	286	0	7	6	2	18	0	4	5.4	3.9	0.72	34.0	52.3
Early Choice	1283	66	2	13	5	0	4	250	0	4	54	63	17	0	1	3.9	2.2	0.56	26.5	50.2
Eastwell Golding	1371	33	1	6	12	0	5	289	0	4	5	4	16	0	1	7.0	4.7	0.67	25.9	48.7
Emerald	1570	43	4	14	7	1	4	297	0	3	4	3	16	0	1	6.1	7.2	1.18	26.0	42.7
Eroica	4209	331	21	105	5	3	4	138	0	5	10	11	12	0	1	11.1	9.2	0.83	40.5	63.4
Estera	1939	95	2	5	23	0	6	273	14	4	3	2	18	0	1	5.2	3.9	0.75	28.1	50.7
First Gold	7068	380	3	21	27	3	10	254	13	5	96	121	20	0	1	9.8	4.0	0.41	28.3	56.3
Fuggle	2106	110	1	6	16	0	5	255	17	3	3	2	16	0	1	4.5	3.1	0.69	28.5	49.5
Galena	5584	401	36	134	6	8	7	163	0	4	9	8	12	0	1	14.1	10.2	0.72	40.9	64.5
Ging Dao Do Hua	2164	468	3	4	22	0	10	249	0	13	36	37	32	0	3	6.2	3.9	0.63	36.1	59.6
Glacier	2738	38	2	4	21	0	8	282	0	5	4	2	18	0	0	3.4	5.7	1.68	13.4	38.6
Golden Star	1880	580	4	4	21	0	8	256	0	17	46	45	40	0	4	5.5	3.2	0.58	35.8	61.7
Granit	1674	72	5	8	6	2	10	188	4	3	8	8	13	0	1	8.3	4.9	0.59	28.7	48.7
Green Bullet	6707	173	14	17	30	0	11	375	0	13	7	4	26	0	7	7.4	4.7	0.64	42.3	69.0
Hallertauer Gold	2041	78	22	6	28	0	6	299	0	4	4	2	19	0	1	6.9	6.4	0.93	21.2	41.7
Hallertauer Mag.	5778	89	28	22	8	2	4	282	0	2	2	2	13	0	1	16.5	6.4	0.39	28.0	48.8
Hallertauer Merk.	3727	166	14	7	21	2	4	283	0	3	4	3	15	0	1	16.2	7.4	0.46	20.4	42.0
Hallertauer Mfr.	580	32	2	1	15	0	6	307	0	5	4	4	19	0	1	3.7	4.2	1.14	19.3	39.2
Hallertauer Taurus	12791	85	15	24	44	0	8	245	0	4	58	67	17	0	1	17.0	5.9	0.35	20.2	41.4
Hallertauer Trad.	1926	76	6	4	26	0	5	295	0	6	3	2	16	0	1	5.4	4.5	0.83	24.5	47.2
Harmony	2784	17	2	10	24	0	8	247	0	7	72	80	19	0	1	7.7	6.8	0.88	17.8	38.6
Herald	8456	456	5	134	14	3	13	186	0	3	22	27	14	0	1	12.4	5.4	0.44	38.0	60.8
Herkules	7107	278	48	64	12	0	6	278	0	9	3	2	15	0	2	17,0	5,7	0,34	33,0	54,4

Table 7.3 (cont.)

Variety	Myr-cene	2-M.-iso-butyrate	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendrene	Unde-canone	Humu-lene	Farne-sene	γ-Muu-rolene	ß-Seli-nene	α-Seli-nene	Cadi-nene	Seli-nadiene	Gera-niol	α-acids	ß-acids	ß/α	Cohu-mulone	Colu-pulone
Hersbrucker Pure	2567	48	1	8	32	10	12	195	0	6	29	33	17	48	2	6.0	3.4	0.57	23.5	44.9
Hersbrucker Spät	1436	19	4	13	31	19	10	170	0	6	41	43	17	47	1	2.3	5.8	2.52	16.7	34.2
Horizon	4233	133	4	26	24	0	5	123	9	3	9	10	9	0	1	11.2	6.1	0.54	29.5	50.1
Hüller Anfang	349	47	1	10	16	0	7	332	0	7	4	3	22	0	1	3.1	4.1	1.32	20.9	44.1
Hüller Aroma	877	65	4	2	26	0	7	317	0	5	5	4	21	0	1	4.5	5.2	1.16	22.6	42.9
Hüller Bitter	5041	185	34	7	39	8	6	154	0	21	49	49	67	54	2	6.6	5.3	0.80	27.7	46.7
Hüller Fortschritt	670	18	1	11	23	0	8	325	0	7	4	3	21	0	1	3.9	4.4	1.13	28.0	46.4
Hüller Start	351	14	1	2	7	1	7	337	0	5	5	3	21	0	1	2.9	3.5	1.21	23.3	45.6
Jap. C 730	583	18	9	30	20	0	11	140	12	17	12	11	13	0	3	4.3	2.3	0.53	29.6	58.5
Jap. C 845	1346	8	3	17	4	0	2	266	24	5	3	2	15	0	0	11.7	4.8	0.41	22.1	47.8
Kirin 1	1409	427	3	4	16	0	7	250	0	13	37	37	36	0	3	5.9	3.8	0.64	40.3	62.4
Kirin 2	2117	553	4	4	17	0	8	221	0	15	46	47	38	0	3	6.0	3.4	0.57	37.4	64.3
Kitamidori	1411	8	3	19	4	0	3	278	19	4	3	3	17	0	1	12.8	5.1	0.40	20.6	45.9
Kumir	3463	87	3	22	19	0	7	274	12	3	3	2	15	0	1	12.2	4.9	0.40	25.3	51.1
Late Cluster	21089	480	32	57	47	9	15	44	9	23	73	76	100	88	2	9.7	5.9	0.61	26.3	47.6
Lubelski	1080	2	3	4	17	0	12	317	18	8	4	2	19	0	2	5.0	5.4	1.08	25.0	44.8
Malling	2149	82	2	5	24	0	5	255	15	4	4	2	17	0	1	4.8	3.7	0.77	28.1	48.2
Marynka	4201	199	3	34	9	5	6	146	97	5	7	7	11	0	1	10.7	5.2	0.49	26.4	48.8
Mt. Hood	331	44	13	2	15	0	4	254	0	4	6	5	24	0	1	4.0	5.4	1.35	26.4	41.6
Neoplanta	1752	94	2	21	5	0	3	191	18	3	3	2	16	0	1	9.5	3.9	0.41	32.5	65.7
Neptun	3299	132	28	6	15	0	3	204	0	2	4	3	16	0	0	14.3	4.9	0.34	21.1	40.7
Northern Brewer	3267	85	2	49	7	0	4	244	0	3	3	2	17	0	1	9.6	5.0	0.52	26.1	48.9
Nugget	2925	92	3	21	16	1	3	162	0	3	6	5	10	0	1	12.3	4.6	0.37	26.7	53.3
NZ Hallertauer	2603	132	2	13	26	0	5	154	7	4	18	19	15	25	2	4.9	7.5	1.53	36.6	47.7
Olympic	3627	112	3	25	16	0	4	157	0	3	8	8	9	0	0	15.1	4.6	0.30	26.9	55.1
Opal	4730	30	13	28	29	2	7	213	0	3	3	2	15	16	1	7.9	5.8	0.73	13.4	32.8

Table 7.3(cont.)

Variety	Myr-cene	2-M.-iso-butyrate	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendren	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
Orion	1382	80	4	6	14	0	4	207	0	8	4	2	17	0	1	8.4	6.3	0.75	28.1	45.9
Pacific Gem.	5813	322	4	34	23	0	10	232	0	6	8	8	15	0	3	10.8	6.1	0.56	40.4	66.5
PCU 280	1730	40	1	9	4	0	3	271	0	3	3	2	15	0	1	11.4	4.8	0.42	26.8	53.9
Perle	1670	44	1	22	5	0	3	250	0	3	3	3	15	0	1	7.0	4.9	0.70	29.8	52.4
Phoenix	3310	200	2	10	9	0	5	258	10	3	54	61	19	0	1	15.0	5.4	0.36	25.1	48.5
Pioneer	6531	449	3	233	11	3	16	203	0	3	28	35	16	0	1	10.3	4.1	0.40	34.6	59.7
Premiant	4591	89	3	25	20	2	6	270	12	2	4	3	15	0	1	11.1	4.9	0.44	20.5	43.2
Pride of Kent	1864	25	3	3	26	0	7	297	0	4	4	3	16	0	1	5.7	2.9	0.51	30.3	55.5
Pride of Ringwood	2073	36	1	1	6	0	5	15	0	5	61	68	14	0	1	8.9	5.9	0.66	33.2	54.3
Progress	16302	449	31	45	48	0	15	42	0	25	77	79	98	105	3	10.0	4.8	0.48	24.9	49.5
Rubin	3589	99	26	12	11	0	4	216	13	5	61	66	20	1	1	13.9	4.4	0.32	26.7	57.0
Saazer	1470	1	1	4	18	0	11	296	26	3	4	2	16	0	2	3.4	4.4	1.29	26.0	41.9
Saphir	3855	26	2	22	25	7	17	190	0	4	18	18	13	23	1	3.1	5.5	1.77	13.1	44.9
Serebrianker	471	25	2	3	15	0	6	199	0	4	32	33	20	0	1	2.8	5.4	1.93	21.1	40.6
Sirem	1364	2	5	6	39	0	19	330	21	15	6	2	24	0	3	5.0	4.8	0.96	31.3	49.4
Sladek	2973	59	3	15	18	0	7	276	11	2	3	3	16	0	1	11.8	4.5	0.38	24.5	50.7
Smaragd	2151	21	8	11	29	0	5	272	0	5	7	5	17	22	1	4.9	4.4	0.90	14.4	31.3
Spalter	1198	1	2	5	17	0	10	301	23	7	4	2	17	0	2	3.2	4.8	1.50	26.6	43.5
Spalter Select	6704	36	14	9	78	12	16	177	68	6	29	31	16	40	2	5.2	5.0	0.96	20.9	43.3
Sterling	3268	120	3	33	15	1	4	153	0	3	8	9	11	0	1	13.4	4.7	0.35	26.8	53.9
Sticklebract	12006	310	5	28	27	0	11	212	0	13	52	54	12	0	5	8.6	5.0	0.58	42.2	68.8
Strisselspalter	1921	20	3	16	27	16	8	191	0	5	34	36	16	43	1	3.1	6.6	2.13	17.1	35.3
Super Alpha	5214	287	4	17	39	0	8	283	0	6	3	2	14	0	3	8.7	3.6	0.41	31.2	67.3
Talisman	3240	104	2	36	9	0	4	242	0	3	5	4	16	0	1	10.9	5.7	0.52	26.5	48.8
Tettnanger	1511	6	2	5	20	0	11	300	22	5	4	2	18	0	2	3.9	4.9	1.26	22.3	41.0
Toyomidori	2379	353	12	85	13	0	9	192	0	8	11	9	33	9	2	10.5	5.1	0.49	31.9	57.0

Table 7.3(cont.)

Variety	Myr-cene	2-M.-iso-butyrate	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendrene	Unde-canone	Humu-lene	Farne-sene	γ-Muu-rolene	ß-Seli-nene	α-Seli-nene	Cadi-nene	Seli-nadiene	Gera-niol	α-acids	ß-acids	ß/α	Cohu-mulone	Colu-pulone
Urozani	1400	10	1	2	36	0	9	244	19	7	23	23	19	34	2	5.6	6.3	1.13	25.2	45.4
USDA 21055	4700	352	2	199	7	0	3	112	45	5	16	17	14	0	1	11.8	4.5	0.38	35.6	64.9
Vojvodina	2489	83	2	22	9	0	6	240	6	2	3	1	15	0	1	7.4	4.3	0.58	27.2	50.3
WFG	1041	5	4	5	26	0	14	315	18	8	5	3	21	0	3	4.5	4.6	1.02	26.7	45.7
Willamette	1818	87	1	5	15	0	3	235	16	4	5	4	17	1	1	4.4	3.7	0.84	34.0	55.9
Wye Challenger	5925	349	6	36	33	0	10	252	8	5	50	56	16	0	2	6.4	5.1	0.80	27.1	47.9
Wye Northdown	3089	67	2	10	14	0	3	240	0	4	3	2	14	0	1	8.3	5.7	0.69	26.9	45.4
Wye Target	4638	204	3	28	18	2	6	139	0	5	7	6	26	6	1	11.3	5.4	0.48	36.2	60.3
Wye Viking	2373	86	4	39	9	0	11	214	40	4	41	43	17	0	1	6.7	5.1	0.76	26.0	46.2
Yeoman	4097	180	12	14	9	0	4	227	0	3	37	43	15	0	1	14.7	5.3	0.36	25.7	50.5
Zatecki	1557	87	1	7	20	0	5	267	15	5	3	2	17	0	1	4.4	4.2	0.95	24.6	46.3
Zenith	3912	75	2	21	23	0	6	257	0	4	79	96	18	0	1	8.9	3.9	0.44	24.7	49.0
Zeus	4904	120	9	11	7	0	3	134	0	9	10	9	35	9	1	15.0	5.3	0.35	34.0	56.4
Zitic	2142	3	1	11	10	1	7	284	9	2	5	3	17	0	1	6.4	5.4	0.84	29.4	46.0
Zlatan	1420	20	4	6	40	0	21	341	20	11	7	2	24	0	4	4.3	4.7	1.09	32.0	48.5

7.5 Quality assurance in α-acid determination for hop supply contracts

7.5.1 Ring analyses of the 2010 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, as the case may be. The specification compiled by the Working Group of Hop Analysis (AHA) describes exactly how samples are to be treated (sample division and storage) and lays down which laboratories carry out post-analyses and what tolerance ranges are permissible for the analysis results. In 2010, the IPZ 5d team was once again responsible for organising and evaluating ring tests to guarantee the quality of the α-acid analyses.

The following laboratories took part in the 2010 ring tests:

- Hallertauer Hopfenveredelungsgesellschaft (HHV), Au/Hallertau plant
- $NATECO_2$ GmbH & Co. KG, Wolnzach
- Hopfenveredlung St. Johann GmbH & Co. KG, St. Johann
- Hallertauer Hopfenveredelungsgesellschaft (HHV), Mainburg plant
- HVG Hop Processing Cooperative, Mainburg
- Agrolab GmbH, Oberhummel
- Thuringia State Research Centre for Agriculture (TLL)
- Hops Dept. of the Bavarian State Research Center for Agriculture (LfL), Hüll

On account of the late harvest, ring tests in 2010 commenced a week later than usual. In all, nine ring tests were conducted during the nine weeks from September 14^{th} - November 12^{th}, this being the period during which most of the hop lots were examined in the laboratories. Sample material was kindly provided by Mr. Hörmannsperger (Hallertau Hop Producers' Ring). To ensure maximum homogeneity, each sample was drawn from a single bale. Every Monday, the samples were ground with a hammer mill in Hüll, divided up with a sample divider, vacuum-packed and delivered to each of the laboratories. The laboratories then analysed one sample daily on each of the following weekdays. A week later, the results were sent back to Hüll and evaluated there. Altogether 35 samples were analysed in 2010.

The evaluations were passed on to the individual laboratories as quickly as possible. Fig.7.6 shows a sample evaluation serving as a model ring-test evaluation. The laboratory numbering (1-8) does not correspond to the above list. Grubb's test was performed according to ISO 5725 to detect any outliers among the laboratories. At a significance level of a = 0.05, five outliers were detected in 2010; none was detected at a significance level of a = 0.01. Tab. 7.4 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 outliers for the years 2000 to 2010.

Nr. 22: HSD (20.10.2010)

Labor	KW		mittel	s	cvr
1	7,33	7,34	7,34	0,007	0,1
2	7,44	7,49	7,47	0,035	0,5
3	7,45	7,71	7,58	0,184	2,4
4	7,51	7,51	7,51	0,000	0,0
5	7,51	7,68	7,60	0,120	1,6
6	7,49	7,43	7,46	0,042	0,6
7	7,52	7,56	7,54	0,028	0,4
8	7,60	7,60	7,60	0,000	0,0

mean	7,51
sr	0,081
sL	0,069
sR	0,106
vkr	1,07
vkR	1,42
r	0,23
R	0,30
Min	7,33
Max	7,71

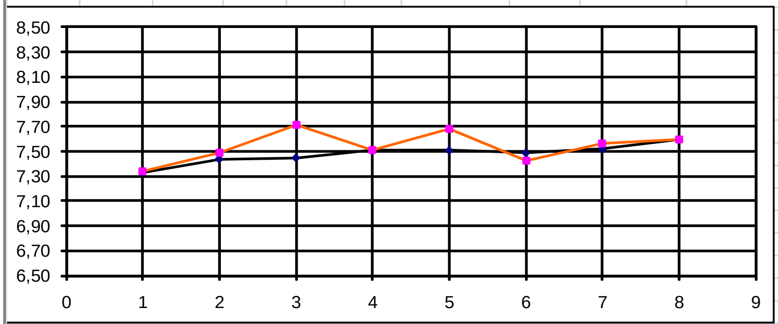


Fig.7.6 : Evaluation of a ring analysis

Tab. 7.4 : Tolerance limits set by EBC 7.4 and outliers in the years from 2000 to 2010

	Up to 6.2 %	6.3 % - 9.4 %	9.5 % - 11.3 %	From 11.4 %
Critical diff. CD	+/-0.3	+/-0.4	+/-0.5	+/-0.6
Tolerance range	0.6	0.8	1.0	1.2
Outliers in 2000	0	3	0	3
in 2001	2	1	0	2
in 2002	4	4	2	4
in 2003	1	1	1	0
in 2004	0	0	0	4
in 2005	1	0	1	3
in 2006	2	0	1	0
in 2007	1	0	0	0
in 2008	2	0	0	6
in 2009	3	2	0	4
in 2010	0	0	0	1

In 2010, only 1 result was outside the permissible tolerance range. Fig. 7.7 shows all analysis results for each laboratory as relative deviations from the mean (= 100 %), broken down 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.

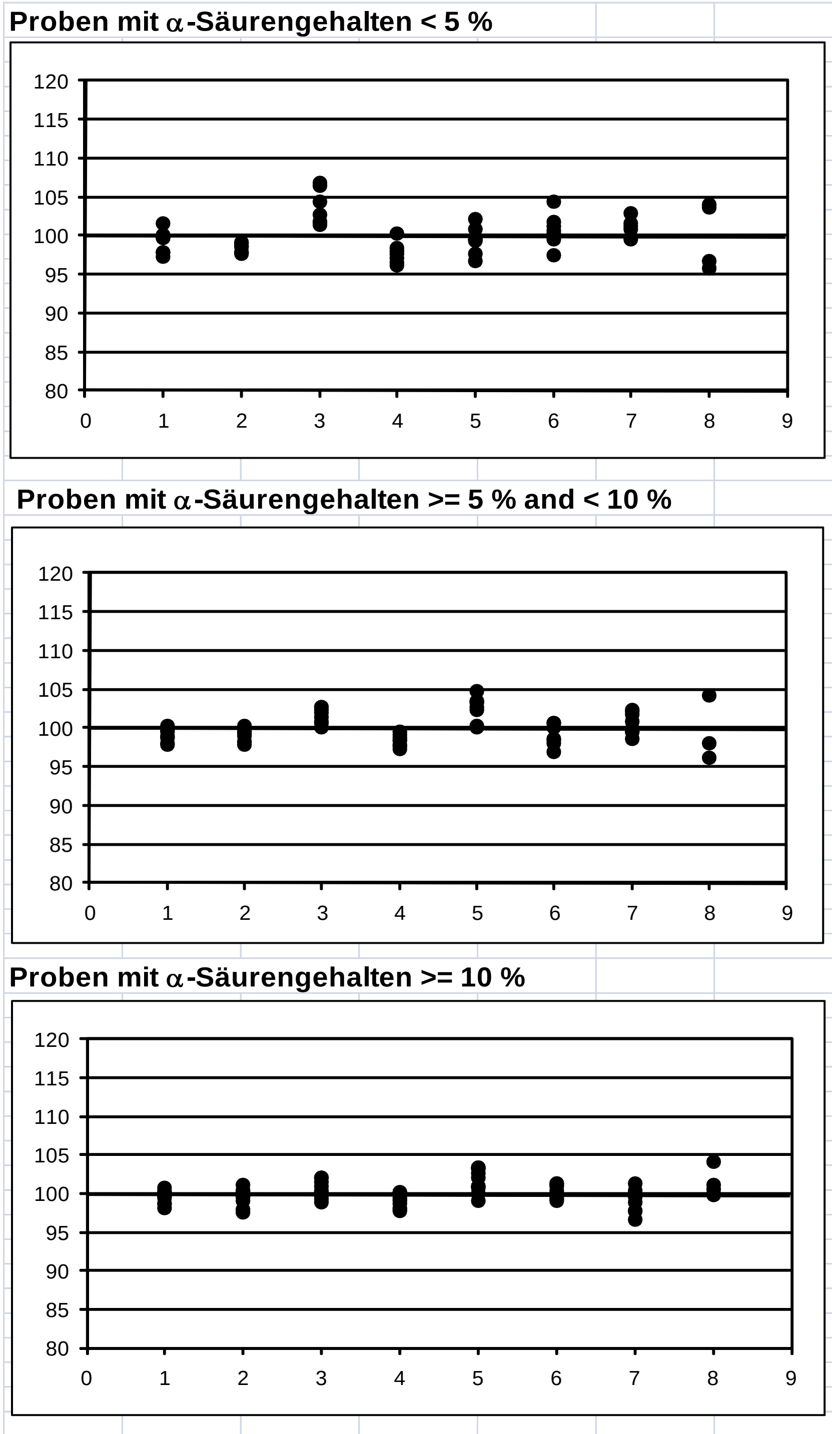


Fig. 7.7 : Analysis results of the laboratories relative to the mean

With α-acid contents of < 5 % and also ≥ 5 % and <10 %, laboratory three's results are relatively high. With α-acid values of ≥10 %, laboratory eight's results are too low. The Hüll laboratory is number 5.

7.5.2 Evaluation of post-analyses

Since 2005, post-analyses have been performed to confirm the results of the ring tests. The post-analyses are evaluated by the IPZ 5d work group, which passes on the results to the laboratories involved, the Hop Growers Association and the German Hop Trade Association (DHWV). Each of the laboratories conducting ring tests selects three samples weekly that are then analysed by three other laboratories according to the specifications of the AHA. The result of the initial ring test is confirmed if the post-analysis mean and the inital ring test result are within the specified tolerance limits (Tab. 7.4). Tab. 7.5 shows the 2010 results. As from 2005, all the initial test results have been confirmed.

Tab. 7.5 : Post-analyses in 2010

Sample designation	Initial test laboratory	Initial test result	Post-analysis			Mean	Result confirmed
			1	2	3		
KW 37 HHT	HHV Au	6.7	6.7	6.8	6.8	6.8	Yes
KW 37 HPE	HHV Au	8.8	8.6	8.6	8.7	8.6	Yes
KW 37 HHM	HHV Au	13.3	13.2	13.4	13.6	13.4	Yes
QK 1063 HHT	NATECO2 Wolnzach	6.3	6.2	6.2	6.2	6.2	Yes
QK 1067 HPE 1	NATECO2 Wolnzach	9.7	9.4	9.4	9.5	9.4	Yes
QK 1069 HPE 2	NATECO2 Wolnzach	7.7	7.5	7.5	7.5	7.5	Yes
HNB KW 39	HVG Mainburg	10.2	10.0	10.0	10.1	10.0	Yes
HHT KW 39	HVG Mainburg	6.9	6.8	7.0	7.0	6.9	Yes
HHM KW 39	HVG Mainburg	13.2	13.2	13.5	13.5	13.4	Yes
KW 40 HMR	HHV Au	13.3	13.0	13.4	13.6	13.3	Yes
KW 40 HHM 1	HHV Au	10.8	10.7	10.7	11.1	10.8	Yes
KW 40 HHM 2	HHV Au	14.6	14.3	14.6	14.8	14.6	Yes
KW 41/QK 2773 HHS 1	NATECO2 Wolnzach	17.9	17.4	17.4	17.5	17.4	Yes
KW 41/QK 2777 HHS 2	NATECO2 Wolnzach	15.9	16.1	16.2	16.3	16.2	Yes
KW 41/QK 2779 HTU	NATECO2 Wolnzach	13.8	13.9	14.1	14.2	14.1	Yes
HHS 1-KW 42	HVG Mainburg	16.1	16.4	16.6	16.8	16.6	Yes
HHS 2-KW 42	HVG Mainburg	16.6	16.4	16.5	16.7	16.5	Yes
HNU 2-KW 42	HVG Mainburg	12.4	12.0	12.1	12.2	12.1	Yes
KW 43 HMR	HHV Au	12.6	12.4	12.5	12.7	12.5	Yes
KW 43 HHM	HHV Au	11.8	11.5	11.7	11.9	11.7	Yes
KW 43 HHS	HHV Au	14.5	14.3	14.5	14.6	14.5	Yes
KW 44/QK 3760 HNB	NATECO2 Wolnzach	10.2	9.9	10.2	10.2	10.1	Yes
KW 44/QK 3763 HNU	NATECO2 Wolnzach	12.2	12.1	12.2	12.2	12.2	Yes
KW 44/QK 3769 HHM	NATECO2 Wolnzach	13.3	13.1	13.2	13.3	13.2	Yes
HHS1-KW 45	HVG Mainburg	16.2	16.1	16.1	16.2	16.1	Yes
HHS2-KW 45	HVG Mainburg	16.0	16.0	16.1	16.2	16.1	Yes
HHM-KW 45	HVG Mainburg	13.0	13.0	13.2	13.3	13.2	Yes

7.6 Production of pure alpha acids and their ortho-phenylenediamine complexes for monitoring and calibrating the HPLC standards

In autumn 2010, the AHA introduced the new international calibration extract (ICE 3). It was the task of the Hüll laboratory to produce ultra-pure α-acids (>98 %) that are needed as standards for calibrating and monitoring the extract. The stability of the calibration standard is checked twice yearly by the AHA laboratories. The ortho-phenylenediamine complex is first prepared from a CO_2 extract with a high α-acid content by reaction with ortho-phenylenediamine (Fig.7.8).

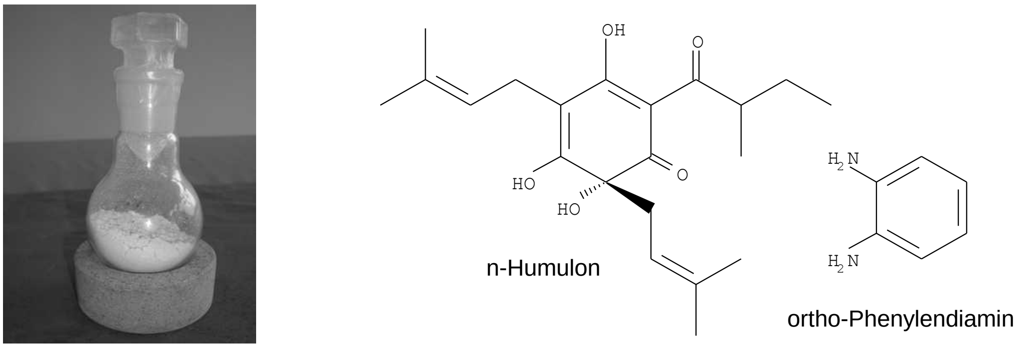


Fig.7.8 : ortho-phenylenediamine complex and its chemical structure

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

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

In 2010, 20 ml valerian root essential oil were prepared by steam distillation. This necessitated carrying out 30 distillations as the Hüll steam distillation equipment is designed for only 200 g starting material, and 200 g valerian root contain only 0.7 ml essential oil. IPZ 5d also participated in a ring test for determining rosemary acid, salvianolic acid and tanshinone in salvia root (Tab.7.6) In addition, three gas-chromatographic analyses of the essential oils in hop cones, hop pellets and peppermint were performed.

Tab.7.6 : Salvia ring test results

Sample no.	Rosmary acid			Salvianolic acid			Tanshinone		
	Det. 1	Det. 2	Ø	Det. 1	Det. 2	Ø	Det. 1	Det. 2	Ø
1125	0.40	0.42	0.41	9.12	9.04	9.08	0.35	0.33	0.34
1126	0.34	0.32	0.33	8.14	7.98	8.06	0.31	0.31	0.31
1127	0.45	0.40	0.43	8.19	7.72	7.96	0.43	0.41	0.42
1128	0.38	0.38	0.38	7.48	7.47	7.48	0.33	0.35	0.34
1137	0.37	0.32	0.35	8.17	8.03	8.10	0.42	0.41	0.42
1141	0.35	0.27	0.31	9.12	8.82	8.97	0.35	0.27	0.31

Results quoted in %.

7.8 Monitoring of variety authenticity

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

Variety checks for the food control authorities
(District administrator's offices) 34
Complaints 0

8 Publications and specialist information

8.1 Summary of PR work

	Number		Number
Practice-relevant information and scientific papers	34	Guided tours	68
LfL publications	2	Exhibitions and posters	5
Press releases	3	Basic and advanced training sessions	15
Radio and TV broadcasts	6	Final-year university-degree projects	1
Conferences, trade events and seminars	19	Participation in working groups	17
Talks	75		
Foreign guests	287		

8.2 Publications

8.2.1 Practice-relevant information and scientific papers

Author(s), title, journal, page

Engelhard, B., Weihrauch, F. (2010): Nachhaltige Optimierung der Bekämpfung von Blattläusen (*Phorodon humuli*) im Hopfen (*Humulus lupulus*) durch Bekämpfungsschwellen und Züchtung blattlaustoleranter Hopfensorten. Zwischenbericht 2009 des Forschungsprojektes im Auftrag der Deutschen Bundesstiftung Umwelt, Osnabrück. 11 pp.

Forster, A., Gahr, A., Biendl, M., Schmidt, R., Lutz, A., Toft, E. (2010): Pocket Guide to German Hop Varieties. Deutscher Hopfenpflanzerverband und deutscher Hopfenwirtschaftsverband (Herg.).

Kammhuber, K. (2010): Alternative Verwendungen von Hopfen außerhalb der Brauerei, Schule und Beratung, Heft 5-6/10, Seite III-10 .- III-14

Lutz, A. (2010): Deutsche Hopfenausstellung 2010 - Hopfensortensieger in Berlin. Brauwelt 43/10, 10.

Lutz, A. (2010): Neue Tendenzen in der Hüller Aromazüchtung. New trends in Hüll aroma breeding. Hopfenrundschau – Internationale Ausgabe 2010/11, 22-23.

Lutz, A., Kammhuber, K., Kneidl, J., Petzina, C., Sperr, B., Wyschkon, B. (2010): Bonitierung und Ergebnisse für die Deutsche Hopfenausstellung 2010. Hopfenrundschau, Nr. 11, November 2010., 295-298.

Münsterer, J. (2010): Steigerung der Trocknungsleistung von Hopfen durch ein optimales Schüttgewicht. Hopfen Rundschau 61 (8), 214-215.

Niedermeier, E. (2010): Pflanzenstandsbericht. Hopfen Rundschau 61 (5), 133.

Niedermeier, E. (2010): Pflanzenstandsbericht. Hopfen Rundschau 61 (6), 160.

Niedermeier, E. (2010): Pflanzenstandsbericht. Hopfen Rundschau 61 (7), 185.

Niedermeier, E. (2010): Pflanzenstandsbericht. Hopfen Rundschau 61 (8), 217.

Niedermeier, E. (2010): Pflanzenstandsbericht. Hopfen Rundschau 61 (9), 248.

Portner, J. (2010): Aktuelle Hopfenbauhinweise. Hopfenbau-Ringfax Nr. 5; 8; 10; 12; 13; 14; 17; 18; 19; 20; 21; 22; 23; 24; 25; 26; 27; 28; 29; 30; 32; 33; 36; 37; 38; 40; 41; 42; 43; 44; 46; 48; 50; 54

Portner, J. (2010): Ehrung der Sieger der Moosburger Hopfenschau im Landratsamt Kelheim. Hopfen Rundschau 61 (1), 31.

Portner, J. (2010): Nmin-Untersuchung in Hopfen und anderen Ackerkulturen; Empfehlungen zur Stickstoffdüngung 2010. Hopfen Rundschau 61 (3), 78.

Portner, J. (2010): Nährstoffvergleich bis 31. März erstellen. Hopfen Rundschau 61 (3), 78-79.

Portner, J. (2010): Gezielte Stickstoffdüngung des Hopfens nach DSN (Nmin). Hopfen Rundschau 61 (3), 79.

Portner, J., Brummer, A. (2010): N_{min}-Untersuchung 2010. Hopfen Rundschau 61 (5), 131-132.

Portner, J. (2010): Zwischenfruchteinsaat im Hopfen für KuLaP-Betriebe spätestens am 30. Juni. Hopfen Rundschau 61 (5), 132-133.

Portner, J. (2010): EU-Erntebericht Hopfen 2009. Hopfen Rundschau 61 (5), 134-135.

Portner, J. (2010): Peronosporabekämpfung. Hopfen Rundschau 61 (6), 149.

Portner, J. (2010): Zwischenfruchteinsaat im Hopfen für KuLaP-Betriebe spätestens bis 30. Juni vornehmen. Hopfen Rundschau 61 (6), 164.

Portner, J. (2010): Oberamtsrat Franz Brandl vom AELF Abensberg verstorben. Hopfen Rundschau 61 (7), 188-189.

Portner, J. (2010): Rebenhäcksel bald möglichst ausbringen. Hopfen Rundschau 61 (8), 211.

Portner, J. (2010): Kostenfreie Rücknahme von Pflanzenschutz-Verpackungen PAMIRA 2010. Hopfen Rundschau 61 (8), 214.

Portner, J, Niedermeier, E. (2010): Unterscheidung der Hopfenwelke (*Verticillium albo-atrum*) in milde und aggressive (letale) Rassen mit unterschiedlichen Bekämpfungsstrategien. Hopfen Rundschau 61 (8), 215-216.

Portner, J. (2010): Hopfen-Kolloquium 2010 in Abensberg. Hopfen Rundschau 61 (9), 244.

Portner, J. (2010): Fachkritik zur Moosburger Hopfenschau 2010. Hopfen Rundschau 61 (10), 268-273.

Portner, J. (2010): Aktuelles zum Pflanzenschutz. Hopfenring-Information v. 27.07.2010, 1-2.

Portner, J. (2010): Gründung eines Arbeitskreises „Hopfenschlagkartei"; Fortbildungsveranstaltungen; KuLaP-Förderung; Flächenzu- und -abgänge melden. Hopfenring-Information v. 03.11.2010, 1-2.

Seigner, E., Lutz, A., Seigner, L. (2010): Keine Chance für den Befall – Monitoring auf Hop stunt viroid-Infektionen bei Hopfen in Deutschland. Brauindustrie 1/2010, 18-20.

Seigner, E., Lutz, A., Seigner, L. (2010): Qualitätssicherung bei Hopfen: Monitoring von Virus- und Viroiderkrankungen. Hopfenrundschau, Nr. 9, September 2010., 245-246.

Seigner, L., Seigner, E., Lutz, A. (2010): Monitoring auf Hop stund viroid-Infektionen bei Hopfen in Deutschland. Hopfenrundschau Nr. 3, März 2010, 62-64.

Weihrauch, F., Baumgartner, A., Felsl, M., Kammhuber, K., Kneidl, J., Lutz, A., Neuhof-Buckl, E., Petzina, C., Sperr, B., Weihrauch, S., Wyschkon, B. (2010): The influence of aphid infestation during the hop growing season on the quality of harvested cones. Programme, EBC Hop Symposium 2010, 12 – 14 September 2010, Wolnzach (Bavaria): 29

8.2.2 LfL publications

Name	Work group	LfL publications	Title
Portner, J.	IPZ 5a	“Grünes Heft” ”Green Leaflet”	Hopfen 2010 (Hops 2010)
Weihrauch, F., Baumgartner, A., Felsl, M., Lutz, A., Schwarz, J.	IPZ 5b	LfL information, May 2010, 16 pp.	Richtlinien für die Bonitur getrockneter Hopfendolden auf Befall mit den wichtigsten Krankheiten und Schädlingen des Hopfens (Guidelines for assessing dried hop cones for infection with major hop diseases and pests).

8.2.3 Press releases

Author(s) / Work group	Title
Seigner, E., Lutz, A., IPZ 5c	Regional-Agrarminister aus Russland zeigt reges Interesse an der Hopfenforschung in Hüll (Regional minister of agriculture from Russia shows keen interest in Hüll hop research)
Portner, J., IPZ 5a	Über 5000 t CO_2-Einsparung bei der Hopfentrocknung durch technische Entwicklungen auf Initiative und unter Mitwirkung der LfL (LfL-driven technical progress in hop drying cuts CO_2 emissions by 5,000 t)
Portner, J., IPZ 5a	Hopfenforscher aus ganz Deutschland trafen sich zum Erfahrungsaustausch in der Hallertau (Hop researchers from all over Germany met in the Hallertau to share their experience)

8.2.4 Radio and TV broadcasts

Name / WG	Date of broadcast	Topic	Title of programme	Station
Engelhard, B., IPZ 5	16.09.10	Hop research and climate change	teleschau	IN-TV
Engelhard, B.; IPZ 5	05.10.10	Hop research and climate change	Aktuelle	FRANCE 24
Münsterer, J., IPZ 5a	19.10.10	Interview on hop-drying optimisation		IN TV
Schwarz, J., Weihrauch F., IPZ 5b	25.04.10	Plant protection in hop yards	Aus Schwaben und Altbayern	Bavarian TV
Lutz, A., IPZ 5c	25.04.10	Breeding	Aus Schwaben und Altbayern	Bavarian TV
Kammhuber, K., IPZ 5d	25.04.10	Hop components	Aus Schwaben und Altbayern	Bavarian TV

8.3 Conferences, talks, guided tours and exhibitions

8.3.1 Conferences, trade events and seminars

Organised by	Date / Venue	Topic	(Number of) participants
Münsterer, J.	08.01.10 Wolnzach	Seminar: Latest findings concerning hop drying	34 hop growers
Münsterer, J.	26.01.10 Wolnzach	Seminar: Optimal hop conditioning	28 hop growers
Münsterer, J.	09.02.10 Wolnzach	Workshop: Irrigation control	12 hop growers
BMELV	10.02.10 Bonn	Technical discussion on plant protection	Hop organizations, Federal Office for Consumer Protection and Food Safety (BVL), Julius Kühn Institute (JKI)
Münsterer, J.	03.03.2010 Tettnang	Seminar: Hop drying and conditioning	25 hop growers
Portner, J.	04.03.10 Hüll	"Grünes Heft" meeting	Colleagues from hop research institutes in Germany
Münsterer, J.	11.03.2010 Mainburg	Seminar: Hop drying and conditioning	35 participants
Münsterer, J.	16.03.2010 Mainburg	Seminar: Hop drying and conditioning	40 participants
Münsterer, J.	18.05.2010 Wolnzach	Seminar: Hop drying and conditioning	10 participants
Portner, J., Fuß, S.	18.05.10 Tettnang area	Instructive tour to investigate structural designs of hop trellises	10 students from the Regensburg Univ. of Applied Sciences + 1 civil engineer
Portner, J. Fuß, S.	18.05.10 Elbe-Saale hop-growing area	Instructive tour to investigate structural designs of hop trellises	10 students from the Regensburg Univ. of Applied Sciences + 1 civil engineer
Münsterer, J.	21.05.2010 Pfaffenhofen	IT training: Hop card index (HSK) recording and evaluation program	10 participants
Schätzl, J.	19.05.10; 02.06.10; 16.06.10; 30.06.10; 01.07.10; 14.07.10; 28.07.10 Various venues	Experience sharing and training	Ring consultants and Ring experts
Schätzl, J., Portner, J.	07.06.10; 28.07.10 Various venues	Information pooling	BayWa employees
Portner, J.	03.08. - 04.08.10 Abensberg	Hop congress	Colleagues from government agencies and hop research institutes in Germany
VdH	02.09.10 Wolnzach	Plant protection conference	Hop organizations, BVL, JKI, Federal Ministry for the Envronment, Nature Conservation and Nuclear Safety (BMU), Federal Instit. for Risk Assessment (BfR)

Organised by	Date / Venue	Topic	(Number of) participants
VdH	02.09.10 Hüll, Hallertau	Guided hop tour	Politicians, govt. agencies, associations
Portner, J.	14.09.10 Moosburg	Hop judging at the Moosburg hop show	20 members of the hop-quality assessment commission
Portner, J., Münsterer, J	19.10.10 Wolnzach	Hop-drying information day with equipment exhibition	350 hop growers, guests and exhibitors

8.3.2 Talks

WG	Name	Topic / Title	Organiser / Attended by	Date /Venue
IPZ 5	Lutz, A. Niedermeier, E. Portner, J. Seigner, E.	Hop growing in the Hallertau	Guided hop-growing bus tour, approx. 170 participants	02.09.10, Wolnzach
IPZ 5a	Fuß, S.	Hop trellis systems in the Hallertau	IPZ 5a /10 students from the Regensburg Univ. of Applied Sciences, Prof. Springer and 1 civil engineer	30.03.10 Wolnzach
IPZ 5a	Fuß, S.	Irrigation for hop growing: methods, equipment and cost	Hop Producers' Ring (HPR) and LFL / 25 hop growers	06.12.2010 Spalt
IPZ 5a	Münsterer, J.	Reasons for and ways to avoid tainted cones during harvesting, drying and conditioning	HPR / 42 hop growers	18.01.2010 Osselts-hausen
IPZ 5a	Münsterer, J.	Reasons for and ways to avoid tainted cones during harvesting, drying and conditioning	HPR / 38 hop growers	20.01.2010 Oberhatz-kofen
IPZ 5a	Münsterer, J.	Reasons for and ways to avoid tainted cones during harvesting, drying and conditioning	HPR / 38 hop growers	21.01.2010 Hiendorf
IPZ 5a	Münsterer, J.	Reasons for and ways to avoid tainted cones during harvesting, drying and conditioning	HPR / 88 hop growers	25.01.2010 Niederlauter-bach
IPZ 5a	Münsterer, J.	Reasons for and ways to avoid tainted cones during harvesting, drying and conditioning	HPR / 49 hop growers	28.01.2010 Aiglsbach
IPZ 5a	Münsterer, J.	Reasons for and ways to avoid tainted cones during harvesting, drying and conditioning	HPR / 43 hop growers	01.02.2010 Uttenhofen
IPZ 5a	Münsterer, J.	Reasons for and ways to avoid tainted cones during harvesting, drying and conditioning	HPR / 16 hop growers	03.02.2010 Hedersdorf
IPZ 5a	Münsterer, J.	Reasons for and ways to avoid tainted cones during harvesting, drying and conditioning	HPR / 43 hop growers	04.02.2010 Spalt

WG	Name	Topic / Title	Organiser / Attended by	Date / Venue
IPZ 5a	Münsterer, J.	Reasons for and ways to avoid tainted cones during harvesting, dryinhg and conditioning	HPR / 54 hop growers	08.02.2010 Biburg
IPZ 5a	Münsterer, J.	Latest findings concerning hop drying and conditioning	LfL colloquium / 30 visitors	23.02.2010 Freising
IPZ 5a	Münsterer, J.	Field-record evaluation methods	IPZ 5b/ 35 hop growers involved in the aphid project	05.03.2010 Wolnzach
IPZ 5a	Münsterer, J.	Latest hop-drying findings; latest update on plant protection	HPR / 19 hop growers	09.03.2010 Eschelbach
IPZ 5a	Münsterer, J.	Saving energy by optimising hop drying	Hop Processing Coop. (HVG) / Supervisory Board members	24.03.2010 Wolnzach
IPZ 5a	Münsterer, J.	Hop-card-index evaluation	IPZ 5a / 7 hop growers	29.03.2010
IPZ 5a	Münsterer, J.	Irrigation trials in 2010	LfL and Instit. f. Agric. Ecology, Org. Farming + Soil Prot. (IAB) / Climate project partners	08.11.2010 Wolnzach
IPZ 5a	Niedermeier, E.	Measures to reduce wilt infection	Beiselen GmbH / 18 participants from rural trading companies	12.02.2010 Mainburg
IPZ 5a	Niedermeier, E.	Measures to reduce wilt infection	BayWa / 25 employees	18.02.2010 Wolnzach
IPZ 5a	Niedermeier, E.	Measures to reduce wilt infection	LfL and national offices for food, agriculture and forestry (ÄELF) / 665 hop growers and guests	22.02. - 03.03.2010 9 venues
IPZ 5a	Niedermeier, E.	Latest update on plant protection	Hop syndicate / 25 participants	26.05.2010 Niederlauter-bach
IPZ 5a	Niedermeier, E.	Post-hail measures	HVH / approx. 220 participants	31.05.2010 Aiglsbach
IPZ 5a	Portner, J.	Evaluating hop production costs	IPZ 5a / 18 hop growers (working group)	21.01.2010 Haunsbach
IPZ 5a	Portner, J.	Future scenarios for technical solutions in hop-growing	MR Mainburg / 150 hop growers	02.02.2010 Mainburg
IPZ 5a	Portner, J.	Appropriate catch cropping for erosion protection in hop growing	Beiselen GmbH / 18 participants from rural trading companies	12.02.2010 Mainburg
IPZ 5a	Portner, J.	Appropriate catch cropping for erosion protection in hop growing	BayWa / 25 employees	18.02.2010 Wolnzach
IPZ 5a	Portner, J.	Appropriate catch cropping for erosion protection in hop growing	LfL and ÄELF / 665 hop growers and guests	22.02. - 03.03.2010 9 venues
IPZ 5a	Portner, J.	Chemical plant protection in hop-growing – a problem for beekeepers?	Lower Bavarian beekeepers' association / 35 participants	25.03.2010 Elsendorf
IPZ 5a	Portner, J.	Increasing drying performance and simultaneously improving hop quality	GfH and Tech. scientific committee of the GfH (TWA) / 30 committee members	15.04.2010 Wolnzach

WG	Name	Topic / Title	Organiser / Attended by	Date / Venue
IPZ 5a	Portner, J.	Latest update on plant protection	AELF Roth / 40 hop growers	16.07.2010 Spalt
IPZ 5a	Portner, J.	Harvesting time for Hallertauer Mittelfrüher / Wilt problems	HPR / 70 participants	17.08.2010 Reicherts-hausen
IPZ 5a	Portner, J.	Harvesting time for Hallertauer Mittelfrüher / Wilt problems	HPR / 40 participants	18.08.2010 Elsendorf
IPZ 5a	Portner, J.	Expert hop review (2010)	Town of Moosburg / 150 guests	16.09.2010 Moosburg
IPZ 5a	Portner, J.	Measures to reduce nitrate leaching in hop-growing	Regensburg Water Authority (WWA) / 20 monitoring officers	06.10.2010 Regensburg
IPZ 5a	Portner, J.	Analysing drying performance and energy consumption	IPZ 5a / 13 hop growers (working group)	15.12.2010 Haunsbach
IPZ 5a	Schätzl, J.	Latest update on fertilising with primary and trace nutrients	LfL / hop growers	17.03.2010 Laimerstadt
IPZ 5a	Schätzl, J.	Update on downy mildew situation in 2010, downy mildew forecasting service, characteristics of last year's hail-hit area	LfL / 18 hop growers	04.06.2010 Hirnkirchen
IPZ 5a	Schätzl, J.	Training in forecasting, latest update on plant protection	LfL and AELF Roth / 78 hop growers	02.06.2010 Spalt
IPZ 5a	Schätzl, J.	Soil suitability and optimal plot layout for hop growing	LfL and Ansbach Rural Development Office (ALE) / 17 participants	11.08.2010 Mosbach
IPZ 5a	Schätzl, J.	Ring consultant training – 2010 review	HPR and LfL / 10 Ring consultants	09.12.2010 Wolnzach
IPZ 5b	Engelhard, B.	Chemical plant protection in hop-growing – a problem for beekeepers?	Pfaffenhofen beekeepers' assoc. / 40 participants	08.01.2010 Pfaffenhofen
IPZ 5b	Engelhard, B.	Will there be a sufficient range of plant protectives for hop cultivation in future?	Leutschach hop producer group 40 participants	04.02.2010 Leutschach (A)
IPZ 5b	Engelhard, B.	Powdery mildew (PM) forecasting: experience gained in 2009, implementation in 2010	BayWa rural trading company	12.02.2010 Mainburg 18.02.2010 Wolnzach
IPZ 5b	Engelhard, B.	PM forecasting: experience gained in 2009, implementation in 2010	IPZ 5 / ÄELF 665 hop growers and guests	22.02. – 03.03.2010 9 venues
IPZ 5b	Engelhard, B.	The current situation regarding plant protectives for hops	Hop farm management working group / 18 participants	15.03.2010 Haunsbach
IPZ 5b	Engelhard, B.	Research project: bees, hops and guttation	District beekeepers' assoc. / 15 participants	18.03.2010 Pfaffenhofen
IPZ 5b	Engelhard, B.	PM control according to the forecasting model	Tech. scientific committee of the GfH	15.04.2010 Wolnzach
IPZ 5b	Engelhard, B.	Update on plant protection issues – HSdH, *Verticillium*, primary downy mildew	Hop brewers' society (VdH) – Advisory Board meeting	21.07.2010 Altenburg
IPZ 5b	Engelhard, B.	Is adequate plant protection in hop cultivation still ensured under the current environmental regulations?	Hop syndicate – hop day	26.08.2010 Niederlauter-bach

WG	Name	Topic / Title	Organiser / Attended by	Date / Venue
IPZ 5b	Engelhard, B.	Research project: bees in the hop yard	VdH – plant protection conference	02.09.2010 Wolnzach
IPZ 5b	Engelhard, B.	The registration situation for hop plant protectives – prospects for 2011	VdH – plant protection conference	02.09.2010 Wolnzach
IPZ 5b	Engelhard, B.	PM control according to the forecasting model	Federal Agency for Agriculture and Food (BLE) / 50 participants	07.10.2010 Berlin
IPZ 5b	Engelhard, B. Schwarz, J.	Additional aspects of integrated plant protection methods to combat the Lucerne weevil in hops Part 1: Field trials Teil 2: Semi-outdoor trials	JKI / 24 participants	08.12.2010 Ellerhoop
IPZ 5b	Schwarz, J.	The registration situation for hop plant protectives in 2010	Leutschach hop producer group / 40 participants	04.02.2010 Leutschach (A)
IPZ 5b	Schwarz, J.	Latest results of trials on the use of copper and whey in organic hop production	Bioland working group for hops, hop production day / 30 participants	10.02.2010 Berching-Plankstetten
IPZ 5b	Schwarz, J.	The registration situation for hop plant protectives in 2010	IPZ 5 / ÄELF 665 hop growers and guests	22.02. – 03.03.2010 9 venues
IPZ 5b	Weihrauch, F.	Spider-mite control with insect glue – plan B?	Bioland working group for hops, hop production day / 30 participants	10.02.2010 Berching-Plankstetten
IPZ 5b	Weihrauch, F.	The DBU (Deutsche Bundesstiftung Umwelt) aphid project: initial results of a research project on aphid control	Research project work meeting with the hop farmers cooperating / 33 participants	05.03.2010 Hüll
IPZ 5b	Weihrauch, F.	The influence of aphid infestation during the hop growing season on the quality of harvested cones	EBC Hop Symposium 2010 / 130 participants	14.09.2010 Wolnzach
IPZ 5b	Weihrauch, F.	Minimizing or replacing copper as a component of the German organic farming project: report on the trials in hop farming	Fed. Ministry of Food, Agric. + Consumer Prot. (BMELV) - Technical discussion on “Copper in plant protection” / 60 participants	10.11.2010 Berlin-Dahlem

WG	Name	Topic / Title	Organiser / Attended by	Date / Venue
IPZ 5b	Weihrauch, F.	Development of integrated methods of plant protection against the Lucerne weevil *(Otiorhynchus ligustici)* in hops	29th annual convention of the "Useful Arthropods" working group of the German Phytomedical Society (DPG) and the German Soc. for General and Applied Entomology (DgaaE) / 60 participants	30.11.2010 Berlin - Dahlem
IPZ 5c	Lutz, A.	Hop breeding in Hüll – always at the cutting edge of developments with new hop cultivars	Spring 2010 general meeting of the Tettnang hop growers' association / 100 participants	22.03.2010, Tettnang
IPZ 5c	Lutz, A.	PM isolates and their use in breeding PM-resistant hops	HVG Supervisory Board meeting / 35 participants	25.10.2010, Wolnzach
IPZ 5c	Lutz, A.	Hop cultivars and assessment of quality features	"Alt-Weihenstephaner Brauerbund" / approx. 25 participants	03.11.2010, Freising
IPZ 5c	Oberhollenzer, K.	Characterisation of different PM-resistance responses and functional analysis of suspected resistance genes via a gene transfer approach	TWA of the GfH / 30 participants	15.04.2010
IPZ 5c	Oberhollenzer, K.	Powdery mildew on hops: transient transformation and histochemical studies	Doctoral-student seminar, Prof. Hückelhoven, Munich Technical University (TUM)	10.05.2010, Freising
IPZ 5c	Oberhollenzer, K.	Host and non-host resistance of hop leaf hairs	Doctoral-student seminar, Prof. Hückelhoven, TUM,	15.11.2010, Freising
IPZ 5c	Seefelder, S.	*Verticillium* wilt research results and measures to reduce wilt infection in hops	Spring 2010 general meeting of the Tettnang hop growers' association / 100 participants	22.03.2010, Tettnang
IPZ 5c	Seefelder, S.	Research results for *Verticillium* wilt in hops	Hop growers' meetings in 2010 / 9 venues, approx. 350 participants	22.02.-03.03.
IPZ 5c	Seefelder, S.	Studies to assess the risk of *Verticillium* infections in German hop-growing areas	Agricultural committee of the German brewers' association / 17 participants	09.09.10, Hüll
IPZ 5c	Seefelder, S.	Soil-borne fungal diseases as exemplified by *Verticillium*	16th workshop for ISO-certified hop farmers / 55 participantsTN	08.12.10, Aiglsbach
IPZ 5c	Seigner, E.	Gene transfer in hops – studies concluded to date	GfH, 30 participants	15.04.2010
IPZ 5c	Seigner, E.	PM isolates and their use in breeding PM-resistant hops	Scientific Station for Brewing in Munich / 60 participants	28.06.10, Munich
IPZ 5c	Seigner, E.	Breeding of resistant hops particularly suited for growth on low-trellis systems	BMELV and BLE, Innovation days 2010 / 40 participants	07.10.2010, Berlin

8.3.3 Guided tours

(WG = work group)

WG	Name	Date	Topic/Title	Guest institution	No. of partic.
IPZ-L, IPZ 5	Doleschel, P. Engelhard, B. Seigner, E. Weihrauch, F.	14.09.10	Hüll Hop Research Centre	EBC Hop Symposium 2010	40
IPZ 5	Engelhard, B.	29.06.10	Climate change as reflected by the Hüll weather station, hop breeding	Teachers from Pfaffenhofen grammar school	35
IPZ 5	Engelhard, B.	14.07.10	Hop research	Regensburg episcopal ordinariat,	24
IPZ 5	Engelhard, B.	30.07.10	Bavarian hop research	MD Neumeier, Ltd.MR Mayer	2
IPZ 5	Engelhard, B. Seigner, E.	18.08.10	Bavarian hop research	ISAA – Formulation experts from the plant protectives branch	40
IPZ 5	Engelhard, B.	26.08.10	Latest update on hop development and the Herkules variety	Hop syndicate	~100
IPZ 5	Engelhard, B.	10.09.10	Bavarian hop research	German master brewers and malters assoc. (DBMB), Rhineland-Palatinate group	38
IPZ 5	Engelhard, B.	15.09.10	Hop rsearch and climate change	TUM ecoclimatology	12
IPZ 5	Engelhard, B. Kammhuber, K.	17.09.10	Bavarian hop research	German Agricultural Museum in Hohenheim	40
IPZ 5	Engelhard, B.	25.09.10	Bavarian hop research	AB-Inbev customers from Russia and Turkey	55
IPZ 5	Engelhard, B.	29.09.10	Bavarian hop research	Pfaffenhofen District Administrator	2
IPZ 5	Engelhard, B.	04.10.10	Bavarian hop research	Santori (I) brewery	6
IPZ 5	Engelhard, B.	05.10.10	Bavarian hop research	Plar (VEN) brewery	3
IPZ 5	Engelhard, B.	17.10.10	Bavarian hop research	Ashai (J) brewery	1
IPZ 5	Engelhard, B.	02.12.10	Bavarian hop research	Schyren grammar school (Pfaffenhofen)	20
IPZ 5	Engelhard. B. Lutz, A. Schwarz, J. Weihrauch, F.	13.04.10	Hop research at Hüll	Bavarian Broadcasting (BR), Ms. Sarre-Mock and TV team	3
IPZ 5	Engelhard, B. Kammhuber, K. Lutz, A. Seigner, E.	13.04.10	Hop Research at Hüll	T. Tangaro, Dr. Buholzer, AB-InBev	2
IPZ 5	Engelhard, B., Kammhuber, K. Seigner, E.	24.06.10	Hop Research at Hüll	VLB Berlin, international brewmaster course	43
IPZ 5	Engelhard, B. Kammhuber, K. Seigner, E.	15.07.10	Hüll Hop Research Centre	Brewing and beverage technology students from the Centre of Life and Food Sciences (WZW), Dr. Hanke	40
IPZ 5	Engelhard, B. Kammhuber, K. Seigner, E.	18.08.10	Hüll Hop Research Centre	Bayer Crop Science	35

WG	Name	Date	Topic/Title	Guest institution	No. of partic.
IPZ 5	Engelhard, B. Kammhuber, K. Seigner, E.	20.08.10	Hüll Hop Research Centre	Kirin, Mitsubishi, Japan; HVG	6
IPZ 5	Engelhard, B., Kammhuber, K., Seigner, E.	04.10.10	Hüll Hop Research Centre	Suntory, Japan, Dr. Pichlmaier, HVG	7
IPZ 5	Engelhard, B. Kammhuber, K. Seigner, E.	05.10.10	Hop research at Hüll	Polar brewers from Venezuela	3
IPZ 5	Engelhard, B. Seigner, E.	05.10.10	Hop research at Hüll	Dr. Haunold, USA, and company	3
IPZ 5	Fuß, S., Lutz, A.	02.11.10	Hop breeding and hop production	Instit. for Agric. Engineering and Animal Husbandry (ILT)	2
IPZ 5	Lutz, A. Kammhuber, K. Schwarz J.	11.06.10	Hop breeding, hopy analysis and plant protection	Pfaffenhofen vocational school	8
IPZ 5	Lutz, A. Kammhuber, K. Weihrauch, F.	25.06.10	Hop Research at Hüll; hop research, organic hop farming	Dr. Ebner with Italian students (slow food)	15
IPZ 5	Lutz, A. Weihrauch, F.	23.08.10	Hop Research at Hüll, low trellis system,	Zatec Hop Research Institute, Czech Republic	4
IPZ 5	Lutz, A. Kammhuber, K. Seigner, E.	25.08.10	Hop varieties, hop production and hop analysis	Russian regional agricultural minister and delegation	3
IPZ 5	Lutz, A. Kammhuber, K. Weihrauch, F.	20.10.10	Hüll Hop Research Centre	SAB-Miller, Poland and Russia, Ms. Ohnesorge, HVG	4
IPZ 5a	Fuß, S.	25.07.10	Current pest and disease situation, recommendations	Hop growers from Oberumelsdorf and vicinity	25
IPZ 5a	Münsterer, J.	04.08.10	Hop irrigation trials	München/Freising Water Authroity	12
IPZ 5a	Münsterer, J.	08.09.10	Hop drying measuring techniques	HVG employees	5
IPZ 5a	Niedermeier, E.	24.06.10	Hop farmland walkthrough; current plant-protection situation and strategies	Hop growers from Osselts-hausen and vicinity	22
IPZ 5a	Niedermeier, E.	30.06.10	Hop farmland walkthrough; current plant-protection situation and strategies	Hop growers from Uttenhofen and vicinity	17
IPZ 5a	Niedermeier, E.	04.08.10	Farmland walkthrough; current crop production and plant protection measures	Hop growers from Wolnzach	19
IPZ 5a	Niedermeier, E.	18.08.10	Farmland walkthrough; current crop production and plant protection measures	Bavarian Farmers' Assoc. (BBV), representatives from the Geisenfeld municipality. Venue: Engelbrechtsmünster	37
IPZ 5a	Niedermeier, E.	26.08.10	Guided bus tour, hop syndicate hop day	Niederlauterbach hop syndicate	50
IPZ 5a	Niedermeier, E.	02.09.10	Guided bus tour	Guests of the Association of German Hop Growers	50

WG	Name	Date	Topic/Title	Guest institution	No. of partic.
IPZ 5a	Portner, J.	21.06.10	Farmland walkthrough; current crop production and plant protection measures	Hop growers	35
IPZ 5a	Portner, J.	22.06.10	Farmland walkthrough; current crop production and plant protection measures	Hop growers	30
IPZ 5a	Portner, J.	04.08.10	Guided tour of trial plantings	Hop syndicate hop growers	10
IPZ 5a	Portner, J.; Fuß, S.	05.08.10	Guided bus tour of trial plantings	Assoc. of graduates from Kehlheim Agric. College	60
IPZ 5a	Portner, J.; Fuß, S.	06.08.10	Guided bus tour of trial plantings	Assoc. of graduates from Landshut Agric. College	15
IPZ 5a	Portner, J.; Fuß, S.	10.08.10	Guided bus tour of trial plantings	Young Hop Growers' Association	40
IPZ 5a	Portner, J.; Fuß, S.	11.08.10	Guided bus tour of trial plantings	Empoyees of the Freising District Administrator's office	15
IPZ 5a	Portner, J.	02.09.10	Guided bus tour	Guests of the Association of German Hop Growers	50
IPZ 5a	Schätzl, J.	23.06.10	Latest update on plant protection and fertilisation	Hop growers from Grafendorf, Rudelzhausen and Au	20
IPZ 5a	Schätzl, J.	29.06.10	Current pest and disease situation, recommendations	Hop growers from Walkertshofen and vicinity	19
IPZ 5a	Schätzl, J.	22.07.10	Latest update on plant protection	Hop growers from Abens	13
IPZ 5a	Schätzl, J.	05.08.10	Irrigation experience, final downy-mildew treatments	Hop growers from Au and Rudelzhausen	19
IPZ 5	Seefelder, S. Seigner, E.	19.08.10	Genome analysis in hops, hop breeding	Suntory, Japan	2
IPZ 5c	Lutz, A.	21.07.10	Hüll Hop Research Centre	Association of hop-trial experts	25
IPZ 5c	Lutz, A.	13.04.10	Breeding of hop varieties	D. Gamache, USA	1
IPZ 5c	Lutz, A.	31.08.10	Breeding line assessment	Barth-Haas Group, Nuremberg	2
IPZ 5c	Lutz, A.	09.09.10	Hop varieties and lines; breeding	Dr. Kaltner, Niederlauterbach hop syndicate	1
IPZ 5c	Lutz, A.	27.09.10	Hop research at Hüll	Food technology students from Belarus	21
IPZ 5c	Lutz, A.	08.11.10	Hüll Hop Research Centre	Asahi Brewery, Japan; Joh. Barth	3
IPZ 5c	Lutz, A.	18.11.10	Hüll Hop Research Centre	Mr. Takishita, Asahi Brewery, Japan;	1
IPZ 5c	Lutz, A. Kammhuber, K. Seigner, E.	03.02.10	Hop research at Hüll	Suntory Liquors Ltd.	3
IPZ 5c	Lutz, A. Seigner, E.	08.07.10	Hop breeding	Federal and European Plant Variety Offices	3

WG	Name	Date	Topic/Title	Guest institution	No. of partic.
IPZ 5c	Lutz, A. S. Seefelder Seigner, E.	09.08.10	Hop Breeding	Sapporo Breweries, Japan	1
IPZ 5c	Lutz, A. Seigner, E.	07.09.10	Hop Breeding	SAB-Miller, South Africa	2
IPZ 5c	Seefelder, S.	10.02.10	Hop genome analysis, medicinal and soice plants, grasses	Postgraduate students (sustainable raw materials) from Regensburg university	9
IPZ 5c	Seigner, E.	10.02.10	Hop research and current biotechnological studies	Postgraduate students (sustainable raw materials) from Regensburg university	9
IPZ 5c	Seigner, E.	09.09.10	Biogenesis patterns and studies in 2010	Agricultural committee of the German brewers' association	8
IPZ 5c	Seigner, E.	19.09.10	Hop Research at Hüll	AB-InBev	57
IPZ 5c	Seigner, E.	05.10.10	Biotechnology and genome analysis in hop research	Brewers from Polar brewery, Venezuela	3

8.3.4 Exhibitions and posters

(WG = work group)

Name of exhibition	Exhibition objects/projects and poster topics	Organiser	Duration of exhibit	WG
Hop-drying information day in Wolnzach	• Hop drying (poster) • Optimising hop drying (poster) • Necessary measuring points for drying optimisation (poster) • Development of a novel measuring technique to further enhance drying performance (poster) • Integrated energy-saving strategy (poster)	LfL, HVG, HR, HVH	19.10.2010	IPZ 5a
HopFA at the Mainburg Gallimarkt	Equipment for fully automated hop training-wire suspension (poster)	Soller booth	09.10.-11.10.10	IPZ 5a + ILT
HopFA at the Mainburg Gallimarkt	• Hop drying (poster) • Necessary measuring points for drying optimisation (poster) • Integrated energy-saving strategy (poster)	ATEF booth	09.10.-11.10.10	IPZ 5a
Attenkirchen beer festival	• Hop components • Hop is not only indispensable for beer brewing but is also a medicinal plant	Attenkirchen Tourismus GmbH	29.-30.05.10	IPZ 5d
Medicinal plant production in Germany – success through coordinated research	• Hop is not only indispensable for beer brewing but is also a medicinal plant	BMELV	25.10.-26.10.10	IPZ 5d

8.4 Basic and advanced training

Name, work group	Topic	Participants
Engelhard, B., Lutz, A., IPZ 5	Practical semester, Weihenstephan univ.	Stefan Elfinger
Engelhard, B., Lutz, A., Seigner, E., Seefelder, S., IPZ 5	Practical component of degree course in brewing, Technical University of Munich (TUM) in Weihenstephan; hop breeding, biotechnology, genome analysis and plant protection	Sebastian Schmid
Engelhard, B., Portner, J., Fuß, S., Lutz, A., IPZ 5	Bachelor degree thesis, Ludwig Maximilian University: Statistical forecasting of crop yield and of alpha-acid content for various hop varieties in the Hallertau region	Igor Lomow
IPZ 5	Hop Dept. practical: breeding, plant protection, chemical analysis and crop husbandry	Sabrina Lachermeier, Mathias Pitzel, Stefanie Bergsteiner, Sebastian Netter, Anna Bauer
Lutz, A., Fuß, S., IPZ 5	Doctoral thesis, LfL-Instit. for Agric. Engineering and Animal Husbandry (ILT): Greenhouse gas accounting in agriculture	Yu Han
Lutz, A., IPZ 5	Doctoral thesis, TUM: Climate-change impacts on various crops (e.g. wine, hops)	Anna Bock
Portner, J., IPZ 5a	Hop drying	9 1st and 3rd-semester students from the Pfaffenhofen School of Agriculture
Portner, J., IPZ 5a	Hop conditioning	9 1st and 3rd-semester students from the Pfaffenhofen School of Agriculture
Portner, J., IPZ 5a	Hop varieties	17 1st and 3rd-semester students from the Pfaffenhofen School of Agriculture
Portner, J., IPZ 5a	Supervision and evaluation of hop-growing work projects for the Masters examination	3 Master-diploma candidates
Schätzl, J., IPZ 5a	Diseases and pests, current plant protection methods, warning service	7 2nd-semester students from the Pfaffenhofen School of Agriculture studying hop production
Schätzl, J., IPZ 5a	Final professional-farming examination (hop production) in Dornbach	Exam. candidates from the Freising district (focus on hop production)
Schätzl, J., Münsterer, J., alle IPZ 5a	Final professional-farming examination (hop production) in Jauchshofen	Exam. candidates from the Kehlheim, Landshut and Pfaffenhofen districts
Lutz, A., IPZ 5c	Seminar work: hop pests and diseases and development of control methods, as exemplified by the aphid, over the past 30 years	Simon Renkl
Seefelder, S., IPZ 5c	Chemistry-lab technician training: hop genome analysis, characterisation of *Verticillium* pathotypes	Tim Nerbas

8.5 Final-year university degree projects

WG	Name	Topic/title of final-year university degree project	Duration	LfL supervisors / Cooperation
IPZ 5	Lachermeier, Ute	Determination of leaf surface area in different hop varieties and its impact on plant-protective dose rates	01.04. - 30.11.2010	B. Engelhard, TUM, Institute of Phytomedicine, Prof. Hückelhoven, Dr. Hausladen

8.6 Participation in work groups, memberships

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

8.7 Awards and commendations

8.7.1 Anniversaries

9 Current research projects financed by third parties

WG Project manager	Project	Duration	Sponsor	Cooperation
IPZ 5a J. Portner	Automatic hop-yield recording and mapping	2008-2011	Erzeugergemeinschaft HVG	J. Rottmeier, Erding; 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	2008-2011	Erzeugergemeinschaft HVG	5 hop growers; Mitterer, Terlan Italy
IPZ 5a J. Portner	Development of fully automated wire-stringing equipment for hop-growing	2008-2010	BLE (Federal Agency for Agriculture and Food)	ILT, Freising; Soller GmbH, Geisenfeld
IPZ 5a J. Portner	Studies to investigate the structural design of hop trellis systems	2009-2010	Erzeugergemeinschaft HVG	Bauplanungs- u. Ing.-Büro S. Breitner, Wolnzach
IPZ 5b B. Engelhard	Review of an innovative forecasting model for the control of powdery mildew (*Podosphaera macularis*) in hops	2010-2012	Erzeugergemeinschaft Hopfen HVG	4 hop farms;
IPZ 5b/IPZ 5a B. Engelhard	Leaf surface-area development in 3 hop varieties and its impact on plant protection measures	2010	LfL, Syngenta	TUM, Chair of Phytomedicine
IPZ 5b B. Engelhard	Reducing copper in plant protectives for organic farming	2010 – 2013	BLE	Organic hop farm
IPZ 5b B. Engelhard	Behaviour of bees in the hop yard and guttation studies in hops	2010	Erzeugergemeinschaft Hopfen HVG	Apicultural State Instit. at Hohenheim Univ.; Bav. State Research Centre for Viticulture and Horticulture, Knowledge Centre Bees; Julius Kühn Instit.; beekeepers
IPZ 5b F. Weihrauch	*Agriotes* species diagnosis in hop yards	2010	LfL., Syngenta	Syngenta
IPZ 5b B. Engelhard	Development of integrated methods of plant protection against the Lucerne weevil (*Otiorhynchus ligustici*) in hops	2008-2010	BLE (Federal Agency for Agriculture and Food)	Curculio-Institut e.V., Hanover; hop farms; joint project organised by JKI;

IPZ 5b/IPZ 5c B. Engelhard	Long-term optimization of aphid (*Phorodon humuli*) control in hops (*Humulus lupulus*) by means of control thresholds and breeding of aphid-tolerant hop cultivars	2008-2011	DBU (Deutsche Bundesstiftung Umwelt)	Hop farms
IPZ 5b/IPZ 5c/ IPZ 5d B. Engelhard	Identification of compounds involved in the attraction and resistance of hop to the damson-hop aphid: preliminary surveys in 2009	2010-2011	Erzeugergemeinschaft Hopfen HVG	Plant Research International B .V., Wageningen, NL
IPZ 5c Dr. E. Seigner A. Lutz	Breeding of resistant hops particularly suited for growth on low-trellis systems	2007-2011	BLE (Federal Agency for Agriculture and Food)	Hop growers J. Schrag und M. Mauermeier; GfH
IPZ 5c Dr. E. Seigner A. Lutz Dr. S. Seefelder	PM isolates and their use in breeding PM-resistant hops	2006-2010 2011-2012	Wissenschaftliche Station für Brauerei in München e.V.; Erzeugergemeinschaft Hopfen HVG e.G.	EpiLogic
IPZ 5c Dr. E. Seigner	Characterisation of hop/hop powdery mildew interaction at cell level and functional analysis of defence-related genes	2008-2011	Erzeugergemeinschaft Hopfen HVG	Prof. Hückelhoven, TUM-WZW; Dr. Reichmann; IPZ 3b; EpiLogic
IPZ 5c Dr. S. Seefelder Dr. E. Seigner	Genotyping of *Verticillium* pathotypes in the Hallertau – basic findings concerning *Verticillium*-infection risk assessment	2008-2013	Erzeugergemeinschaft Hopfen HVG; Wissenschafts-förderung der Deutschen Brau-wirtschaft (Wifö)	E. Niedermeier, IPZ 5a; Dr. Radisek, Slov. Institute of Hop Research and Brewing; SL; Prof. G. Berg, Karl-Franzens-Uni. Graz, Austria,
IPZ 5c Dr. E. Seigner A. Lutz IPS 2c Dr. L. Seigner	Monitoring for Hop Stunt Viroid in hops Monitoring for dangerous viral and viroid hop infections in Germany	2008-2010 2011	Erzeugergemeinschaft Hopfen HVG Wissenschaftliche Station für Brauerei in München e.V.	Dr. K. Eastwell, Washington State University Prosser, USA
IPZ 5d Dr. Kammhuber	Differentiation and classification of the world hop range with the help of low-molecular polyphenols	2010-2011	Bayerisches Staatsministerium für Ernährung Landwirtschaft und Forsten (StMELF)	TUM Weihenste-phan, Dr. Coelhan

10 Main research areas

WG	Project	Duration	Cooperation
5a	Specialist advice on hop production techniques and business management	Ongoing	
5a	Production-related and economic evaluation of hop card indices	Ongoing	
5a	Compilation and updating of advisory-service documentation	Ongoing	
5a	Evaluation of downy mildew forecasting models and preparation of information for the warning service	Ongoing	
5a	Optimisation of plant-protective application methods and equipment; 2009: Spray-coating measurements with various blower models Spray-coating measurements with an innovative sprayer	Ongoing	
5a	Trials to investigate irrigation control in hop growing	2005-2011	Mosler; German weather service (DWD); IAB
5a	Drying and conditioning automation	2007-2010	ATEF
5a	Nitrogen enrichment trial to compare broadcast and banded fertilizer application	2007-2011	
5a	Development of fully automated wire-stringing equipment for hop-growing	2008-2010	Institute for Agricultural Engineering and Animal husbandry; Soller
5a	Response of various hop cultivars to reduced trellis height (6 m) and testing of new plant-protective application techniques	2008-2010	Mitterer
5a	Leaf fertilisation with Pentakeep	2008-2010	
5a	Testing of the Adcon weather model for the downy mildew warning service	2008-2013	Hop Producers' Ring
5a	Studies to investigate the structural design of hop trellis systems	2009-2010	Planungs- und Ingenieurbüro Breitner
5a	Positioning of drip hose in hop irrigation	2009-2011	
5a	Hallertauer model for resource-saving hop cultivation	2010-2014	Bav. State Instit. of Foresatry (LWF); Bav. Environment Agency (LfU); Ecozept
5b	Testing of plant-protectives for their efficacy against various harmful organisms and their compatibility in hops as a prerequisite for registration and authorisation of these products for hop growing – offical pesticide testing according to EPPO and GEP guidelines; 2010: 87 trial variants with 40 products at 29 locations	Ongoing	Plant protection companies; hop growers
5b	Phytosanitary measures for the re-establishment of hop yards on areas previously used for hops - 2 trial variants	2009 - 2010	2 hop growers
5b	Soil-pest control	2005 -	Hop growers
5b	EU-wide harmonisation of trial procedures for plant-protective products in hops	2005 -	Institutes in FR, CR, SI, UK, PL
5b	Trials aimed at reducing the amount of copper used to control downy mildew	2006 -	Spiess-Urania
5b	Testing of additives to improve the efficacy of insecticides	2009 - 2010	1 hop grower

WG	Project	Dura-tion	Cooperation
5b	Plant protection according to the warning service and control thresholds in two varieties being grown in a commercial hop yard; a cost and labour comparison with conventional methods	2009 - 2013	1 hop grower
5c	Breeding of high-quality, disease-resistant aroma and bitter varieties	Ongoing	EpiLogic, Dr. F. Felsenstein, Freising
5c	Testing of wild hops as a new genetic resource for breeding powdery-mildew-resistant cultivars	Since 1999	EpiLogic, Dr. F. Felsenstein, Freising
5c	Breeding of high-quality aroma and bitter varieties containing optimised hop components	Ongoing	IPZ 5d
5c	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
5c	Use of molecular markers for testing breeding material for PM resistance and for distinguishing between male and female seedlings	Ongoing	
5c	Meristem cultures to eliminate viruses – a basic requisite for virus-free planting stock	Since 2009	
5c	Optimisation of in-vitro propagation – especially for foreign varieties and wild hops	Since 2010	
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 analytical methods for hop polyphenols (total polyphenols, flavomoids and individual substances such as quercetin and kaempferol based on HPLC)	2007-open-ended	Working Group of Hop Analysis (AHA)
5d	Production of pure alpha acids and their ortho-phenylenediamine complexes for monitoring and calibrating the ICE 2 and ICE 3 calibration extracts	Ongoing	Working Group of Hop Analysis (AHA)
5d	Ring tests for checking and standardising important analytical parameters within the AHA laboratory (e.g. linalool, nitrate, HSI)	Ongoing	Working Group of Hop Analysis (AHA)
5d	Development of an NIRS calibration model for alpha-acid content based on HPLC data	2000-offen	
5d	Organisation and evaluation of ring analyses for α-acid determination fo hop supply contracts	2000-open-ended	Working Group of Hop Analysis (AHA)
5d	Variety checks for the food control authorities	Ongoing	District adminis-trators' offices (food control)
5d	Introduction and establishment of UHPLC in hop analytics	2008-open-ended	

11 Personnel at IPZ 5 – Hops Department

The following staff members were employed at the Bavarian State Research Centre for Agriculture, Institute for Crop Science and Plant Breeding, at Hüll, Wolnzach and Freising in 2010 (WG = Work Group)

IPZ 5

Coordinator: LLD Engelhard Bernhard

Dandl Maximilian
Felsl Maria
Fischer Elke (as of 01.07.2010)
Hertwig Alexandra (special leave as of 01.07.2010)
Hock Elfriede
Krenauer Birgit
Maier Margret
Mauermeier Michael
Pflügl Ursula
Presl Irmgard
Suchostawski Christa
Waldinger Josef
Weiher Johann

IPZ 5a

WG Hop Cultivation/Production Techniques
LD Portner Johann

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

IPZ 5b

WG Plant Protection in Hop Growing
LLD Engelhard Bernhard

LOI Eicheldinger Renate (parental leave)
LTA Ehrenstraßer Olga
B. Sc. Lachermeier Ute
LHS Meyr Georg
Dipl.-Ing. (FH) Schwarz Johannes
Dipl.-Ing. (FH) Sterler Andreas (from 19.04. to 30.09.2010)
Dr. rer. nat. Weihrauch Florian

IPZ 5c

WG Hop Breeding Research
RD Dr. Seigner Elisabeth

Agr.-Techn. Bogenrieder Anton
CTA Forster Brigitte
Frank Daniel
MS Biotech. (Univ.) Drofenigg Katja (as of 01.06.2010)
CTA Hager Petra (as of 01.03.2010)
LTA Haugg Brigitte
LTA Kneidl Jutta
LAR Lutz Anton
CL Mayer Veronika (until 14.03.2010)
Dipl.-Biol. (Univ.) Oberhollenzer Kathrin
CL Petosic Sabrina
BL Püschel Carolyn
ORR Dr. Seefelder Stefan
Ziegltrum Ursula (until 31.12.2010)

IPZ 5d

WG Hop Quality/Hop Analytics
ORR Dr. Kammhuber Klaus

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