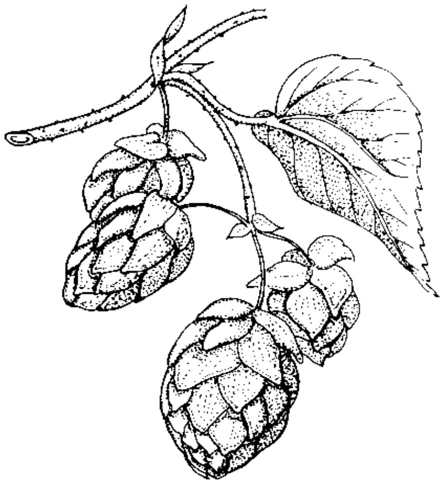
Bayerische Landesanstalt für Landwirtschaft

Gesellschaft für Hopfenforschung e.V.

Annual Report 2012

Special Crop: Hops



Bavarian State Research Center for Agriculture

- Institute for Crop Science and Plant Breeding -

and the

Society of Hop Research e.V.

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Foreword

The 2012 Annual Hops Report provides its customary detailed insights into the consulting and research activities taking place in and around the Hops Research Centre in Hüll. This work is as important today as it was when hops research commenced 90 years ago. Being export-oriented, the German hop-growing industry is directly affected by the challenges posed by the global market. In high-wage Germany, this industry can only be ensured by ongoing, generally accessible research activities and reliable, objective knowledge transfer.

The Institute for Crop Science and Plant Breeding (IPZ) of the Bavarian State Research Center for Agriculture (LfL) and the Society of Hop Research are jointly committed to this challenge. With its sites in Freising (biotechnology), Hüll (Hop Research Centre with plant protection, breeding and quality research and analytics) and Wolnzach (hop cultivation and production techniques), the Hops Department performs extensive, holistic research into all important questions relating to hops. Advantage is taken of all conceivable synergies. Cooperation partners include German and foreign university institutes, state and federal agencies and organisations from the brewing and hops industries. Apart from ongoing tasks, a large number of third-party-financed projects are also processed. The Institute for Crop Science and Plant Breeding is in a position to react rapidly and flexibly to questions, suggestions and ideas coming from hop industry participants. High-ranking representatives from the brewing industry and brewing science are in close contact with the Hops Research Centre via the Advisory Board of the Society of Hop Research.

In the field of breeding, the new "Special Flavor Hops" are setting the course for innovative beers with new market opportunities. At the same time, plant hygiene occupies an equally important role in breeding activities, the goal being to ensure environmentally friendly, cost-efficient cultivation with the help of resistant varieties.

At the same time, intrinsic product quality plays a more important role in the case of hops than anywhere else. Special analytics and dedicated quality research are indispensable for the breeding process. The Hüll quality team have succeeded in taking full advantage of the technical opportunities available to them and obtaining aroma profiles that attest to the high quality of the Hüll special-flavor cultivars.

In the field of plant protection, the usual projects and routine tests were accompanied by the setup of promising EU-level cooperation aimed at maintaining and enhancing the availability of plant protection procedures for hops. In the research field, special emphasis is placed on environmentally friendly techniques, modern disease forecasting and the protection of non-target organisms.

Work was performed on a large number of research issues relating to production techniques. Optimised, precise equipment, irrigation control, harvesting methods and ongoing enhancement of post-harvest technology – hop drying and conditioning - are but a few examples.

Of decisive importance for hops research as a whole are the transfer of knowledge and practical consulting services provided. Facts and current research findings are transferred objectively and effectively by providing up-to-date expert information - via fax, Internet, specialist publications - and through countless lectures and events.

For hop research, the future holds old and new challenges that can only be met by a motivated team. Together with numerous partners within and without the LfL, the staff employed in hops research at Hüll, Freising and Wolnzach have performed excellent work in the period under review, for which they deserve our sincere thanks.

It is equally important for research opportunities to be ensured in the long term and findings constantly updated. In the face of strained budgets and rising costs for energy, servicing, equipment and material, this is not always an easy task. The public-private partnership that finds special expression in the cooperation between the LfL and the Society of Hop Research is therefore all the more valuable. Common goals here are the technical optimisation of quality and pathogen analytics, the upgrading of the buildings and IT enhancement.

Dr. Michael Möller	Dr. Peter Doleschel
Chairman of the Managing Committee	Head of the Institute for
of the Society of Hop Research	Crop Science and Plant Breeding

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1 Research projects and main research areas of the Hops Department

1.1 Current research projects

Cross breeding with the Tettnanger landrace

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtung und AG Hopfenqualität/Hopfenanalytik *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Breeding Research and WG Hop Quality/Hop Analytics*
Financed by:	Ministry of Rural Affairs, Food and Consumer Protection, Baden-Württemberg Tettnang Hop Growers' Association; Erzeugergemeinschaft Hopfen HVG e.G. *(HVG hop producer group)* Gesellschaft für Hopfenforschung e.V., (Society of Hop Research)
Project manager:	Dr. E. Seigner, A. Lutz
Project staff:	A. Lutz, J. Kneidl; D. Ismann and breeding team (all from IPZ 5c) Dr. K. Kammhuber, C. Petzina, B. Wyschkon, M. Hainzlmaier and S. Weihrauch (all from IPZ 5d)
Cooperation:	Straß experimental station, F. Wöllhaf
Duration:	01.05.2011 - 31.12.2014

Objective

The aim of this breeding project is to significantly improve yield and fungal resistance of the Tettnanger landrace while maintaining the aroma of the original Tettnanger as closely as possible. Since this objective cannot be achieved purely by selective breeding within the naturally occurring variability of the Tettnanger landrace, attempts must be made to cross Tettnanger with pre-selected male aroma lines showing broad disease resistance and good agronomic performance.

Results

The preliminary selection of seedlings obtained from the seven crosses performed in 2011 commenced in spring. After they had been artifically inoculated, first with various PM strains and then with downy mildew zoosporangia, the seedlings were tested in the greenhouse for their disease resistance and tolerance. 428 seedlings classified as disease resistant/tolerant were subsequently transferred to the vegetation hall for further selection based on growth vigour, sex, disease resistance and cone formation. In spring 2013, 303 promising female lines will be planted out in the Hüll breeding yard, where the seedlings will be assessed for 3 years. A few male lines will be planted out for further monitoring in the male-hops breeding yard.

242 pre-selected female seedlings stemming from the initial two crosses performed in 2010 have been under assessment in the Hüll breeding yard since the autumn of 2011.

In autumn 2012, cones were harvested for the first time from seven of these first-generation seedlings (2011/24 seedlings), these seven having been assessed as having a fine, hoppy aroma, and the cone contents chemically analysed (EBC 7.7).

Properties	Tettnanger	Seedlings (2011/24)
Aroma	Fine, hoppy, spicy	Fine, hoppy, spicy
α-acids (%)[1]	3.8	4.3 – 5.8
β-acids (%)[1]	4.0	2.3 – 4.7
Cohumulone (%)[2]	23	20 – 23
Xanthohumol (%)[1]	0.4	0.2 – 0.4

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

The chemical data obtained for the first seedlings from this breeding programme provide initial evidence that the breeding objective can be reached. Assessment of the results must take into account the fact that the cones of young hop plants (in their first year of cultivation) do not yet show their full potential. Moreover, reliable assessment of the agronomic qualities is not yet possible at this early development stage. Only in the next two years will these seedlings demonstrate their growth vigour, disease resistance (resistance/tolerance towards downy mildew, powdery mildew, botrytis and *Verticillium* wilt) and their potential yield. Reliable findings relating to aroma assessment and bitter content will also be available by then.

In keeping with the project plan, four more crosses were performed between Tettnanger and four pre-selected male lines showing potential for traditional or fruity aroma, disease resistance and good agronomic qualities.

With 13 crosses and 525 female seedlings that stem from this breeding programme and are either already being monitored in the breeding yard or will be planted out in 2013, the project plan specifications were already fulfilled during the second year of the 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:	Erzeugergemeinschaft Hopfen HVG e.G. *(HVG Hop Producer Group)*
Project manager:	Dr. E. Seigner, A. Lutz
Project staff:	A. Lutz, J. Kneidl, K. Oberhollenzer, S. Hasyn (EpiLogic)
Cooperation:	Dr. F. Felsenstein, EpiLogic GmbH, Agrarbiologische Forschung und Beratung, Freising
Duration:	01.01.2011 - 31.12.2012

Objective

PM isolates with characteristic virulence properties have been used for PM resistance-testing in the greenhouse and lab since 2000. Together with the greenhouse and lab testing systems, which are subject to constant improvement, they are the mainstays of effective breeding of PM-resistant hop cultivars.

Results

Eleven previously characterised single-spore isolates of *Podosphaera macularis*, the fungus that causes powdery mildew in hops, and the above resistance-testing systems were used in 2012 with the following objectives:

- As every year, to assess the virulence situation of all eleven PM isolates prior to the commencement of tests in February. To this end, a selection of eleven hop varieties carrying all the hitherto-known resistance genes were used to differentiate between the virulence properties. This provided certainty that, even years after their cultivation, none of the isolates available for testing had lost any of their virulence genes via mutation. Three new isolates with unknown virulence properties were cultivated in 2012. These will be characterised for the first time in 2013.
- All the seedlings from 90 crosses performed in 2011 were inoculated artificially in the greenhouse, under standardized infection conditions, with three PM isolates carrying all the virulence properties widespread throughout the Hallertau region of Bavaria.
- In addition, breeding lines, cultivars and wild hops assessed in the greenhouse as resistant were re-assessed by EpiLogic in laboratory tests. To this end, use was made of an English PM isolate (R2 resistance gene) and an isolate of regional importance from the Hallertau growing region. Only breeding lines and cultivars found in both tests to show broad resistance to powdery mildew were used for advanced breeding purposes.

Overview of PM-resistance testing in 2012

2012	**Greenhouse tests**		**Laboratory tests**	
	Plants	**Assessments**	**Plants**	**Assessments**
Seedlings from 90 crosses	Approx. 100,000 by mass screening		-	-
Breeding lines	216	588	193	1,367
Cultivars	14	26	10	48
Wild hops	5	9	2	12
Virulence properties of the PM isolates	-	-	11	375

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 and Dr. Ruth Eichmann of Munich Technical University, Chair of Phytopathology at the Wissenschaftszentrum Weihenstephan *(Centre of Life and Food Sciences)* Dr. F. Felsenstein, EpiLogic GmbH Agrarbiologische Forschung und Beratung, Freising
Duration:	01.04.2008 - 31.03.2012

Ms. K. Oberhollenzer is currently writing a dissertation on this work.

Research work on the increased incidence of *Verticillium* infections

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtungsforschung Hopfen und AG Hopfenbau/Produktionstechnik *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Breeding Research and WG Hop Cultivation/Production Techniques*
Financed by:	Erzeugergemeinschaft Hopfen HVG e.G. *(HVG hop producer group)* Wissenschaftsförderung der Deutschen Brauwirtschaft (Wifö)
Project manager:	Dr. S. Seefelder
Project staff:	K. Maurer , C. Püschel, P. Hager, K. Oberhollenzer, K. Hofmann, H. Schmid, E. Niedermeier
Cooperation:	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 Cultivation/Production Techniques)
Duration:	01.03.2008 - 31.05.2013

Objective

The current serious extent of hop wilt in certain parts of the Hallertau and also in isolated regions of the Tettnang growing area is necessitating huge efforts in various research areas. One important aim is to establish a reliable diagnostic system for *Verticillium*, the fungus that causes hop wilt, thus enabling hop farmers to destroy plants that are already infected but show no symptoms. This is crucial if this dangerous disease is to be prevented from spreading.

Given the worldwide absence of plant protectives that are effective against *Verticillium* wilt in hops or any other crops, another important area of research is focusing on preventive biological control strategies. The aim here is to test various bacterial strains successful in protecting other crops against soil-borne fungal pathogens for their suitability for use in hop growing.

Results

A rapid molecular *Verticillium* test, in which the fungus is identified directly from the hop bine, was developed successfully during the project. This real-time assay not only obviates the need for tedious fungus cultivation but also permits more sensitive detection of *V. albo-atrum* and *V. dahliae* than is possible with the standard PCR used to date. Four bacterial strains showing "potential" antagonistic effects were shown to have successfully colonized the experimental Hallertauer Tradition cultivar. A field trial with bioantagonists and two hop cultivars was set up to determine whether greenhouse tests can be reproduced in the field, and, in view of the urgency of exploring all possible methods by which hop farmers might control *Verticillium*, to save time. Work on the establishment of a selection system for possible *Verticillium*-tolerant seedlings in the breeding material via artificial *Verticillium* infection is currently being intensified as a protection against the new, far more aggressive forms of the pathogen.

Monitoring for dangerous viroid and viral hop infections in Germany

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenschutz, AG Pathogendiagnostik und Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtungsforschung Hopfen *(Bavarian State Research Center for Agriculture, Institute for Plant Protection, WG for Pathogen Diagnostics, and Institute for Crop Science and Plant Breeding, WG for Hop Breeding Research)*
Financed by:	Wissenschaftliche Station für Brauerei in München e.V. *(Scientific Station for Brewing in Munich)*
Project manager:	Dr. L. Seigner, Institute for Plant Protection (IPS 2c); Dr. E. Seigner, A. Lutz (both from IPZ 5c)
Project staff:	S. Kaiser[1], J. Matzka[2], C. Huber, L. Keckel, M. Kistler, D. Köhler, F. Nachtmann (all from IPS 2c); A. Lutz, J. Kneidl (IPZ 5c)

Cooperation:	Dr. K. Eastwell, Washington State University, Prosser, USA [1]Prof. Wolfgang W.P. Gerlach, Weihenstephan-Triesdorf University of Applied Sciences, Department of Horticulture and Food Technology [2]Prof. Thomas Ebertseder, Weihenstephan-Triesdorf University of Applied Sciences, Department of Agriculture and Food Economy IPZ 5a (WG Hop Cultivation/Production Techniques) IPZ 5b (WG Plant Protection in Hop Growing) Local hop consultants Hop Producers' Ring Hop farms Eickelmann propagation facility, Geisenfeld
Duration:	March - December 2012

Objective

Virus and viroid infections cause pronounced yield and alpha-acid losses in hops, particularly under stress conditions. This applies all the more because these infections are very easily spread mechanically or by aphids and cannot be controlled with plant protectives. Since 2009, the LfL has been monitoring hop-growing areas and the LfL's breeding yards in order to obtain information on the spread of hop stunt viroid. Monitoring was extended in 2011 to include five hop viruses. The intention, in the event of the dreaded hop stunt viroid (HSVd) being detected, is first and foremost to identify primary infection centres and rapidly eliminate them, thus preventing the disease from spreading.

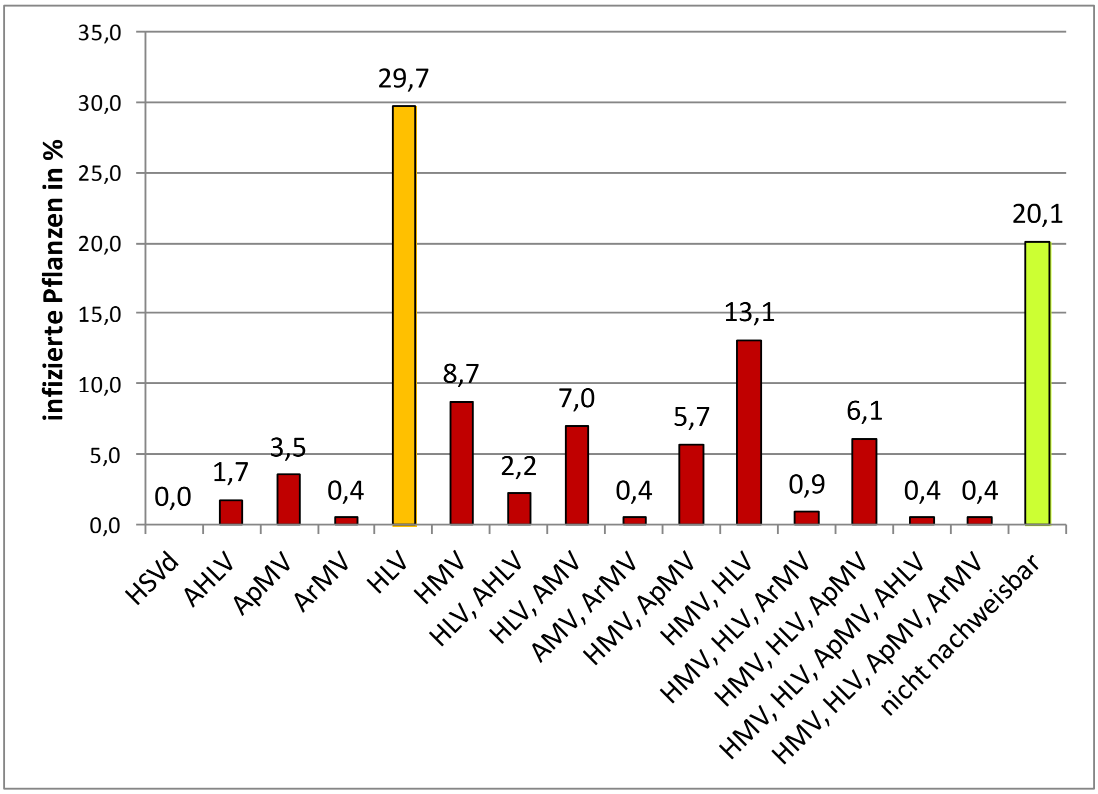
Method

Leaf samples taken from the LfL's breeding yards, the GfH's propagation facility and hop farms in the Hallertau and Tettnanger growing areas were tested molecularly and immunologically in the LfL's pathogen diagnostics lab (IPS 2c) for the following pathogens: apple mosaic virus (ApMV), hop mosaic carlavirus (HMV) and arabis mosaic virus (ArMV) with the DAS-ELISA (Double Antibody Sandwich Enzyme Linked Immunosorbent Assay); latent hop carlavirus (HLV) and hop stunt viroid (HSVd) with the RT-PCR (Reverse Transcriptase Polymerase Chain Reaction) assay, using primers from Eastwell and Nelson (2007) and from Eastwell (personal communication, 2009). This technique was also used to test for American latent hop carlavirus (AHLV) in a number of samples taken at random.

To ensure that the RT-PCR assay was functioning correctly and to rule out "false negative" results, it was backed up by an internal, hop-specific, mRNA-based RT-PCR control (Seigner et al. 2008). Most of the tests were performed by two undergraduates from the Weihenstephan-Triesdorf University of Applied Sciences.

Results

HSVd was not detected in any of the 249 hop samples tested in 2012. By contrast, massive infection with the various viruses was identified. However, the infection incidence is less serious than it may appear, because most of the samples from hop farms were taken from plants showing disease symptoms.



Overview of virus and viroid infections detected in 2012; red = infections that impair crop yields and alpha-acid yields; HLV (orange)= latent infection only with no recognizable effects. 44 % of the samples tested for viruses were infected with only one virus, while 31 % showed multiple infections.

HLV was identified in very many samples (59 %). Hop plants infected solely with this virus showed no visible damage. However, hop latent carlavirus was often found in combination with up to three other virus types. Serious effects on yields and hop components must be expected in these plants, especially since all other virus types, such as ApMV, HMV and, in particular, ArMV, cause pronounced damage. 94 % of the samples that tested positive were infected with the aphid-borne HMV and HLV carlaviruses. Testing for AHLV, which is also transmitted by aphids, was only performed on random samples because, according to the literature, this virus is only relevant in the USA and in hop material from the USA. Nine of the 53 hop plants tested were found to be infected with AHLV. Very few samples tested positive for ArMV. All the virus-infected plants identified at one of the Society of Hop Research's propagation facilities were destroyed immediately, thus guaranteeing that cuttings from this source are healthy and virus-fee.

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 Hopfen HVG e.G. *(HVG hop producer group)*
Project manager:	B. Engelhard (until 03/2011), Dr. F. Weihrauch
Project staff:	J. Schwarz, G. Meyr
Duration:	01.01.2010 - 31.12.2012

Objective

A preliminary forecasting model formulated over a number of years by B. Engelhard on the basis of empirical data and a weather-based forecasting model formulated in a dissertation by Dr. S. Schlagenhaufer and based on scientific data were tested over a number of years in field trials. However, the infection pressure in several untreated plots was too low at the time of the trials to permit conclusive statements on the reliability of the forecasts. The trials were intended to clarify whether one of the two models might be implemented in a reliable forecasting system.

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.

As in the preceding years, PM outbreak on the untreated plots was low in 2012 and neither model triggered any spray warnings except for one in July. At harvesting time, infection levels in the untreated plots were again much too low for the trial to furnish conclusive results.

The only genuine spray warning of the season was triggered by both models for all cultivars on July 4th. The “preliminary model” also triggered a pre-weekend preventive warning for all locations on June 6th following five relevant daily sections. On conclusion of the assessment at the end of August, no relevant infection levels were detected in either the untreated control plots or the treated plots.

Evaluation of the two powdery mildew forecasting models will be continued during the coming years as a long-term task of the same magnitude.

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

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Pflanzenschutz Hopfen *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Plant Protection)*
Financed by:	Bundesanstalt für Landwirtschaft und Ernährung (BLE) *(Federal Agency for Agriculture and Food),* Bundesprogramm Ökologischer Landbau und andere Formen nachhaltiger Landwirtschaft (BÖLN)
Project manager:	B. Engelhard (until 03/2011), Dr. F. Weihrauch
Project staff:	J. Schwarz, D. Ismann, G. Meyr
Cooperation:	Pichlmaier's Naturland farm, Haushausen
Duration:	19.04.2010 - 28.02.2014

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. At this juncture, however, organic farmers of practically all crops cannot manage without this active agent. The aim of this four-year experimental project is thus to test the extent to which the amount of copper used per season in hops can be reduced without affecting crop yields and the quality of the harvested hops. The intention is to reduce the currently permitted copper dose rate of 4.0 kg/ha/year by at least 25 %, to 3.0 kg/ha/year.

Results

A downy mildew station for monitoring zoosporangia was set up once again (this time in an organic hop yard next to the trial yard) and the findings evaluated. In June 2012, zoosporangia counts were up to 8 times higher (10 and 15 times higher in 2010 and 2011 respectively) in the organic hop yard than at comparable stations set up by the warning service in conventional hop yards. Once again, increases and decreases in the number of zoosporangia followed a relatively similar time pattern in the organic hop yard and in conventional hop yards.

The full-scale trial was conducted again in 2012. This time, in contrast to 2011, there were no statutory obstacles preventing the use of the originally planned copper hydroxides ("Cuprozin progress" and "Funguran progress"). In addition to these two products, two other copper-containing fungicides were used in 2012: the tribasic copper sulphate "Cuproxat" and microencapsulated copper sulphate (CuCaps), which is designed to release the copper ions, i.e. the active agent, slowly and continuously.

As in the preceding years, no completely copper-free variants were included in the 2012 trial apart from the untreated control.

The three selected plant tonics, "Herbagreen", "Biplantol" und "Frutogard", basically characterise the most important compositions among the wide variety of available tonics. Each of the three tonics was used in combination with "Funguran progress". The giant knotweed extract "Sakalia" and the fungicide "Polyversum" were used, again in combination with "Funguran progress", in tentative experiments, each of which was only performed in one plot.

- As in the preceding years, copper application was distributed over six sprayings. The specified dose rates of 4.0, 3.0 and 2.0 kg copper/ha were not exceeded with any of the products. Conventional organic products (stone dust and brown algae) were added to each spray.
- In contrast to the very high infection pressure of 2011, downy mildew outbreaks in the Hallertau growing region were normal again in 2012. This meant that the conditions for conducting the trial were also normal.
- The hops produced in the untreated plots were unmarketable due to the very high infection level (92.8 % of cones infected at harvesting time) and, once again, had to be destroyed. Yield assessments for these plots also showed highly significant losses. Otherwise, marketable hops were produced under all test conditions.
- Assessment of the different variants showed that cone infection was less severe in all variants treated with 3.0 kg copper/ha than in those treated with 2.0 kg copper/ha.
- In contrast to 2011, the addition of synergists to copper hydroxide did not enhance the copper's control effect in all cases, as the cone infection level of 3.4 % shown by the "standard" Funguran progress variant at harvesting time was already excellent. As in the preceding years, however, the two "Frutogard" variants were clearly the most effective against downy mildew.
- The best variant was 3.0 kg Cu/ha Funguran progress plus Frutogard (0.3 % diseased cones), followed by 2.0 kg Cu/ha Funguran progress plus Frutogard (0.7 %). The infection level was slightly higher (2.9 % diseased cones) in the 3.0 kg Cu/ha Funguran progress plus Biplantol variant, followed by 3.0 kg Cu/ha Funguran progress solo (3.4 %), 4.0 kg Cu/ha Funguran (3.7 %), 3.0 kg Cu/ha Funguran progress plus Herbagreen (3.8 %) and 2.0 kg Cu/ha Funguran progress plus Biplantol (4.2 %). All the above-mentioned variants must be confirmed as providing excellent protection against downy mildew, NFQ price reductions therefore being excluded.
- Cone and root samples taken from plots 1 (untreated) and from plots 11 and 12 (3-year use of Frutogard) were tested for residual phosphonate. 15.7 and 12.1 mg/kg dry matter were measured in the cone samples from Frutogard-treated plots 11 and 12 respectively. This is astonishing, especially as the last Frutogard treatment had taken place as long ago as July 9th, before the plants had flowered and eight weeks before the harvest. Since the cones did not form until well after the last treatment, the active agent must have reached them in the form of a detectable residue via systemic distribution within the plant. This phenomenon had not been observed in the two preceding years. In the root samples, as in the untreated cone samples, phosphonate was always below the detection limit of 0.5 mg/kg dry matter. It is therefore unlikely that the active agent accumulates in the root zone.
- Assessment of the results should take account of the fact that the experiment was carried out on the Perle variety, which is tolerant towards downy mildew. When it comes to more susceptible cultivars, the low copper doses probably have their limits.

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

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

Objective

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

Within the framework of a nation-wide, multi-year joint project aimed at remedying this situation, adult click-beetle monitoring commenced in the Hallertau in 2010. In the third project year, 2012, beetles caught in pheromone traps in the LfL's breeding yard in Stadelhof (Pfaffenhofen district, 385 m a.s.l., soil: clay) and in a conventional yard on the edge of the Paar valley (Gambach, Pfaffenhofen district, 425 m a.s.l., soil: sand) were compared. In Gambach, soil traps for wireworms were positioned in a hilled row with young plants showing apparent wireworm damage. The traps were baited with germinating wheat grains and emptied at fortnightly intervals.

Results

Over a 15-week period in 2012 (April 26th – August 2nd), a total of 452 adult beetles (7 species, 6 of them *Agriotes* species) were caught in pheromone traps (Stadelhof: 110 beetles, Gambach: 342 beetles). The striped click beetle, *A. Lineatus*, was the main species at both locations, making up 60 % of the catch. It was followed by the dusky click beetle, *A. Obscurus,* (21.8 and 20.2 %) and the common click beetle, *A. Sputator* (7.3 and 15.2 %). In addition, small numbers (<5 %) of *A. acuminatus*, *A. gallicus* and *A. ustulatus* were caught at both locations.

Astonishingly, the 85 wireworms caught in the soil traps (7 species, identified by Dr. J. Lehmhus, JKI Braunschweig) presented a completely different picture: *Agriotes lineatus*, *A. obscurus* and *A. sputator* together accounted for only 10 % of the total catch, the majority of which consisted of the *Agrypnus murinus* (40 %) and *Selatosomus aeneus* (36 %) species. According to the literature, the latter two tend to be considered as carnivorous beetles. Further research is therefore essential in order to clarify what actually happens in the root zone of hop plants.

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, E. Neuhof-Buckl, B. Wyschkon
Cooperation:	Dr. M. Coelhan and team, Munich Technical University, WZW *(Centre of Life and Food Sciences, Weihenstephan)*, Weihenstephan Research Center for Brewing and Food Quality
Duration:	01.01.2010 - 31.06.2012

Objective

The intention was first to devise a suitable sample preparation technique and HPLC method for analysing the entire global range of hop varieties available in Hüll (2009, 2010 and 2011 harvests). The aim was then to establish whether it is possible to differentiate between hop varieties and divide them up into groups, possibly even by country.

Results

The entire global range of hop varieties harvested in 2009, 2010 and 2011 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, have relatively similar flavonoid compositions. A country-based classification is possible to some extent. Principal-component analysis and cluster analysis were used to evaluate the data and to identify and visualize similarities and differences. A final report was prepared and some of the results published in “Brewing Science”.

Improvement of aroma characterisation for Hüll "Special Flavor Hops"

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

Objective

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

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

Results

Work on the research project is currently underway. The results will be published in the next annual report.

Development and optimisation of an automatic hop-picking machine

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, *(Bavarian State Research Center for Agriculture),* Institut für Pflanzenbau und Pflanzenzüchtung *(Institute for Crop Science and Plant Breeding)* and Institut für Landtechnik und Tierhaltung *(Institute for Agricultural Engineering and Animal Husbandry)*
Financed by:	Bundesanstalt für Landwirtschaft und Ernährung (BLE) *(Federal Agency for Agriculture and Food)*
Project manager:	J. Portner
Project staff:	IPZ 5 and Drs. G. Fröhlich and Z. Gobor from the Institute for Agricultural Engineering and Animal Husbandry
Cooperation:	Fuß Maschinenbau GmbH & Co. KG, Schkölen
Duration:	01.09.2011 - 31.03.2014

Objective

The aim is to automate attachment of the hop bines to the intake arm of the picking machine and thus manage without the largely foreign seasonal workers currently employed for picking purposes without compromising picking quality. The first step will be to cut the hop bines, which are 6-7 m long, into pieces measuring approx. 1m in length. The cutting machine is under development. A metering device will then feed the bine segments uniformly to a modified picker that is basically similar to the already-improved lateral picker produced by Fuß Maschinenbau GmbH. The picker will strip the hop cones from the bine segments and convey them as before, together with the loose leaves, to the cleaning unit.

Results

Various configurations for the future cutting device were tested during the 2011 hop harvest, and preliminary hop picking was filmed with a high-speed camera. The findings were incorporated in the development and design of an automatic hop-picker prototype. In 2012, construction of the prototype was commenced and initial picking trials were performed.

The stack of bines deposited by the transport vehicle was supplied via an inclined ramp with a scraper floor to a pre-cutting device whose upward moving cutters sever bine segments of approx. 1 m length from the stack. A pre-picking belt, which is positioned adjacent to the cutting device and moves upwards together with the cutter, strips off some of the cones during the cutting process and conveys the severed bine segments to a belt via which they are conveyed to a picker (still to be constructed) which strips the remaining cones from the hop bine stems and laterals. On the way there, the cones and leaves already stripped off are separated from the bine segments by a sorting belt.

In an initial, tentative trial, the picking quality of the pre-cut bines was compared with conventional hop-picking, where the bines are attached manually to the picker intake arm.

Optimisation of irrigation management in hop growing

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, *(Bavarian State Research Center for Agriculture),* Institut für PIflanzenbau und Pflanzenzüchtung *(Institute for Crop Science and Plant Breeding)*
Financed by:	Dt. Bundesstiftung Umwelt (DBU) and Erzeugergemeinschaft HVG e.G. *(HVG hop producer group)*
Project manager:	Dr. M. Beck
Project staff:	T. Graf, J. Münsterer
Cooperation:	Dr. M. Beck, Weihenstephan-Triesdorf University of Applied Sciences Prof. U. Schmidhalter, Technical University of Munich/Weihenstephan A. Werner, Thuringia State Research Centre for Agriculture ATEF, Oberhartheim
Duration:	01.12.2011 - 30.11.2014

Objective

The use of irrigation systems in hop growing helps reduce yield fluctuations and guarantees a steady supply of high-quality hops. For irrigation purposes, use is made almost exclusively of drip hoses. Usually, however, they are installed and operated by rule of thumb through lack of experience and information. Inefficient operation may cause high costs and environmental problems stemming from high water consumption and nutrient displacement.

The trial plots selected for the project were equipped with the necessary water distribution and measuring systems. Work during this first project year consisted mainly in installing the drip system, optimizing the experimental setups and configuring the complex measuring system. With the equipment in place at an early stage, it was even possible to obtain initial results.

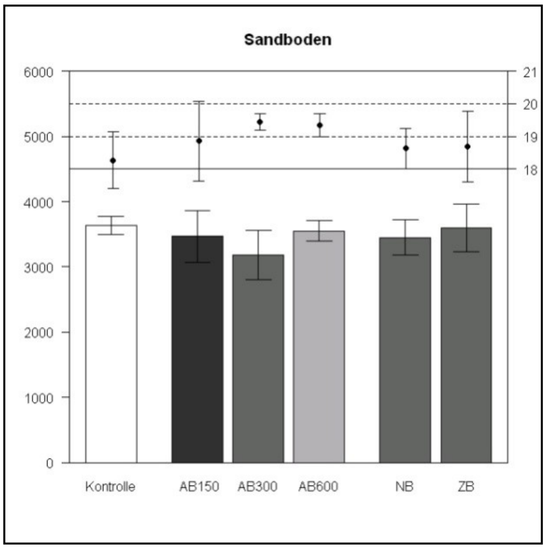
Material and methods

To minimize possible influencing factors and interactions, two soil types (sand and clay) typical of the growing area and planted with the frequently cultivated Herkules variety were selected for the principal trials. Two trial fields for six variants with sixfold replications were pegged out, one on sand and one on clay.

The drip-hose was positioned according to the three variants commonly used by hop farmers (AB = on top of the hilled row, NB = buried beside the hilled row, ZB = buried in the centre of the tractor aisles). Commencement of irrigation was scheduled as a function of soil moisture (water tension). Three tension levels were selected, 150 hPa, 300 hPa and 600 hPa. Commencement of irrigation was set at 300 hPa for all three drip-hose positions. In 2012, the NB and ZB variants were irrigated simultaneously with the AB variant and therefore received the same amount of water. The only difference was the position from which the water was distributed.

Results

The 2012 results showed that the supplemental water supply, which was dosed via objective control modules connected up to Watermark sensors (manufacturer: Irrometer Co., measuring range: 0-200 cbar), had no influence on hop yields. Problems such as correct sensor positioning must be borne in mind here, as this is what determines maximum and minimum volumes of irrigation water. 430 m³ water were distributed per hectare in the trial (AB150, sandy soil). Experience shows this amount of supplemental water to be small, which is perhaps why yields were not enhanced. These problems will be taken into consideration during two further trial years. The basic findings and recommendations will be published in the form of a guide at the end of the project.



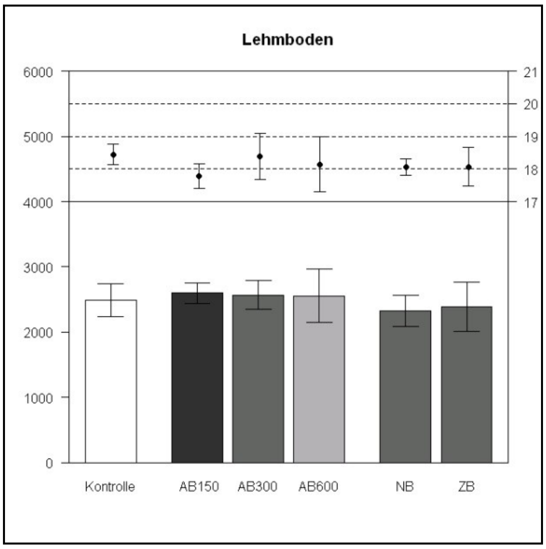


Figure 1: Yield (kg/ha) and α-acid content (%) for different irrigation strategies on sandy soil (control = no irrigation, AB = drip hose on top of the hilled row at soil moisture tensions of 150, 300 and 600 hPa), NB = drip hose buried beside the hilled row, ZB = drip hose buried in the tractor aisle; NB and ZB were

Figure 1: Yield (kg/ha) and α-acid content (%) for different irrigation strategies on clay soil (control = no irrigation, AB = drip hose on top of the hilled row at soil moisture tensions of 150, 300 and 600 hPa), NB = drip hose buried beside the hilled row, ZB = drip hose buried in the tractor aisle; NB and ZB were

1.2 Main research areas

1.2.1 Hop breeding

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

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

Objective

The aim of this project is to help German hop growers compete better with their American counterparts in times of surplus production and low hop prices by breeding hop cultivars with fruity, citrusy and exotic aromas. US craft brewers and other creative brewers around the world are in pursuit of such cultivars for their specialty beers.

Material and methods

Special crosses have been performed since 2006 in order to achieve this breeding goal. Initially, the US variety Cascade was the mother plant of choice on account of its flowery, citrusy aroma, with Hüll male breeding lines contributing characteristics such as improved disease resistance, good agronomic performance and classical aroma nuances. In the course of further breeding work, Hüll breeding material with fruity, exotic aromas was used as well. Additionally, pre-selected lines stemming from earlier high-alpha breeding programmes were tested for novel aromas. The breeder selected lines with interesting organoleptic qualities and chemical data and submitted them for appraisal to a large number of experts in the hop and brewing industries, who then tested them in numerous brewing trials. Testing times for assessing resistance and agronomic performance were considerably reduced in some cases to enable speedy launching of the new hop varieties on the hop market.

Results

By spring 2012, applications for registration as cultivars had been filed with the Community Plant Variety Office for four of several breeding lines presented to the public (Lutz et al., 2012). The multifaceted aroma nuances of these four cultivars had been confirmed in numerous brewing trials.

Chemical data and aroma descriptions of the new Hüll Special Flavor Hops. The data stem from the results of 3-5 crop years; the figures for total polyphenol are based on assays performed solely on the 2012 harvest; [1]in % (w/w); [2]relative, % of alpha acids; [3]ml/100 g dried cones; IPZ 5d chemical analyses

		EBC 7.7				EBC 9.11	EBC 7.10
Variety	**Aroma description**	**α-acids[1]**	**β-acids[1]**	**Cohu-mulone[2]**	**Xantho-humol[1]**	**Total poly-phenols[1]**	**Total oil[3]**
Mandarina Bavaria (2007/018/013)	Hoppy, fresh and fruity, reminiscent of mandarin-orange citrus	7.0-10.0	4.0-7.0	28 - 35	0.5-0.7	2.3-2.7	1.5-2.2
Huell Melon (2009/002/706)	Fruity and sweet, with nuances of honeydew melon, apricot, strawberry	7.0-8.0	6.0-8.0	25 - 28	0.4-0.7	3.0	0.8-2.1
Hallertau Blanc (2007/019/008)	Flowery-fruity, mango, grapefruit, gooseberry, white wine bouquet	9.0-11.0	4.0-7.0	19 - 25	0.2-0.5	3.1	1.5-1.8
Polaris (2000/109/728)	Fresh, spicy, fruity, with peppermint and "glacier mint"	18.0-24.0	5.0-6.5	22 - 29	0.9-1.0	2.6-2.7	4.4-4.8

Reference

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

Breeding of dwarf hops for low trellis systems

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

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

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

Objective

As part of a five-year research project financed by Germany's Federal Agency for Agriculture and Food (BLE), 72 selective crosses had been performed by 2011 with the aim of breeding hop varieties suitable for profitable and ecologically sustainable cultivation on low trellis systems.

Results

Selection of seedlings showing pronounced suitability for cultivation on low trellis systems was continued on the 3-metre trellis system in Starzhausen. In 2012, 67 breeding lines stemming from the crosses made specifically for the BLE-funded dwarf-hop project were harvested. Some of these breeding lines were of particular interest on account of their very fine and pleasant hop aroma, while others boasted crop volumes approaching those of our previously selected high-trellis aroma varieties.

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

In joint work with Dr. Weihrauch from IPZ 5b, the two predatory mite species *Phytoseiulus persimilis a*nd *Neoseiulus californicus* used in 2011 were employed again to combat the common spider mite. For the first time, the hop plants were not treated with acaricide at all. The use of netting proved to advantage here, as the hop plants in the individual rows grew up to form a hedge, enabling the beneficial organisms to spread unhindered over the whole row. Moreover, the spider-mite tolerant seedlings were clearly recognizable. Assisted by the predatory mites, they were highly successful in resisting massive spider mite colonisation.

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

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

Project manager:	Dr. E. Seigner
Project staff:	B. Haugg, A. Lutz
Cooperation:	Dr. L. Seigner, IPS 2c and team

Objective

Virus-free hop planting stock has been an important part of our quality drive for years, great importance also being attached to virus elimination within the context of the commercial release of Special Flavor Hops. Virus-free hops are ultimately essential for all forms of research.

Method

To produce virus-free hop plants, the shoot tips are first heat-treated prior to excision of the uppermost growth zone (= meristem), located at the apex of the shoot. Following heat treatment, these 0.2-0.3 mm cytogenous centres are considered virus-free. The meristems are transferred to special culture media, where they grow into complete plants.

To verify that the hops grown from meristems were really free of virus infections, their leaves were examined by the IPS 2c team for the various hop-typical viruses with the DAS-ELISA (Double Antibody Sandwich Enzyme Linked Immunosorbent Assay) or RT-PCR (Reverse Transcriptase Polymerase Chain Reaction) techniques (see virus testing details in 4.1.5). Testing for HMV and ApMV was always performed via ELISA, as the less expensive detection method, while the molecular technique was used to detect HLV infections and in cases where only very little *in vitro* starting material was available for testing.

Results

In addition to the routine tests for the HMV and ApMV viruses, tests for HLV (latent hop carlavirus) were performed in 2012, because virus monitoring in both 2011 and 2012 had shown high levels of infection with this virus. In the absence of a commercially available antiserum for detecting HLV and AHLV via DAS-ELISA, HLV testing had not been possible prior to the development of the RT-PCR method as a molecular alternative by the Work Group for Pathogen Diagnostics (IPS 2b), working within the framework of the project “Monitoring for dangerous viral and viroid infections in hops”, funded by the Scientific Station for Brewing in Munich.

As the virus-contaminated parent plants had tested free of hop stunt viroid and AHLV, there was no need to test the regenerated hop plants for these two pathogens.

Virus elimination was very reliable in the case of parent plants infected with HMV (hop mosaic virus). It was more difficult to eliminate ApMV (apple mosaic virus) and HLV (latent hop virus).

The effectiveness of the method is always greatly influenced strongly by seasonal fluctuations in growth vigour and vitality of the starting material and seasonal fluctuations in the in-vitro regeneration capability of the excised meristem. It was also found that certain genotypes can be cured more effectively than others with this tissue-culture technique. Herkules proved more difficult than Hüller Bitter, as was demonstrated by a somewhat lower regeneration rate (62 % compared with 73 % in Hüller Bitter) and also a lower percentage of virus-freed regenerated hop plants (75 % compared with 95 % in reference cultivars).

Work is currently underway to obtain virus-free stock in the case of two “Special Flavor Hops”. Some of the regenerated plants have already been confirmed free of HMV and ApMV.

The findings from virus and viroid monitoring in Germany’s hop-growing areas show how important meristem culture is for the provision of virus-free planting stock. In principle, it should also be possible to produce *Verticillium*-free planting stock with this technique.

Adams, A.N. 1975. Elimination of viruses from hop (*Humulus lupulus*) by heat therapy and meristem culture. J. Hort. Sci 50:151-160.

Kremheller, H. T., Rossbauer, G., and Ehrmaier, H. 1989. Reinfection of virus-free planted hop gardens with *Prunus* necrotic ringspot and hop mosaic virus. Effects of the virus infection upon the yield, alpha acids, and the disease symptoms of the various hop varieties. 133-136 in: Proc. Int. Workshop Hop Virus Dis. Giessen.

Kremheller, H.T., Ehrmaier, H., Gmelch, F., Hesse, H. (1989): Production and propagation of virus-free hops in Bavaria, Federal Republic of Germany. Deut. Phytomed. Gesellschaft, 131-134.

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

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

1.2.2 Hop cultivation and production techniques

Evaluation of the specific water requirements of various hop varieties irrigated as a function of soil moisture tension

Project staff: T. Graf, J. Münsterer

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

In an irrigation trial aimed at determining the specific water requirements of the Perle, Hallertauer Magnum and Herkules hop varieties on the basis of soil moisture tension, soil moisture tensions at two depths (30 and 60 cm) were measured and recorded for the period from July 5th – September 21st, 2012. All plants received the same volume of supplemental water.

Soil moisture tensions measured at 60 cm were higher for the Perle variety than for the high-alpa Hallertauer Magnum and Herkules varieties right from the start. Measurements taken at 30 cm were higher for Perle as from August. The tension curves for Hall. Magnum and Herkules followed a similar pattern.

The plan is to repeat the trial in 2013 and verify the results.

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), early-warning forecasts are 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 the peronospora locations is necessary. To this end, the index calculated by the Adcon weather stations is compared with the warnings based on the Kremheller model in order to determine Adcon thresholds for susceptible and tolerant varieties. Scientific tests are then performed to determine whether the different methods of triggering spray warnings have influenced yield and quality.

Optimisation of hop drying in a belt dryer

Project staff: J. Münsterer

It has already been shown how drying performance in floor kilns can be significantly increased and uniform high quality best maintained by selecting the correct ratio between the drying parameters, i.e. drying temperature, air speed and cone depth or weight. It is planned to use the findings from long-term trials in floor kilns in order to ascertain which measuring systems and basic settings produce the best drying results in belt dryers.

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

Project staff: S. Fuß

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

This project is now being continued with the Hallertauer Tradition variety in a commercial hop yard that is highly suitable on account of its homogeneous soil properties. In addition, trial plots with 7m and 6m trellises have been establised in the LfL's new breeding yard in Stadelhof and planted, in several replications, with the Perle, Herkules and Polaris varieties. This trial setup facilitates observation and comparison of the way in which the hop varieties react to the different trellis heights. The additional findings furnished by these trials will be used to draw up recommendation for hop farmers.

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

Project staff: J. Portner
Duration: 2012 - 2015

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

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

1.2.3 Hop quality and analytics

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

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

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

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

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

As of 2000, work commenced on the development of an HPLC-data-based NIRS calibration equation in Hüll and the laboratories of the hop-processing firms. In view of the rising number of alpha-acid analyses, the aim was to replace wet chemical analysis by a cheap, fast method with acceptable repeatability and reproducibility for routine use. It was decided, within the Working Group for Hop Analysis (AHA), that such a method could be deemed suitable for routine use and for use as an analytical method for hop supply contracts if it was at least as accurate as conductometric titration according to EBC 7.4.

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

Development of analytical methods for hop polyphenols

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

Polyphenols are attracting increasing attention within the context of alternative uses of hops, primarily on account of their health-promoting properties but also because they make a definite contribution to the organoleptic properties imparted by hops. It is therefore important to have suitable analytical methods available. To date, however, no officially standardized methods exist. All laboratories that analyse polyphenols rely on their own methods.

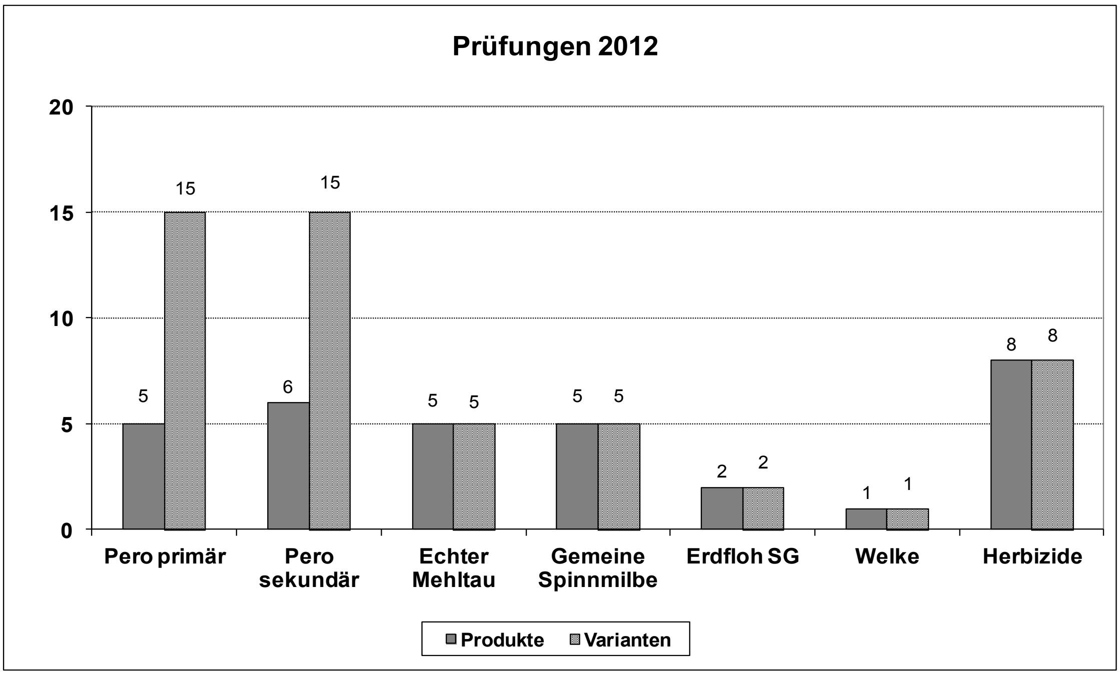
The AHA has been working on improving and standardizing the analytical methods for total polyphenol and total flavonoid contents in hops since 2007.

During the most recent ring tests with international involvement, however, the variation coefficients (cvr) for these techniques were so high that they are not yet suitable as official methods. The intention for the future is to place greater emphasis on more specific HPLC methods.

1.2.4 Plant protection in hops

Tests performed on plant protectives in 2012 for licensing and approval purposes and for advisory-service documentation

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



2 Weather conditions and hop growth in 2012 - effects on production techniques in the Hallertau

LD Wolfgang Sichelstiel, Dipl. Ing. agr.

After a very cold February, favourable weather conditions in March allowed work to commence on soil cultivation and hop pruning. Typical April weather delayed the start of training and stripping activities until late in the month, when a warm-weather period began.

Below-mean rainfall and average temperatures in May permitted timely completion of the necessary maintenance work under favourable conditions. In contrast to past years, hail damage was confined to a few areas of limited size.

The above-average vegetative growth seen in June as the result of heavy rain proceeded to slow down in July, which brought spells of dry weather. Heavy, evenly distributed rainfall in August finally led to a good crop with slightly above-average components; harvesting took place from late August onwards under relatively favourable external conditions.

Special weather conditions and their effects

- Severe spell of winter weather in February – dry, warm March

The winter of 2011/2012 was very changeable. Overall, December and January were too warm and too moist, with mean-temperature deviations at the Hüll location being +3.7 and +2.9°C, respectively, and rainfall amounts exceeding the long-term mean by 43 % and 96 %, respectively. A huge drop in temperature in early February brought winter weather, with minimum temperatures below -20°C and frost damage to crops in regions without sufficient snow cover. Whereas the hop stands in the Hallertau were protected by the snow, the Elbe-Saale region saw frost damage. Soil friability in all regions was very good as the result of the frost.

March was again warmer than average and far too dry, with only 30 % of the long-term average precipitation. As the ground was hard enough to drive on, abutting and pruning work could be performed from mid-March onwards.

- Changeable April

The first three weeks of April were cool and changeable, the last week dry with a temperatures increasing to early summer values. Overall, April was 1.6°C warmer than the long-term mean and the precipitation level 8% higher. Due to the increased moisture in the soil, most of the crowning work had to be delayed until the last week of April. Initial soil cultivation work in the form of shallow cover-crop incorporation also took place. Plant growth varied, depending on the relevant pruning time. Stripping and training activities could not commence until after 26th April, after the soil had warmed up slightly. Flea beetle infestation increased with the onset of warm weather, whereas primary downy mildew infection and crown rot were limited to isolated cases.

- Dry, moderately warm May

Precipitation of 58.8 mm, i.e. only two thirds of the long-term average, was recorded in May. In isolated cases, this took the form of local hailstorms. At 14.4°C, the mean temperature was slightly higher than the corresponding 10-year figure and 2.5°C higher than the long-term figure.

The relatively dry weather made itself felt in new plantings through isolated failures. On the other hand, favourable soil conditions allowed cultivation measures to be carried out, with initial hilling taking place in the 2nd week of May and secondary hilling commencing in the last few days of May.

Depending on the location and variety, the vines had reached a height of 3.0 to 5.5 m, i.e. slightly more than the long-term average, by the end of May. Stripping had already been performed in about 50% of the crops. Primary downy mildew infection occurred in isolated cases and was kept under control by watering or spraying treatments.

The forecasting model did not trigger any spray warnings for secondary downy mildew or powdery mildew. Whereas aphid migration was observed in isolated cases only, initial treatments for the management of the common spider mite were already necessary on southern slopes and in young vines. Severe damage from the Rosy Rustic caterpillar, also know as the potato stem borer, was observed in isolated acreages.

- Sufficient rain in June

Precipitation totalling 130.7 mm, or 22% more than the long-term average, was recorded at the Hüll location in June. It was spread relatively evenly over the month with the exception of two hot, rain-free phases lasting several days and occurring after the middle of the month and in the last week. Although the rain also took the form of thunderstorms, no substantial damage occurred as the result of hail or erosion.

The average temperature was 17.1°C and thus slightly lower than the ten-year mean but well above the long-term figure. Good growing weather led to above-average growth. By the end of the month, all varieties exhibited inflorescence buds and early and mid-season varieties were already blooming. A spray warning for all varieties to combat secondary downy mildew infection was issued on 13th June and one for susceptible varieties on 22nd June. The weather-based forecast models for powdery mildew did not point to any clear risk of infection. Protective treatment was recommended for susceptible varieties and in known infected areas on 13th June, as isolated cases of infection had been reported from the field.

Common spider mite infestation levels in the yards remained high, whereas aphid infestation levels were extremely low. After the hot days in the middle of the month, plant death due to Verticillium wilt infection was observed in infected yards.

- Very little rain in late July

Although precipitation of over 0.1 mm was recorded on 23 days in July, the month was 30% drier than the long-term average. On 13 days of July, less than 1 mm rain was recorded, which was insufficient to supply the roots with water. As temperatures tended to be quite warm at the same time, symptoms of dryness could be observed in yards in light-soil locations without irrigation in the last ten days of the month. Wilt symptoms also increased in affected areas.

The commencement of flowering was in line with the long-term mean. Initially, flowering was above average but declined towards the end of the month as a result of the dry weather. Two spray warnings for the control of downy mildew were issued for all varieties and an additional one for susceptible varieties.

The powdery mildew forecast models signalized a certain risk of infection at the start of the month and a spray recommendation for all susceptible varieties was issued. Measures to combat aphid infestation proved unnecessary in many yards, as there were very few or no aphids present. The common spider mite, on the other hand, proved more difficult to control in many yards. Despite two treatments, spider mites could still be found on leaves at the end of July.

- Rainy, warm weather at cone formation

Precipitation in August exceeded the long-term average by just under 80% and measured 176.5 mm. The lack of water at the start of cone formation in late July was thus offset. As the weather continued to be warm, crops ripened normally. Despite heavy rainfall, which led to soil being eroded and carried away from some hop yards, only two spray recommendations were issued for the control of downy mildew, one of them on 8th August, for all susceptible varieties, and the other on 31st August, for all late-maturing susceptible varieties. The adequate supply of water facilitated the formation of cones with good, slightly above-average alpha-acid contents. Harvesting of the medium-early varieties began on 27th August, this date being in line with the long-term average, as was also the case with the other varietal groups.

2.1 Weather data (monthly means or totals) for 2012 compared with 10- and 50-year means

Month		Temp. 2 m above ground Mean (°C)	Min. (°C)	Max. (°C)	Relat. hum. (%)	Precipi-tation (mm)	Days with ppn. >0.2 mm	Sun-shine (h)
January	2012	0.9	-2.5	5.1	84.8	111.5	19.0	69.3
Ø	10-y.	-1.0	-4.5	2.7	88.6	50.3	12.0	69.1
	50-y.	-2.4	-5.1	1.0	85.7	51.7	13.7	44.5
February	2012	-4.5	-9.8	2.3	77.2	23.5	12.0	108.3
Ø	10-y.	0.2	-4.2	5.1	85.3	41.5	11.9	93.4
	50-y.	-1.2	-5.1	2.9	82.8	48.4	12.8	68.7
March	2012	6.6	0.3	15.1	78.6	16.5	8.0	172.6
Ø	10-y.	3.8	-1.4	9.8	80.0	66.3	11.6	154.6
	50-y.	2.7	-2.3	8.2	78.8	43.5	11.3	134.4
April	2012	8.9	2.7	14.5	71.9	69.3	14.0	165.3
Ø	10-y.	9.5	2.9	16.4	71.8	56.0	9.9	215.2
	50-y.	7.4	1.8	13.3	75.9	55.9	12.4	165.0
May	2012	14.4	7.4	21.4	67.9	58.8	13.0	260.3
Ø	10-y.	13.6	7.4	20.1	74.2	101.6	14.5	216.0
	50-y.	11.9	5.7	17.8	75.1	86.1	14.0	207.4
June	2012	17.1	11.2	23.3	76.4	130.7	17.0	227.5
Ø	10-y.	17.5	10.9	24.1	74.1	92.7	14.3	233.8
	50-y.	15.3	8.9	21.2	75.6	106.1	14.2	220.0
July	2012	18.1	12.1	24.2	76.0	67.4	15.0	225.4
Ø	10-y.	17.5	11.6	24.6	79.8	108.1	13.2	212.1
	50-y.	16.9	10.6	23.1	76.3	108.4	13.9	240.3
August	2012	18.1	11.6	25.4	77.6	176.4	15.0	273.4
Ø	10-y.	17.5	11.6	24.6	79.8	108.1	13.2	212.1
	50-y.	16.0	10.2	22.5	79.4	94.9	13.3	218.4
September	2012	13.6	7.9	19.6	83.7	44.2	12.0	170.7
Ø	10-y.	13.4	7.7	20.3	82.9	59.6	10.3	179.4
	50-y.	12.8	7.4	19.4	81.5	65.9	11.4	174.5
October	2012	7.9	3.7	12.8	89.2	42.7	9.0	108.5
Ø	10-y.	8.5	3.8	14.5	87.0	59.7	11.4	120.6
	50-y.	7.5	2.8	13.0	84.8	60.0	10.4	112.9
November	2012	4.5	2.0	7.7	93.1	77.0	8.0	55.1
Ø	10-y.	3.9	0.4	8.0	91.4	57.7	12.3	63.7
	50-y.	3.2	-0.2	6.4	87.5	58.8	12.6	42.8
December	2012	0.4	-3.0	3.7	89.0	87.1	18.0	59.0
Ø	10-y.	0.1	-2.8	3.3	91.1	62.9	14.6	52.0
	50-y.	-0.9	-4.4	1.6	88.1	49.1	13.3	34.3
Ø 2012		8.8	3.6	14.6	80.5	907.4	160.0	1895.4
10–year mean		8.8	3.7	14.5	81.8	874.7	151.5	1850.6
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 2002 through 2011.

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
1973	8,591	2.33	1993	3,616	6.37
1974	8,120	2.48	1994	3,282	6.69
1975	7,654	2.64	1995	3,122	7.01
1976	7,063	2.79	1996	2,950	7.39
1977	6,617	2.90	1997	2,790	7.66
1978	5,979	2.94	1998	2,547	7.73
1979	5,772	2.99	1999	2,324	7.87
1980	5,716	3.14	2000	2,197	8.47
1981	5,649	3.40	2001	2,126	8.95
1982	5,580	3.58	2002	1,943	9.45
1983	5,408	3.66	2003	1,788	9.82
1984	5,206	3.77	2004	1,698	10.29
1985	5 044	3.89	2005	1,611	10.66
1986	4,847	4.05	2006	1,555	11.04
1987	4,613	4.18	2007	1,511	11.70
1988	4,488	4.41	2008	1,497	12.49
1989	4,298	4.64	2009	1,473	12.54
1990	4,183	5.35	2010	1,435	12.81
1991	3,957	5.70	2011	1,377	13.24
1992	3,796	6.05	2012	1,294	13.23

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 - 2012 vs. 2011				Increase + / Decrease - 2012 vs. 2011			
	2011	2012	ha	%	2011	2012	Farms	%	2011	2012
Hallertau	15,229	14,258	- 971	- 6.4	1,119	1,046	- 73	- 6.5	13.61	13.63
Spalt	366	348	- 18	- 4.9	70	64	- 6	- 8.6	5.23	5.44
Tettnang	1,222	1,215	- 7	- 0.6	157	153	- 4	- 2.5	7.78	7.94
Baden and Bitburg	20	20	± 0	± 0	2	2	± 0	± 0	10.00	10.00
Elbe-Saale	1,392	1,284	- 108	- 7.8	29	29	± 0	± 0	48.01	44.28
Germany	**18,228**	**17,124**	**-1.104**	**- 6.1**	**1,377**	**1,294**	**- 83**	**-6.0**	**13.24**	**13.23**

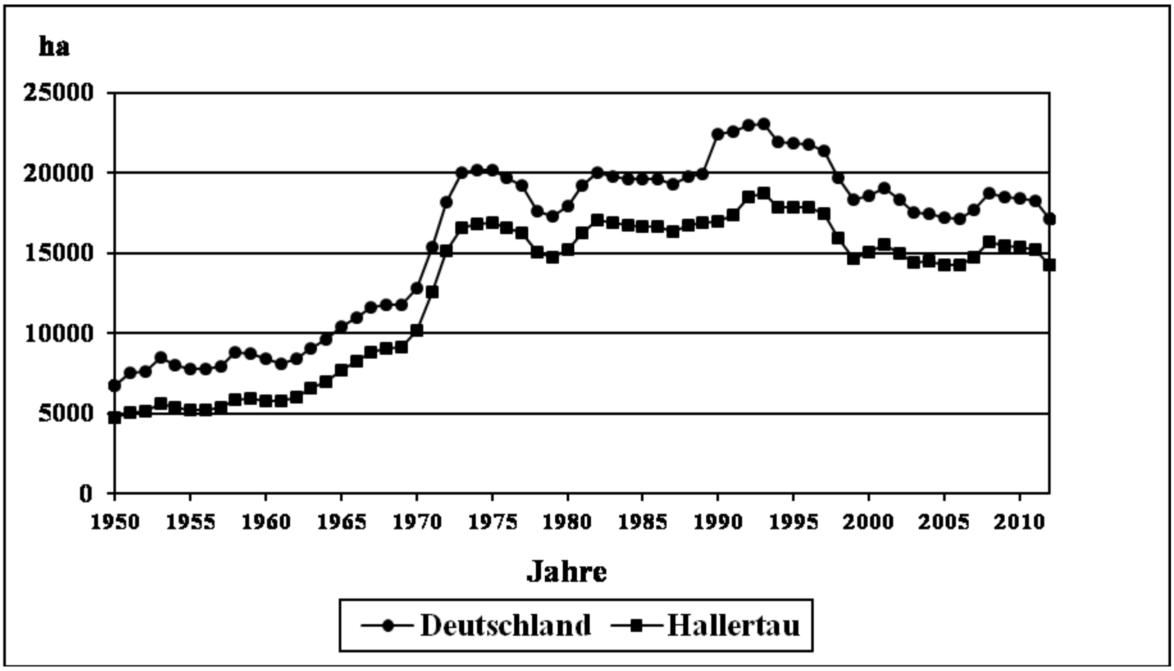


Fig. 3.1: Hop acreages in Germany and in the Hallertau

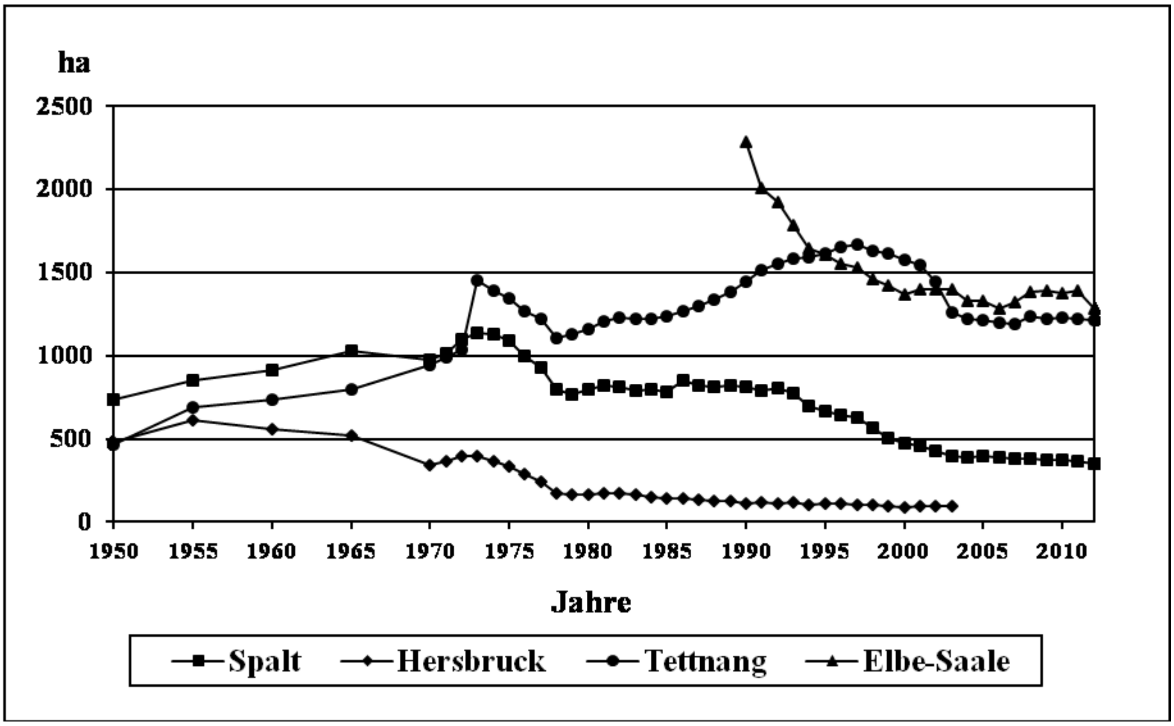


Fig. 3.2: Hop acreages in the Spalt, Hersbruck, Tettnang and Elbe-Saale regions

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 years preceding 2011, has since been reversed. Despite reductions of 368 ha and 735 ha in the acreages of aroma varieties and bitter varieties respectively, the aroma varieties' share in the total acreage under hop production has risen to 55.6 % (plus 1.3 %), while that of the bitter varieties has decreased to 44.4 %. The recent trend towards increased cultivation of "Special Flavor Hops", e.g. hops with flavors reminiscent of fruit and citrus, has not yet caught on in Germany. Only 48 ha, or 0.3 %, of the total area under hop production in 2012 were planted with the newly registered Hüll flavor-hop varieties "Polaris", "Mandarina Bavaria", "Huell Melon" and "Hallertau Blanc" or the American "Cascade" aroma variety.

The glut on the hop market and the subdued forward contracts situation are responsible for the general reduction in hop acreage. In 2012, the total area under hop production in Germany was only 17,124 ha. Of the aroma varieties, Perle and Spalter Select saw complete clearance of a sizeable area previously under cultivation, namely 193 ha and 181 ha respectively. With the exception of Herkules (+ 28 ha), all the bitter varieties saw some of their acreage cleared, with Hall.Magnum witnessing the greatest decrease, namely 530 ha.

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

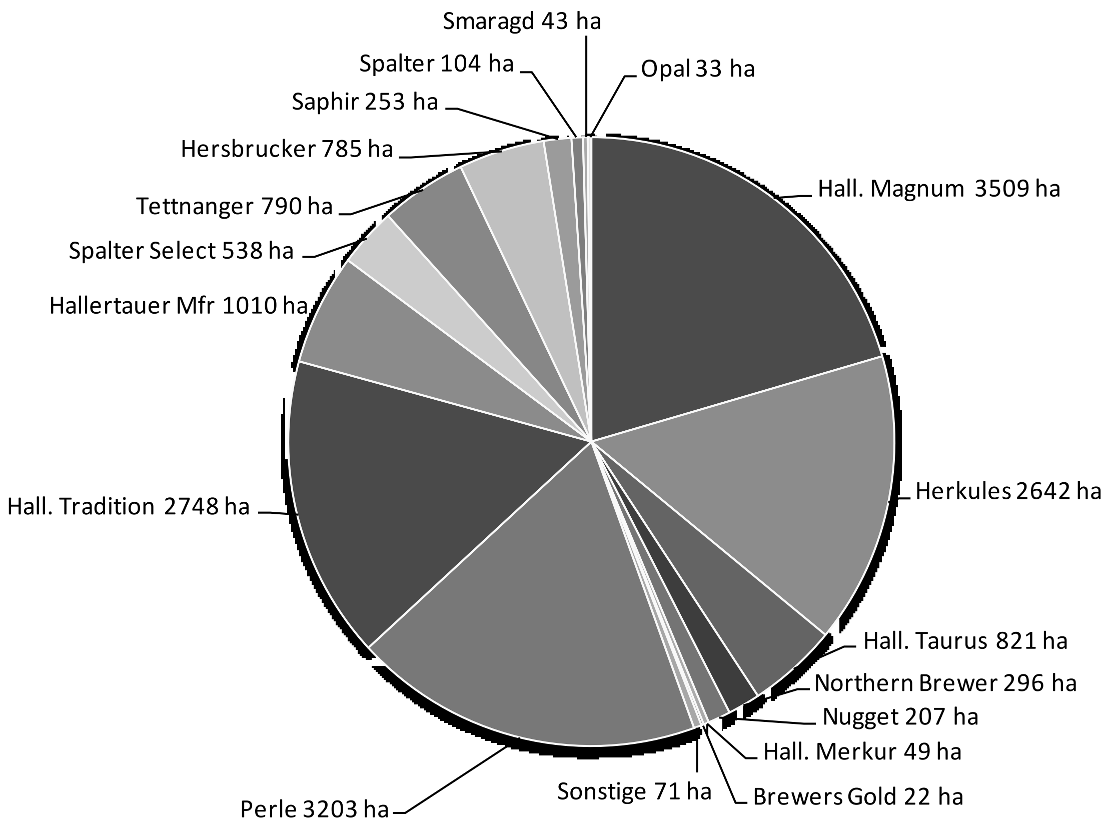


Fig. 3.3: Distribution of hop varieties in Germany in 2012

Tab. 3.3: Aroma hop varieties in the German hop-growing regions in ha in 2012

Region	Total acreage	HA	SP	TE	HE	PE	SE	HT	SR	OL	SD	Other	Aroma varieties	
													ha	%
Hallertau	14,258	716			782	2,965	448	2,624	237	31	31	12	7,845	55.0
Spalt	348	55	104		3	24	84	31	6	1	1		310	89.2
Tettnang	1,215	238		790		71	4	55	10		12		1,179	97.0
Baden, Bitburg and Rhine. Pal.	20	1				8	2	5					16	80.4
Elbe-Saale	1,284					135		33				8	176	13.7
Germany	**17,124**	**1,010**	**104**	**790**	**785**	**3,203**	**538**	**2,748**	**253**	**33**	**43**	**20**	**9,526**	**55.6**
% acreage by variety		5.9	0.6	4.6	4.6	18.7	3.1	16.0	1.5	0.2	0.3	0.1		

Variety changes in Germany

2011 ha	18,228	1,065	91	776	776	3,396	719	2,757	225	33	38	18	9,895	54.3
2012 ha	17,124	1,010	104	790	785	3,203	538	2,748	253	33	43	20	9,526	55.6
Change in ha	-1,104	-55	13	14	10	-193	-181	-10	28	-1	6	2	-368	1.3

Tab. 3.4: Bitter hop varieties in the German hop-growing regions in ha in 2012

Region	NB	BG	NU	TA	HM	TU	MR	HS	Sonst.	Bitter varieties	
										ha	%
Hallertau	190	22	179	2	2,696	795	33	2,457	40	6,412	45.0
Spalt					3		6	28	1	38	10.8
Tettnang						4		29	3	36	3.0
Baden, Bitburg and Rhine. Pal.					3			1		4	19.6
Elbe-Saale	106		29		808	22	11	127	6	1,108	86.3
Germany	**296**	**22**	**207**	**2**	**3,509**	**821**	**49**	**2,642**	**49**	**7,598**	**44.4**
% acreage by variety	1.7	0.1	1.2	0.0	20.5	4.8	0.3	15.4	0.3		

Variety changes in Germany

2011 ha	345	25	244	3	4,039	953	70	2,614	40	8,334	45.7
2012 ha	296	22	207	2	3,509	821	49	2,642	49	7,598	44.4
Change in ha	-49	-3	-36	-1	-530	-131	-21	28	9	-735	-1.3

3.2 Yields in 2012

Approximately 34,475,210 kg (= 689,504 cwt.) hops were harvested in Germany, as compared with 38,110,620 kg (= 762,212 cwt.) in 2011. The crop thus weighed 3,635,410 kg (= 72,708 cwt.) less than in the previous year, a decrease of 9.5 %.

The mean per-hectare yield was 2,013 kg, i.e. slightly above average. Alpha content was also slightly above average in 2012.

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

	2007	2008	2009	2010	2011	2012
Yield kg/ha and (cwt./ha)	1,819 kg (36.4 cwt.)	2,122 kg (42.4 cwt.)	1,697 kg (33.9 cwt.) (Severe hail damage)	1,862 kg (37.2 cwt.) (Hail damage)	2,091 kg (41.8 cwt.) (Hail damage)	2,013 kg (40.3 cwt.)
Acreage in ha	17,671	18,695	18,473	18,386	18,228	17,124
Total yield in kg and 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.	38,110,620 kg = 762,212 cwt.	34,475,210 kg = 689,504 cwt.

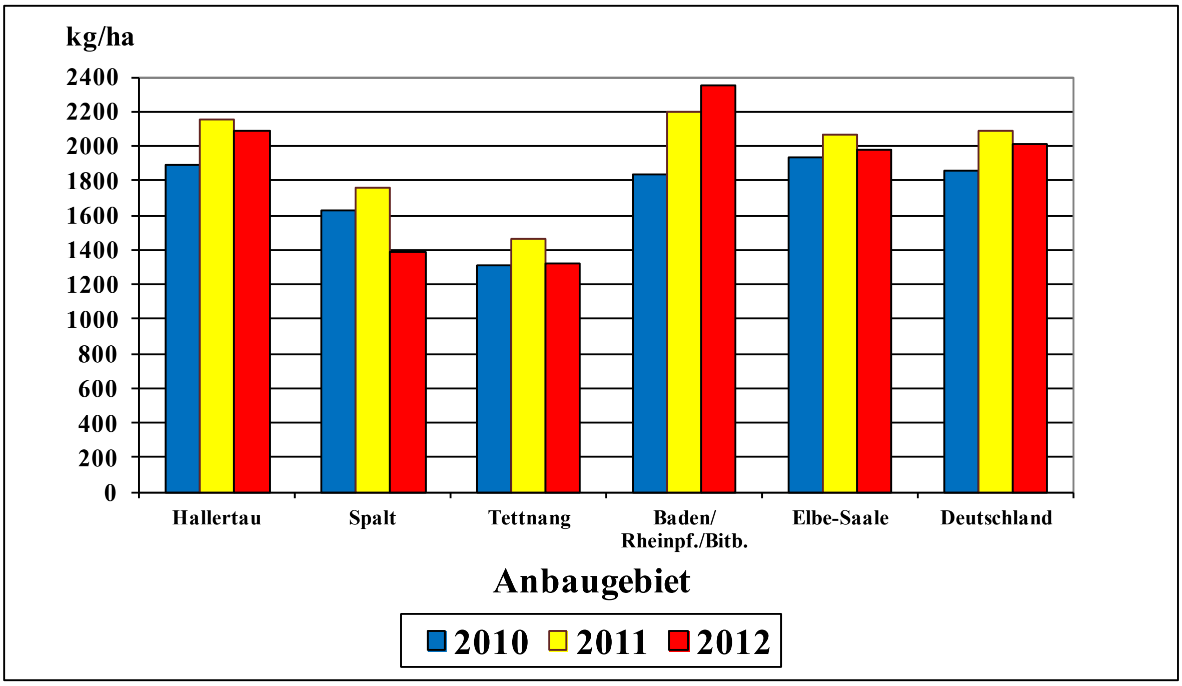


Fig. 3.4: Average yields by hop-growing region in kg/ha

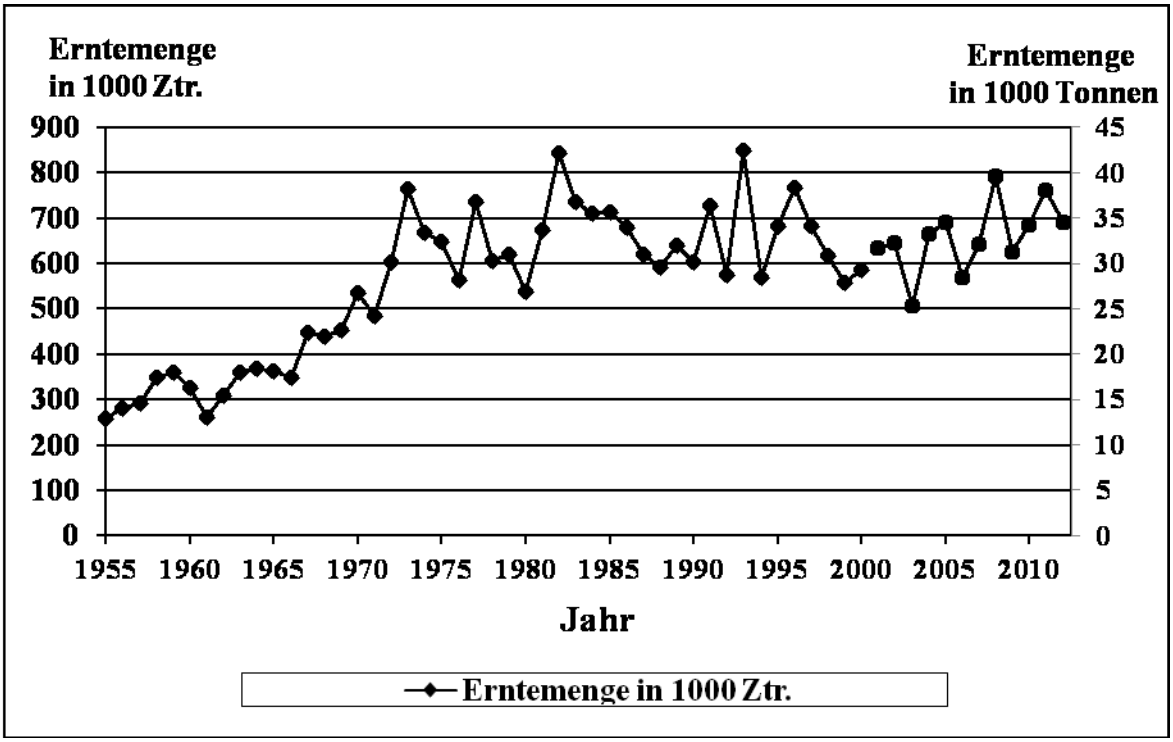


Fig. 3.5: Crop volumes in Germany

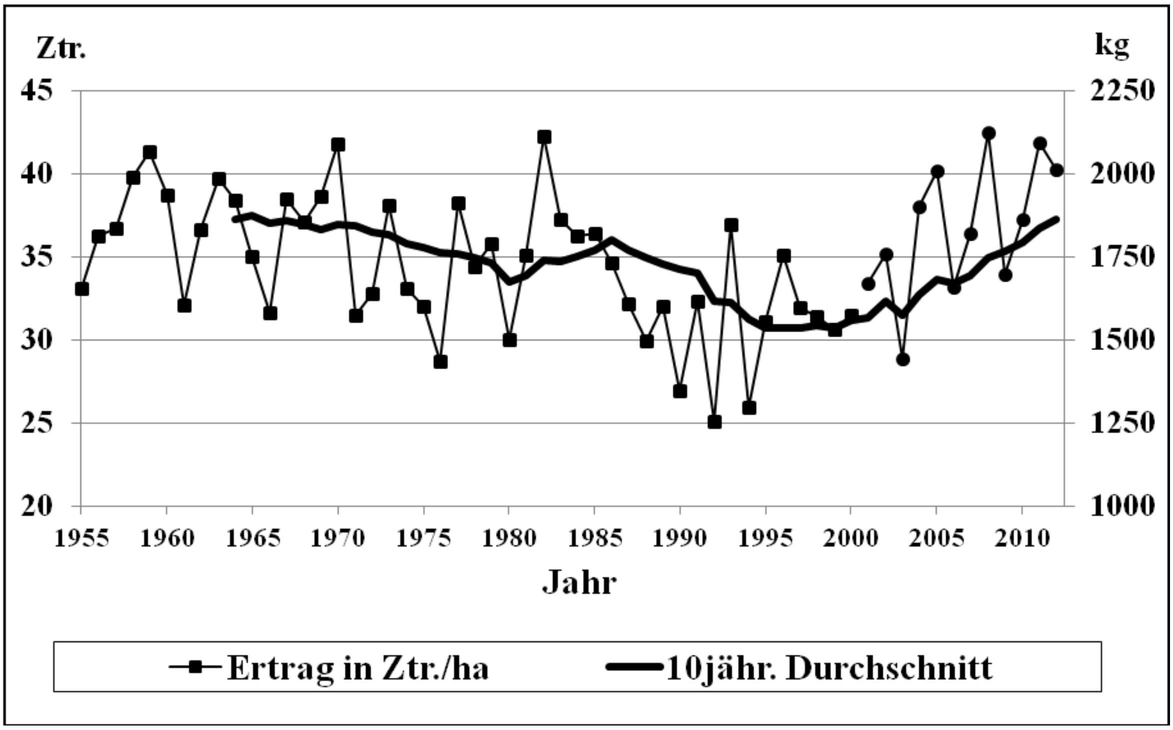


Fig. 3.6: Average yields (cwt. and kg/ha) in Germany

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

Region	Yields in kg/ha total acreage								
	2004	2005	2006	2007	2008	2009	2010	2011	2012
Hallertau	1,946	2,084	1,701	1,844	2,190	1,706	1,893	2,151	2,090
Spalt	1,400	1,518	1,300	1,532	1,680	1,691	1,625	1,759	1,383
Tettnang	1,525	1,405	1,187	1,353	1,489	1,320	1,315	1,460	1,323
Baden, Rhine Pal. and Bitburg	1,889	1,881	1,818	2,029	1,988	1,937	1,839	2,202	2,353
Elbe-Saale	1,895	1,867	1,754	2,043	2,046	1,920	1,931	2,071	1,983
∅ Yield / ha **Germany**	**1,900 kg**	**2,006 kg**	**1,660 kg**	**1,819 kg**	**2,122 kg**	**1,697 kg**	**1,862 kg**	**2,091 kg**	**2,013 kg**
Total crop Germany (t and cwt.)	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	38,111 t 762,212	34,475 t 698,504
Acreage Germany	17,476	17,179	17,170	17,671	18,695	18,473	18,386	18,228	17,124

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

Region/Variety	2003	2004	2005	2006	2007	2008	2009	2010	2011	**2012**	∅ 5 years	∅ 10 years
Hallertau Hallertauer	3.1	4.3	4.4	2.4	3.9	4.4	4.2	3.8	5.0	**4.6**	**4.4**	**4.0**
Hallertau Hersbrucker	2.1	3.0	3.5	2.2	2.6	2.9	3.4	3.5	4.5	**3.0**	**3.5**	**3.1**
Hallertau Hall. Saphir		3.4	4.1	3.2	4.6	5.1	4.5	4.5	5.3	**4.4**	**4.8**	
Hallertau Opal					7.4	9.4	9.0	8.6	9.7	**9.0**	**9.1**	
Hallertau Smaragd					6.1	6.7	6.4	7.4	8.0	**6.0**	**6.9**	
Hallertau Perle	3.9	6.4	7.8	6.2	7.9	8.5	9.2	7.5	9.6	**8.1**	**8.6**	**7.5**
Hallertau Spalter Select	3.2	4.9	5.2	4.3	4.7	5.4	5.7	5.7	6.4	**5.1**	**5.7**	**5.1**
Hallertau Hall. Tradition	4.1	6.3	6.3	4.8	6.0	7.5	6.8	6.5	7.1	**6.7**	**6.9**	**6.2**
Hallertau North. Brewer	6.0	9.8	9.8	6.4	9.1	10.5	10.4	9.7	10.9	**9.9**	**10.3**	**9.3**
Hallertau Hall. Magnum	11.7	14.8	13.8	12.8	12.6	15.7	14.6	13.3	14.9	**14.3**	**14.6**	**13.9**
Hallertau Nugget	8.5	10.6	11.3	10.2	10.7	12.0	12.8	11.5	13.0	**12.2**	**12.3**	**11.3**
Hallertau Hall. Taurus	12.3	16.5	16.2	15.1	16.1	17.9	17.1	16.3	17.4	**17.0**	**17.1**	**16.2**
Hallertau Hall. Merkur		13.5	13.3	10.3	13.0	15.0	14.8	12.6	15.2	**14.0**	**14.3**	
Hallertau Herkules					16.1	17.3	17.3	16.1	17.2	**17.1**	**17.0**	
Tettnang Tettnanger	2.6	4.7	4.5	2.2	4.0	4.2	4.2	4.0	5.1	**4.3**	**4.4**	**4.0**
Tettnang Hallertauer	3.1	5.0	4.8	2.6	4.3	4.7	4.5	4.2	5.1	**4.7**	**4.6**	**4.3**
Spalt Spalter	3.1	4.4	4.3	2.8	4.6	4.1	4.4	3.7	4.8	**4.1**	**4.2**	**4.0**
Elbe-S. Hall. Magnum	10.2	14.0	14.4	12.4	13.3	12.2	13.7	13.1	13.7	**14.1**	**13.4**	**13.1**

Source: Working Group for Hop Analysis (AHA)

4 Hop breeding research

RDin Dr. Elisabeth Seigner, Dipl. Biol.

4.1 Classical breeding

Breeding activities in Hüll encompass the entire hop spectrum, from the noble aroma hops through to super-high-alpha varieties. By successfully breeding new hop cultivars with special, exceptional aromas in recent years, the LfL's Work Group for Hop Breeding Research has remained constantly at the forefront of developments. The primary aim is to continuously improve resistance/tolerance towards the major diseases and pests, thus enabling German hop farmers to grow new top-quality, higher performance cultivars even more cost efficiently and with even less impact on the environment. 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. Molecular techniques are also used, e.g., to investigate the genetic material of hop plants themselves and of hop pathogens, and to exploit the findings for the breeding of new cultivars.

4.1.1 Crosses in 2012

A total of 95 crosses were carried out during 2012. Table 1.1 shows the number of crosses performed for each breeding goal.

Tab. 4.1: Cross-breeding goals in 2012

Breeding direction combined with resistance/tolerance towards various hop diseases	Further requirements	Number of crosses
Aroma type	Traditional aromas	8
	Special aromas	51
	Aphid resistance	4
	High beta-acid content	2
High-alpha-acid type	Special aromas	8
	Improved powdery-mildew (PM) resistance	18
	High beta-acid content	2
	Aphid resistance	2

4.1.2 New hop breeding trend – Hüll Special Flavor Hops with floral, citrusy and fruity aroma nuances

Objective

The primary aim is to substantially improve the competitiveness of German hops on the world market by breeding hop cultivars with special fruity and floral aromas that tend to be untypical of hops. US craft brewers initiated the trend towards expansion of traditional breeding programmes in the 1980s in opposition to the large US breweries. As their name implies, craft brewers see themselves as craftsmen committed to the art of brewing beer. They see hops as a raw material that offers infinite potential for brewing distinctive beers, and are celebrating a completely new approach to its use in their beers. Contrary to the general trend in the international brewing industry, where hop additions, and therefore the demand for hops, have been steadily declining for many years, craft brewers are adding more and more hops in order to create rich, hoppy, and hence distinctive, beers that sell like hot cakes. These innovative brewers are especially interested in the novel aromas shown by certain hop cultivars and are prepared to pay higher raw-material prices for them. So far, US hop farmers have profited most from this new beer boom with varieties such as Cascade, Centennial, Simcoe, Citra and Amarillo. US growers have already adapted their hop production to the steadily increasing demand from craft brewers. The last three years alone saw a significant acreage shift away from high-alpha and traditional aroma varieties towards flavor hops (Fig. 1.1). This enthusiasm for special beers with exceptional aromas and flavors has now spread from the USA, via Canada and Australia, to Europe, where it has also caught on in Germany.

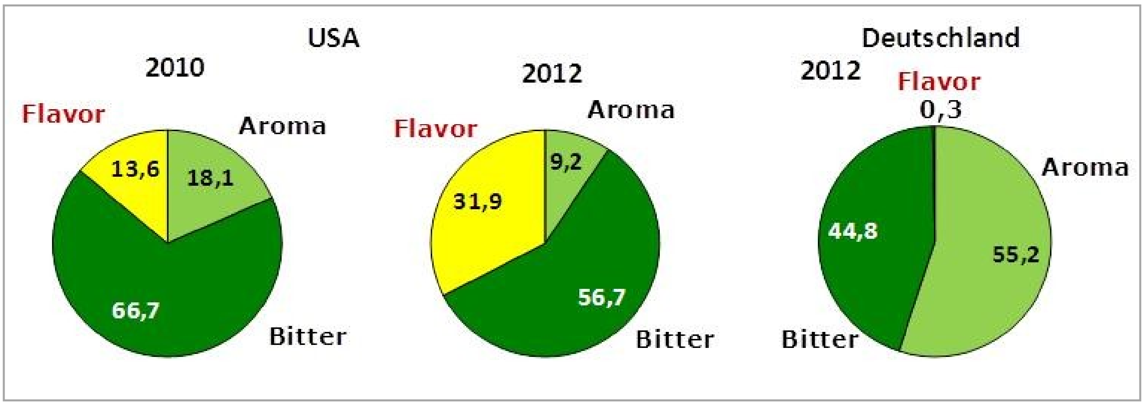


Fig. 4.1: Acreage shift away from aroma and bitter hops towards Flavor Hops in the USA between 2010 and 2012 and acreages under hop production in Germany in 2012

Hops with fruity, citrusy and exotic aromas were discarded from earlier Hüll breeding programmes because they were not accepted by the traditionally conservative brewing industry, and it was not until 2006 that Anton Lutz performed initial crosses aimed at tapping the craft-brewer market for German hops.

Material and methods

Work commenced by crossing the US Cascade variety, which is known for it floral, citrusy aroma, with Hüll male breeding lines intended to impart enhanced disease resistance/tolerance (especially PM resistance and wilt tolerance), good agronomic performance and classical aroma nuances in the progeny. Hüll breeding material with fruity, exotic aromas was used as well in crosses performed subsequently. Additionally, already pre-selected lines stemming from earlier high-alpha breeding programmes were tested for novel aromas.

The organoleptic aroma descriptions of the breeding lines and cultivars were rounded off by chemical analyses of the essential oil components. Headspace gas chromatography, in particular, a technique used routinely in Hüll, was used to back up the selection process.

The breeder, Mr. Anton Lutz, submitted the most interesting breeding lines for aroma appraisal to experts in the hop and brewing industries, who tested them in numerous brewing trials. Monitoring times for assessing resistance and determining agronomic performance characteristics under field cultivation were considerably reduced in some cases to enable speedy launching of the new hop varieties on the hop market.

Results

In light of the very positive resonance at beer tastings and the great interest shown by hop traders and hop growers alike, applications for registration of four new breeding lines as cultivars had been filed with the Community Plant Variety Office by spring 2012. The multifaceted aroma nuances characterisng each of these cultivars had been taken into account when naming them.

For example, mandarin-orange and citrusy nuances dominate in “Mandarina Bavaria” (MB). They combine with the traditional hoppy scent to produce an aroma totally new to Hüll cultivars and similar to that of the US Cascade and Centennial varieties. “Huell Melon” (HN) is reminiscent of ripe honeydew melons. Its sweet apricot and strawberry nuances make this new Hüll Special Flavor cultivar a speciality amongst all internationally available hop varieties. In “Hallertauer Blanc” (HC), which conveys an overall floral-fruity impression, aroma and flavor components reminiscent of green fruits and characterised by a typical white-wine bouquet dominate both in the raw hops and in the beer.

The fourth cultivar, “Polaris” (PA), stems from a cross performed by former Hüll hop breeder Herbert Ehrmaier in 1999. Its lineage is based on Hüll breeding material, the US Nugget variety and a Japanese breeding line. The aim back in 1999 was to further increase alpha-acid content and to improve disease resistance. Tests performed later on the progeny revealed a seedling with a unique, fresh aroma reminiscent of “glacier mints”. The seedling also boasted an extremely high alpha-acid content of up to 24 % and a total essential-oil content of 4.4 – 4.8 ml/100 g hops. Polaris is thus front runner with respect to both qualities within the international cultivar range.

Chemical analyses conducted by the IPZ 5d team (WG Hop Quality/Hop Analytics) confirmed the novelty of the Hüll Special Flavor Hops. Organoleptic aroma impressions, for example, were backed up by essential-oil profiles established via headspace GC. Forty-nine substances were identified from a total of 76 peaks in the GC oil profiles of the individual cultivars. It was possible to assign 39 of these essential-oil components to one of six categories: fruity (7 components), citrusy (4), floral (4), herbal (9), spicy/resinous (3) and woody (10) (see details under Lutz et al., 2012*). The peak areas corresponding to these aromas were then charted to enable a rough comparison between the aroma potential of the Hüll Special Flavor Hops with that of Hallertauer Mittelfrüh, the classical aroma-type variety, and of the US Cascade variety, a typical flavor-hop cultivar.

* Reference

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

Mandarina Bavaria (2007/18/13)

Hoppy, fresh fruity aroma,
intensive mandarin-orange and citrus notes

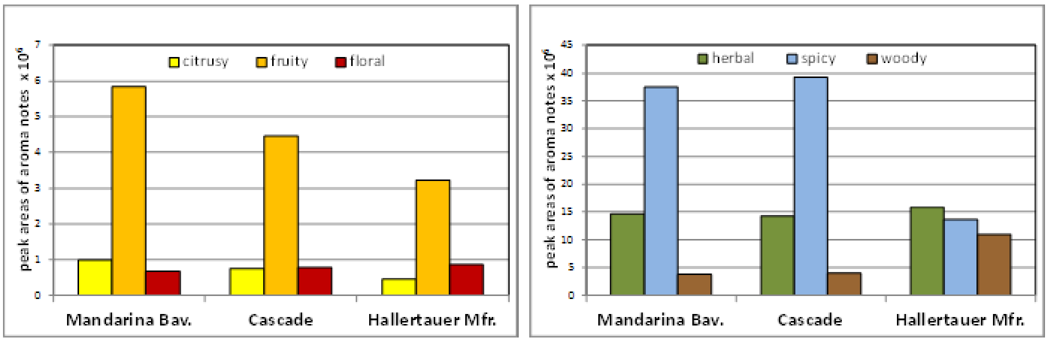
Origin: Cascade x Hüll male breeding line

Bitter substances: (EBC 7.7) % (w/w):

Alpha acids:	7 – 10	Beta acids:	4 - 7
Cohumulone:	28 - 35	Xanthohumol:	0.5 - 0.7

Polyphenols (EBC 9.11): 2.3 - 2.7 % (w/w)

Aroma substances (EBC 7.10): Total oils: 1.5 - 2.2 ml /100 g cones



Peak areas of headspace GC

Huell Melon (2009/02/706)

Fruity and sweet aroma , honeydew melon, apricot, strawberry

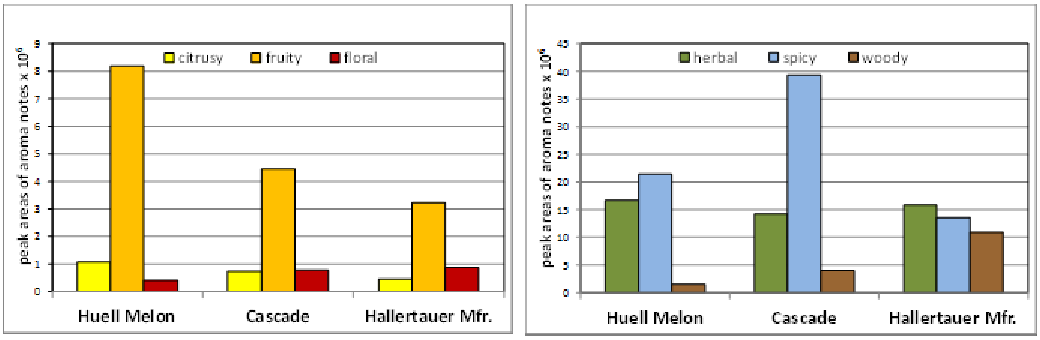
Origin: Cascade x Hüll male breeding line

Bitter substances: (EBC 7.7 %) (w/w):

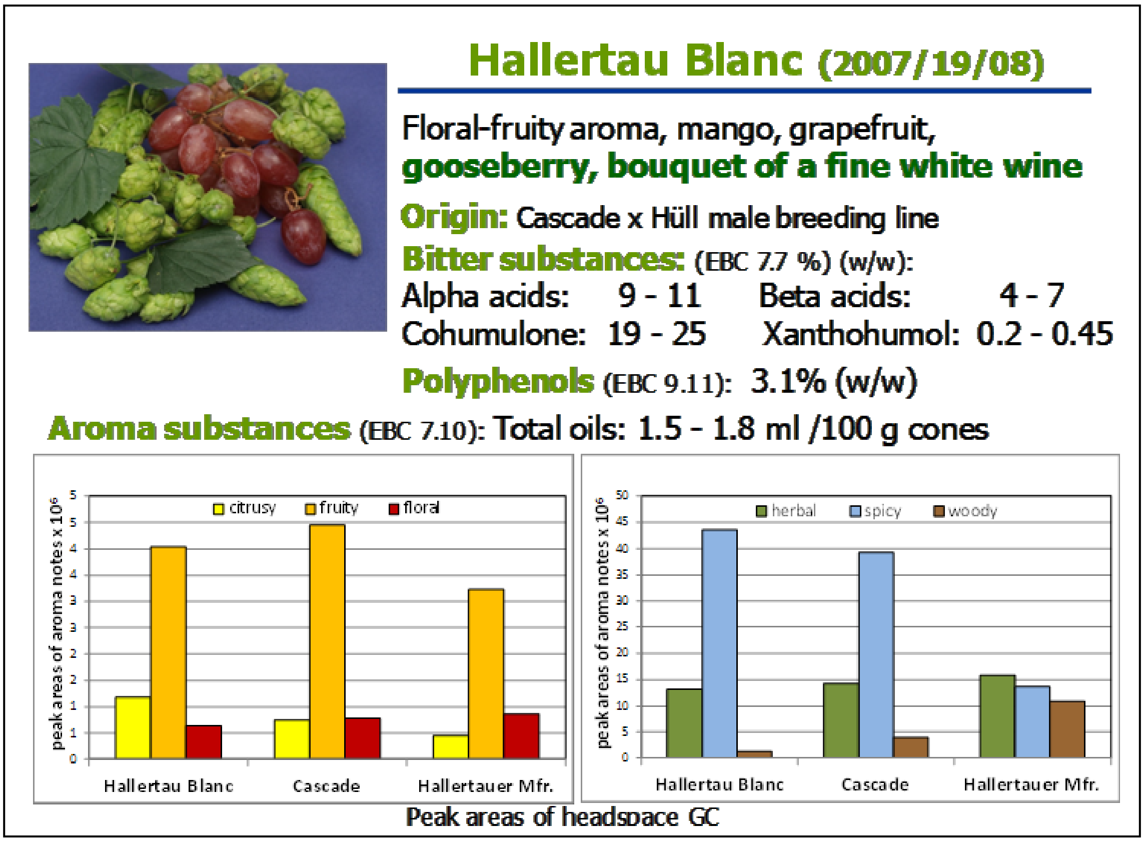
Alpha acids:	7 - 8	Beta acids:	6 - 8
Cohumulone:	25 - 28	Xanthohumol:	0.4 - 0.7

Polyphenols (EBC 9.11): 3.0 % (w/w)

Aroma substances (EBC 7.10): Total oils: 0.8 - 2.1 ml /100 g cones



Peak areas of headspace GC



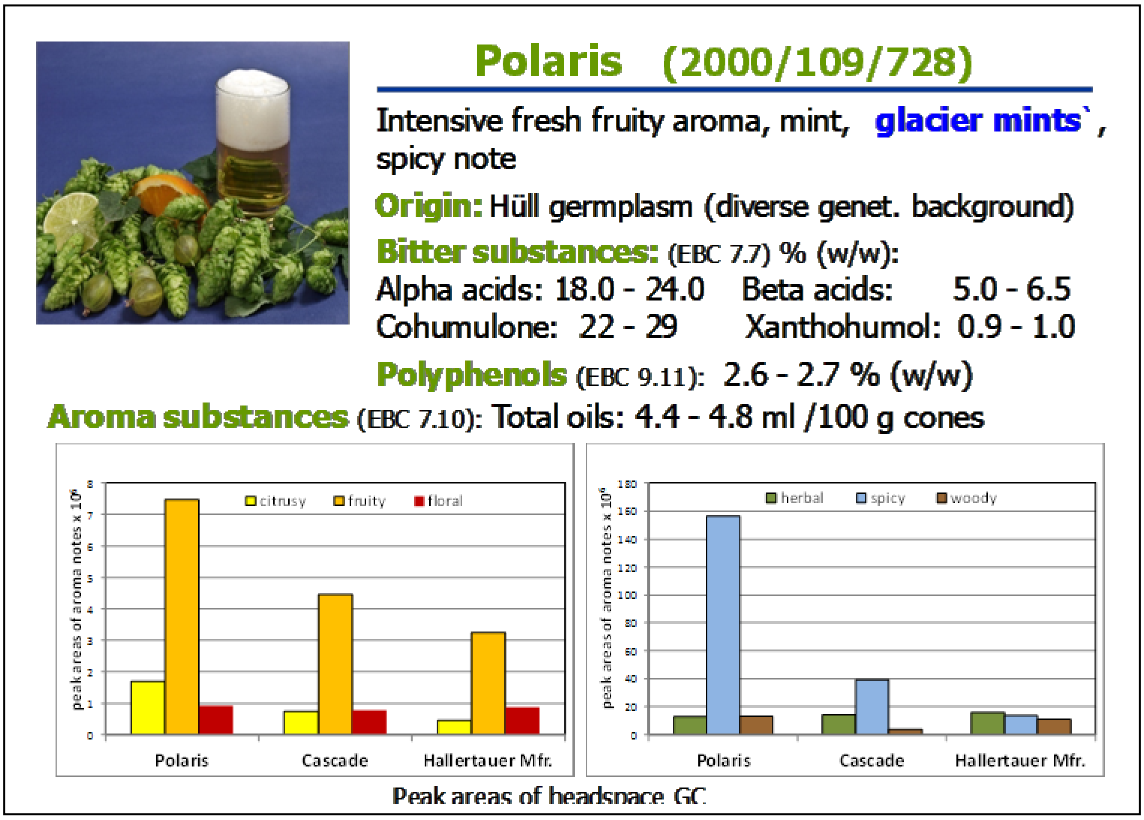


Fig. 4.2: Aroma descriptions, genetic background and chemical analyses of the four new Hüll Special Flavor Hops. The data stem from the results of 3-5 crop years; the figures for total polyphenol are based on assays performed solely on the 2012 harvest; chemical analyses by IPZ 5d

In spring 2012, the Society of Hop Research (GfH) released these four Special Flavor Hop cultivars for cultivation under special cultivation and licence terms. Lengthy farmscale trials normally performed as a matter of course were dispensed with in order to cope with the strong demand as fast as possible. This meant that Mandarina Bavaria and Hallertau Blanc underwent moderate-scale testing for only one year. Huell Melon was only three years old when the application for registration was filed, and results were available for individual plants only. Its unusual and excellent aroma nevertheless justifies the cultivar's release for cultivation. Polaris was the only Flavor Hop cultivar to go through all the test phases, which furnished comprehensive results.

The 2012 harvest provided important information on all four varieties. For one, the up-front aroma classifications were confirmed both in the cones and in beer; for another, the new cultivars showed favourable agronomic properties. Biogenetic analyses were performed for the first time and furnished information regarding the significant influence of soil type and harvesting time on aroma. Individual hop plants of the MB, HC and PA varieties were harvested at weekly intervals from mid-August to the end of September at two locations (Rohrbach: sandy soil and Hüll: clay soil).

Optimal locations with deep soil enabling good rooting are imperative for producing Flavor Hops. Locations with wilt problems are out of the question specifically for MB, HC and HN. Although these cultivars have shown moderately good wilt tolerance to date, they remain descendants of the highly wilt-susceptible Cascade variety. Poorly drained compacted soils are also unsuitable.

A later harvesting date is usually beneficial because this gives the hops enough time to fully develop their aroma. However, the harvesting date will depend on which main aroma nuances the brewer wants in his beer.

Although we do not currently expect to launch a further Hüll Special Flavor variety, breeding activities continue. In autumn 2012, GfH members were accordingly familiarised with new breeds boasting exceptional aromas. A number of brewers have even experimented with breeding lines showing aromas reminiscent of celery and lovage. Table 4.2 summarizes the currently available breeding lines. Naturally, we have no intention whatsoever of neglecting the breeding of traditionally delicate aroma hops. Breeding lines 89/002/025 and 96/001/024, for example, are the progeny of crosses with the Spalter and Tettnanger landrace varieties and representative of classical cross-breeding activities (Tab. 4.2).

Tab. 4.2: Chemical data and aroma descriptions for the new breeding lines. The data stem from the results of 3-5 crop years;the figures for total polyphenol are based on a single assay performed on a sample from the 2012 harvest; [1]in % (w/w); [2]relative, % of alpha acids; [3]ml/100 g dried cones; chemical analyses by IPZ 5d

		EBC 7.7				EBC 9.11	EBC 7.10
Variety	**Aroma description**	**α-acids[1]**	**β-acids[1]**	**Cohu-mulone[2]**	**Xantho-humol[1]**	**Total poly-phenols[1]**	**Total oils[3]**
89/002/025	Hoppy, spicy, classical	7 - 9	5 - 7	16 - 20	0.3 - 0.5	3.7	1.9
96/001/024	Hoppy, slightly citrusy	5 - 8	6 - 8	18 - 22	0.4 - 0.6	3.2	2.1
93/010/036	Hoppy, with a hint of citrus	13 - 16	5 - 7	25 - 30	0.8 - 1.3	2.6	3.6
2006/078/009	Fruity, banana, a slight hint of citrus	15 - 18	5 - 6	19 - 24	0.8 - 1.0	3.3	2.5
2006/099/731	Fresh, fruity, green apple	15 - 20	4 - 6	28 - 34	0.6 - 1.0	2.4	2.6
2008/020/004	Hoppy, spicy, minty	6 - 11	4 - 7	34 - 39	0.5 - 0.6	4.1	2.0
2008/059/003	Fruity, pineapple floral, lavender	15 - 18	5 - 6	19 - 24	0.7 -0.9	3.8	3.9
2008/060/002	Fresh, hint of citrus, slight hint of pineapple	15 - 19	6 - 7	19 - 22	0.8 - 0.9	2.4	4.0
2009/001/718	Very fruity, multivitamin	7 - 10	2 - 4	23 - 30	0.2 - 0.4	3.6	1.6 - 2.5
2010/035/013	Hoppy, fruity, strong hint of apricot	6 - 8	4 - 6	20 - 24	0.4 - 0.6	4.5	1.6
2009/068/008	Very strong hint of lovage	1 - 2	0.3 – 0.8	27 - 40	0.3	4.3	0.5

The chances of these new Hüll Special Flavor Hops enabling hop growers to benefit from the new beer boom triggered by US craft brewers and other creative brewers are excellent. However, there are also risks associated with entry into this segment of the brewing industry. Craft brewers only purchase top quality and are therefore likely to be very choosy.

Moreover, these brewers will probably be subject to enormous innovation pressure and, as a result, constantly in pursuit of new, different and unusual aroma impressions for their beers. We therefore expect only small acreages to be planted with the new flavor-hop varieties and real demand from craft brewers to last only a few years. Special forward contracts are thus urgently necessary, firstly to ensure that brewers are supplied with the desired varieties and, secondly, to safeguard the hop growers.

4.1.3 Laboratory screening method for assessing hop tolerance towards downy mildew (*Pseudoperonospora humuli*)

Objective

Downy mildew, caused by the *Pseudoperonospora humuli* fungus, has posed a huge challenge for hop growers in recent years. 2009 and 2010, in particular, saw very severe primary downy mildew infection. In each case, hail storms at the end of May were one of the reasons. They caused drastic injuries to the plants over wide swathes of land, thereby weakening the affected hop stands and leaving them susceptible to disease. The wet and cold weather that followed and continued into June promoted fungal growth in the rootstock and retarded hop growth significantly. All these factors combined to cause massive emergence of spikes along with secondary infections, even in hop cultivars tolerant to downy mildew. Repeated use of plant protectives was necessary to control the disease.

Breeding to improve hop tolerance is a major cornerstone in solving the downy mildew problem. For decades, thousands of seedlings have been screened for downy-mildew tolerance in the plastic-film greenhouse for purposes of early selection (see Fig. 4.3). The main benefit of this method is that it is a quick and easy way of selecting seedlings, but difficulties are encountered when the exact level of tolerance or susceptibility needs to be assessed in individual plants. A further disadvantage of mass screening is the impossibility of ensuring that comparable infection conditions prevail for all the seedlings (equal concentrations of spores, adequate leaf wetting, no drying off in the edge areas with concomitant termination of the downy mildew infection, etc.).

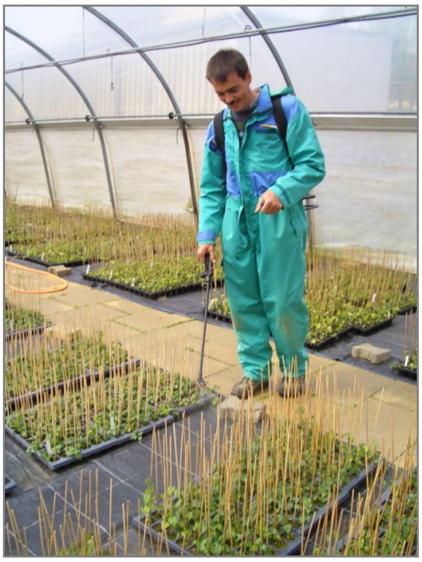


Fig. 4.3: Artificial inoculation of seedlings under test by spraying them with a suspension of the fungal zoosporangia.

Reliable assessment of downy-mildew tolerance in the breeding yard is also difficult for numerous reasons. Disease pressure is strongly influenced by weather patterns, for example, and optimal selection conditions do not prevail every year. Selection is also hampered by other parameters, such as the hop plants' developmental stage at the time of spraying with plant protectives and the length of the interval between the last treatment and the harvesting date. Another problem is that, for want of staff, only a limited number of seedlings can be assessed directly in the breeding yard. A reliable laboratory test might offer a satisfactory solution.

4.1.4 Establishment of a detached-leaf assay in the laboratory

Objective

The aim of this project is to establish a largely standardised detached-leaf assay, of the kind used routinely, and very successfully, for powdery mildew since 2001, that will allow reliable and more accurate assessment of downy-mildew tolerance/susceptibility in the laboratory.

Results

Work on the development of a screening method for downy-mildew tolerance commenced in January 2012 on the basis of published findings from the USA, England, the Czech Republic and various studies conducted by Dr. Kremheller at the Hüll Hop Research Centre in the 1980s.

Hop leaves infected with downy-mildew had been collected as starting material from the breeding yards in Hüll and Freising back in summer 2011 and frozen at -80°C according to the technique described by Mitchell (2010). This fungal material was used to commence inoculation tests in January 2012. The fundamentals of the detached-leaf assay were established in a series of trials, for which downy-mildew infected leaves of plants grown in preserving jars provided the best inoculation material. The sporangia were washed off the leaves with water and then sprayed onto leaves under test with a Preval sprayer (Mitchell, 2010) before being incubated in petri dishes or plastic containers in various trials. Both cuttings and *in-vitro* plants were assessed for their test suitability. The basic procedure for the assay was developed in these preliminary trials.

Outlook

Detailed studies of the various parameters influencing the informative value of the laboratory assay, such as leaf age, inoculation density, incubation conditions, etc., will be conducted in 2013 by a Bachelor student. A scanalyzer tool will be used to obtain a more precise assessment of the resistance/susceptibility of various hop varieties as determined on the basis of the infected leaf areas. The aim of this project is to establish the detached-leaf assay system and use it for fast and reliable assessment of downy-mildew tolerance in interesting breeding lines. In addition, greenhouse screening of seedlings will be optimized.

Mitchell, M.N. (2010): Addressing the Relationship Between *Pseudoperonospora cubensis* and *P. humuli* using Phylogenetic Analyses and Host Specificity Assays. Thesis, Oregon State University, USA, http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/16301/MitchellMelanieN2010.pdf?sequence=1

4.1.5 Monitoring for dangerous viroid and viral hop infections in Germany

Objective

The aim of a broad-based monitoring project for dangerous viroid and viral diseases was to clarify the prevailing infection situation in German hop-growing regions. Both viruses and viroids, first and foremost the dreaded hop stunt viroid (HSVd), pose a special problem in hop-growing. The diseases are spread easily and rapidly by mechanical means both within hop stands and from stand to stand, but often go unnoticed for many years, their potential to cause economic damage in the form of yield and alpha-acid losses only being revealed under stress-inducing weather conditions. Neither plant protectives for controlling these diseases nor effective resistance carriers that might be used for cross-breeding activities aimed at developing high-performance, virus- and viroid-resistant hop cultivars are available. Precautionary measures, including monitoring activities to detect and eliminate primary infection centres and clarify the way in which these pathogens are spread, are therefore an urgent necessity.

Methods

Work groups IPZ 5c and 5a were responsible for choosing the monitoring locations, organising the project and taking samples. Leaf samples taken from the LfL's breeding yards, the GfH's propagation facility and hop farms in the Hallertau and Tettnanger growing areas were examined molecularly and immunologically in the LfL's pathogen diagnostics lab (IPS 2c) for the following pathogens (Tab. 4.3): apple mosaic virus (ApMV), hop mosaic carlavirus (HMV) and arabis mosaic virus (ArMV) with the DAS-ELISA (Double Antibody Sandwich Enzyme Linked Immunosorbent Assay), using commercially available polyclonal antisera; latent hop carlavirus (HLV) and hop stunt viroid (HSVd) with the RT-PCR (Reverse Transcriptase Polymerase Chain Reaction) assay, using primers from Eastwell and Nelson (2007) and from Eastwell (personal communication, 2009). This technique was also used to test for American latent hop carlavirus (AHLV) in a number of samples taken at random. To ensure that the RT-PCR assay was functioning correctly and to rule out false negative results, it was backed up by an internal, hop-specific, mRNA-based RT-PCR control (Seigner et al. 2008). To verify individual results, PCR bands were also sequenced. Most of the tests were performed by two undergraduates from the Weihenstephan-Triesdorf University of Applied Sciences, working jointly with the LfL's pathogen diagnostics lab (IPS 2c) in Freising.

Tab. 4.3: Alphabetical overview of the viroids and viruses for which the samples were tested and of the detection methods used

Viroid/Virus German name	Viroid/Virus English name	Abbreviation	Detection method
Latentes Amerikanisches Hopfen-Carlavirus	American hop latent carlavirus	AHLV	RT-PCR
Apfelmosaik-Ilarvirus	Apple mosaic ilarvirus	ApMV	DAS-ELISA
Arabis Mosaik-Nepovirus	Arabismosaic nepovirus	ArMV	DAS-ELISA
Latentes Hopfen-Carlavirus	Hop latent carlavirus	HLV	RT-PCR
Hopfenmosaik-Carlavirus	Hop mosaic carlavirus	HMV	DAS-ELISA
Hopfenstauche-Viroid	Hop stunt viroid	HSVd	RT-PCR

Results

Monitoring for HSVd infections in hops, commenced in 2008, was maintained in 2012. As in 2011, the leaf samples were additionally tested for HMV and ApMV, diseases subject to routine testing by IPZ 5b in Hüll, and for HLV and ArMV. IPS 2c conducted tests on altogether 250 leaf samples from the LfL's various breeding yards in Hüll, from one of the Society of Hop Research's propagation facilities and from hop farms in the Hallertau and Tettnang growing regions. Leaves from foreign hop varieties were also monitored.

Tab. 4.4: HSVd and virus tests in 2012

Origin and nature of the 2012 sample material	Number of hop samples	RT-PCR			DAS-ELISA		
		HSVd positive	HLV positive	AHLV* positive	HMV positive	ApMV positive	ArMV positive
Hüll breeding yard: mother plants	19	0	19 (100 %)	3 of 3	7+(3) (53 %)	5 (26 %)	1 (5 %)
Hüll breeding yard: Stammesprüfung	7	0	7 (100 %)	nt	1 (1 %)	0	0
Hüll breeding yard: cultivar yard	68	0	47+(3) (73 %)	0 of 3	36+(3) (57 %)	26 (38 %)	0
Hüll breeding yard: registered varieties	41	0	17 +(3) (49 %)	2 of 2	2 (5 %)	6 (15 %)	0
GfH Hallertau propagation facility: mother plants	49	0	24 (49 %)	4 of 30	3 (6 %)	0	(1) (2 %)
Elbe-Saale field crops	0						
Hallertau field crops: cultivars	36	0	12 (28 %)	nt	18+(3) (56 %)	6 (17 %)	(1) (3 %)
Tettnang experimental station and field crops: cultivars	10	0	6 (60 %)	0 von 10	3+(3) (60 %)	8+(2) (100 %)	2 (20 %)
Foreign cultivars	20	0	nt	nt	nt	nt	nt
Total	**250**	**0**	**130**	**9 von 53**	**69+(12)**	**51+(2)**	**3+(2)**

*Tested for AHLV only in a number of samples taken at random; nt = not tested; (number) = weak infection signal

The dreaded HSVd was not detected in a single sample (Tab. 4.4), which means that of the total number of 1,118 samples tested since 2008, the nine plants found to be infected with HSVd in 2010, which were destroyed immediately, were the only ones to test positive. Although the internal RT-PCR control run failed in 20 samples (9 %), making 100 % confirmation of the negative result impossible for these plants, the findings obtained since 2008 are reassuring because they show that no HSVd has been introduced so far from countries with high infection pressure, such as Japan in the past, the USA, where hop stunt viroid infections have been recorded since 2006, or from Slovenia, where they have been recorded since 2007 (Radisek et al., 2012).

The situation is very different with regard to viral diseases. The various sections of the LfL's Hüll breeding yard are severely infected with HLV, HMV and ApMV (Tab. 4.4), the reason being that numerous varieties from the world hop range have been planted out in Hüll for decades. In most cases, the starting material was not examined for virus infections at all and therefore no efforts were made to create virus-free planting stock by way of meristem culture. These hop plants are usually grown in four-plant blocks, providing ideal conditions for the virus to be spread mechanically or via aphids from these small infection centres to neighbouring hop plants.

Very high incidence levels of HLV and HMP were also detected in the samples from the Hallertau and Tettnang growing areas. ApMV infection in these samples was likewise notable, albeit on a smaller scale. The relatively high proportion of plants infected with the two aphid-borne viruses, HMV and HLV, is due to the fact that even a brief trial feed on the part of the aphid suffices for the virus to be transmitted from the aphid to the plant or vice versa. Once plants are infected, the virus is gradually spread within the stand via aphids. The hop latent carlavirus causes no visible damage but was often found in combination with other virus types. Serious effects on yields and hop components must be expected, in particular, in these plants with multiple infections, especially since all other virus types, such as ApMV, HMV and, above all, ArMV, cause pronounced damage. In the case of the leaf samples from hop farms, the actual infection situation may look worse than it actually is because sample material sent in for testing was taken exclusively from hop plants showing disease symptoms.

All the virus-infected plants identified at one of the Society of Hop Research's propagation facilities were destroyed immediately, thus guaranteeing that cuttings from this source are healthy. Only HLV is tolerated, as it may be assumed (Neve, 1999; Pethybridge et al., 2008) that, on its own, this virus causes very little, if any, reduction in quality or yield.

Testing for AHLV, which is also transmitted by aphids, was only performed on random samples because, according to the literature, this virus is only relevant in the USA and in hop material from the USA. However, the majority of the samples sent in for testing by the propagation facility were tested for AHLV because this virus is known to cause pronounced yield and alpha-acid losses (Eastwell and Druffel, 2012). US material and breeding material growing adjacent to US cultivars in our breeding yard were also sampled and tested for AHLV. Nine of the 53 hop samples tested were found to be infected with AHLV.

This monitoring project will be continued in 2013 with the support of the Scientific Station for Brewing in Munich. Although HSVd infections have not yet spread in Germany, as initially feared, this monitoring for viroids must be continued, especially since the Zitrusviroid IV, which causes even more severe yield losses than HSVd (Radisek et al., 2012), has been detected in Slovenia. The plan for 2013 is to check the virus-monitoring findings once again, especially those pertaining to HMV and ApMV infections, so that we can draw conclusions concerning the dynamics of the spread of these diseases and develop strategies for hop farmers to deal with them.

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.

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Appreciation

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

4.1.6 Research work on the increased occurrence of *Verticillium* infections

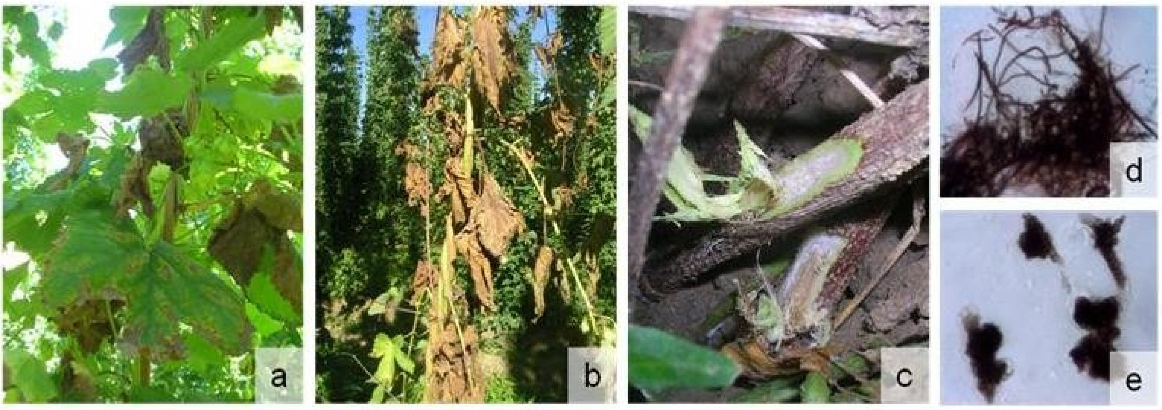

Fig. 4.3: Hop wilt symptoms. (a) Leaves showing wilt symptoms. (b) Dead hop plant (c) Brown discoloration of the vascular tissue. (d) Black mycelia produced by V. albo-atrum as survival structure. (e) Microsclerotia produced by V. dahliae.

Objective

Various parts of the Hallertau growing area are currently severely affected by wilt. The main cause of wilt symptoms, apart from crown rot or *Fusarium* fungi, is without doubt the quarantine organism *Verticillium,* especially *Verticillium albo-atrum*, but also, to a lesser extent, *Verticillium dahliae.* Much more aggressive *Verticillium* races than those of the 70s and 80s are now infecting all hop varieties in the Hallertau. In contrast to other fungal hop diseases, such as powdery mildew, downy mildew or botrytis, the occurrence of which fluctuates strongly from year to year, depending on the weather conditions, and for which effective fungicides are available, the starting point for wilt-control efforts is especially difficult for a number of reasons. Once the soil-borne fungal pathogen has become established in a hop yard, it can survive for five (*V. albo-atrum*) or 15 (*V. dahliae*) years without a host, even if the hop yard is cleared completely of hops and planted with neutral, host-unspecific catch/cover crops. Contrary to the natural spreading of powdery mildew via wind, for example, the spreading of hop wilt can be seen as attributable not only to insufficient cleaning and disinfection of machinery contaminated with adhering soil but also, in particular, to the exchange of infected planting stock.

This research project is therefore intended, first of all, to establish a rapid diagnostic test and thereby provide hop farmers with reliable information on the causes of wilt and, secondly, to detect any latent infection centres in cuttings at an early stage.

Since there are no effective, environmentally friendly plant protection methods anywhere in the world for combating wilt, a further focus of our current *Verticillium* work is the development of a preventive "biological" control strategy, to which end we are testing the suitability of various bacteria as biocontrol agents for the *Verticillium* fungus.

Methods

It was important to establish a method by which the fungus can be detected directly from hop bines and which can be used as a substitute for the very time-consuming and costly diagnostic methodology used in the past, where, prior to molecular analysis, *Verticillium* fungus from hop bines first had to be cultivated in media and the DNA subsequently isolated. To achieve this initial goal, a commercially available DNA isolation kit and a homogenizer with diverse ceramic-glass matrices were tested for their suitability. A multiplex real-time PCR assay was developed to enable simultaneous detection of *V. albo-atrum* and *V. dahliae*. Using the findings from earlier AFLP (Amplified Fragment Length Polymorphism) screening, which allowed specific DNA fragments to be clearly matched with fragments of lethal *Verticillium* strains via comparison with international reference isolates, an attempt was made, via cloning and sequencing steps, to develop SCAR (Sequence Characterized Amplified Regions) markers for identifying the lethal strains.

The search for suitable bioantagonists led to the selection of four bacterial strains belonging to the genera *Burkholderia*, *Serratia*, *Pseudomonas* and *Stenotrophomonas*, which have demonstrated a successful preventive effect in other crops, such as sugar beet and strawberries, by virtue of their beneficial antagonistic properties. It was first of all necessary to furnish evidence of bacterial colonisation on and in the hop roots. To this end, plants of the Hallertauer Tradition variety were immersed in a bacterial suspension. After four weeks, evidence of colonisation was furnished by way of plating and CLSM (Confocal Laser Scanning Microscopy).

Result

The most important outcome of this project was the establishment of a fast, molecular-based diagnostic test soon to be published (Maurer, Katja A., Radišek, Sebastjan, Berg, Gabriele, Seefelder, Stefan (2013): Real-time PCR assay to detect *Verticillium albo-atrum* and *V. dahliae* in hops: development and comparison with a standard PCR method. Journal of Plant Diseases and Protection, 120 (3), 97-104. The new method cuts the time needed to identify the quarantine organism *Verticillium* to one day, compared with a few weeks for the conventional cultivation method. In addition, 16.7 % more *Verticillium*-infected plants were identified via the new method than via the conventional method, More specifically, the fungus was identified in a number of phenotypically healthy plants only by the new method. In future, this real-time technique will also permit simultaneous identification of *V. albo-atrum* and *V. dahliae* (Fig. 4.5).

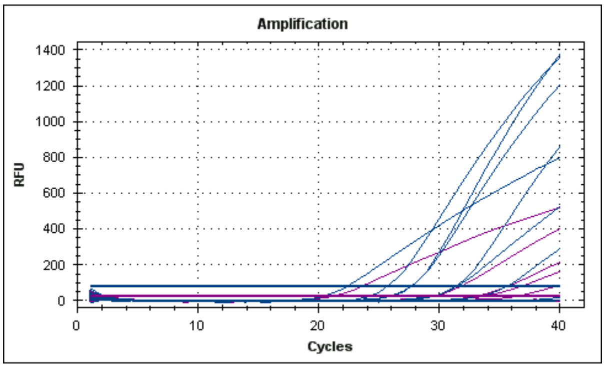

Fig. 4.4: Result of a multilplex real-time PCR assay to detect V. albo-atrum (blue) and V. dahliae (violet)

Four AFLP fragments typical of lethal *Verticillium* isolates are currently making it difficult to transform diagnostic markers. One of the reasons is seemingly the very slight detectable genetic differences between the mild and lethal forms of *Verticillium,* with the underlying restriction site polymorphism often being solely attributable to a single nucleotide polymorphism (SNP). Evidence that the antagonists had colonised both the rhizosphere and the endosphere was furnished by re-isolation and microscopic examination (Fig. 4.6), with *Burkholderia* showing the highest cell density.

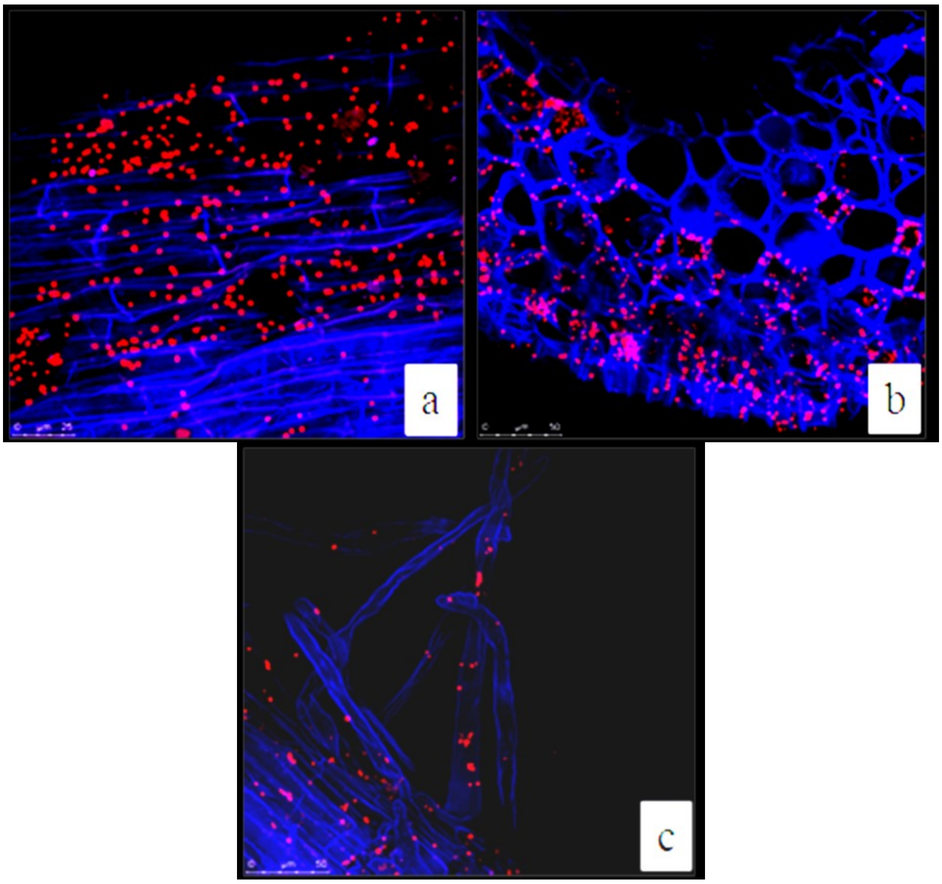

Fig. 4.5: Root cross-section 6 days post inoculation. Evidence of successful colonisation of the rhizosphere (a), endosphere (b) and root hairs (c) of Hallertauer Tradition by Burkholderia terricola (red cells)

Outlook

Bacterial/fungal interaction in bioantagonist-inoculated hop plants subsequently infected artifically with *Verticillium* strains is now being monitored in the greenhouse. In view of the dramatic *Verticillium* situation in the Hallertau region, the scheduled 5-year field trial on 0.2 ha planted with Hersbrucker Spät and 0.2 ha planted with Hallertauer Tradition has been brought forward and is being conducted simultaneously with the up-and-running laboratory and greenhouse trials. To aid in the selection of wilt-tolerant breeding lines, we are screening breeding stock planted outdoors on land confirmed to be contaminated with lethal forms. In addition, work is currently underway to establish an artifical *Verticillium*-tolerance screening system in the greenhouse. In contrast to field trials, where tedious selection processes lasting several years are necessary on account of different levels of pathogen pressure, artifical infection of isolates with a defined virulence may be expected to provide reliable information as to genuine "*Verticillium* tolerance" within a very short time.

5 Hop cultivation and production techniques

LD Johann Portner, Dipl.-Ing. agr.

5.1 N_{min} test in 2012

The N_{min} nitrogen fertiliser recommendation system has become an integral part of fertiliser planning on hop farms. In 2012, 541 hop farms (48.7%) in the Hallertau and Spalt growing areas of Bavaria participated in the N_{min} test, with 3,023 hop yards being tested for their N_{min} levels and the recommended amount of fertiliser calculated.

The table below tracks the numbers of samples tested annually for N_{min} since 1983. N_{min} levels in Bavarian hop yards averaged 74 kg N/ha in 2012 and were thus almost identical with those of 2011 (76 kg). The average recommended amount of fertiliser, which is calculated from this figure, was 157 Kg N/ha.

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

Year	Number of samples	N_{min} kg N/ha	Fertiliser recommendation kg N/ha
1983	66	131	
1984	86	151	
1985	281	275	
1986	602	152	
1987	620	93	
1988	1,031	95	
1989	2,523	119	
1990	3,000	102	
1991	2,633	121	
1992	3,166	141	130
1993	3,149	124	146
1994	4,532	88	171
1995	4,403	148	127
1996	4,682	139	123
1997	4,624	104	147
1998	4,728	148	119
1999	4,056	62	167
2000	3,954	73	158
2001	4,082	59	163
2002	3,993	70	169
2003	3,809	52	171
2004	4,029	127	122
2005	3,904	100	139
2006	3,619	84	151
2007	3,668	94	140
2008	3,507	76	153
2009	3,338	85	148
2010	3,610	86	148
2011	3,396	76	154
2012	3,023	74	157

The next table lists the number of hop yards tested, average N_{min} levels and average recommended amounts of fertiliser by administrative district and hop-growing region in Bavaria in 2012. It can be seen from the list that Nmin levels were highest in the Spalt area. The lowest levels were measured in the Freising district of the Hallertau growing region.

Tab. 5.2: Number, average N_{min} levels and fertiliser recommendations for hop yards by administrative district and region in Bavaria in 2012

District / Region	**Number of samples**	**N_{min} kg N/ha**	**Fertiliser recommendation kg N/ha**
Spalt (minus Kinding)	71	102	118
Eichstätt (plus Kinding)	232	84	152
Kelheim	1,141	74	158
Pfaffenhofen	1,080	74	158
Landshut	143	70	156
Hersbruck	47	69	147
Freising	309	67	162
Bavaria	**3,023**	**74**	**157**

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

Tab. 5.3: Number, average N_{min} levels and fertiliser recommendation in 2012 for various hop varieties in Bavaria

Variety	**Number of samples**	**Nmin kg N/ha**	**Fertiliser recommendation kg N/ha**
Herkules	496	67	176
Nugget	36	59	172
Hall. Magnum	496	70	161
Saphir	43	72	155
Hall. Taurus	216	81	154
Perle	573	75	153
Hall. Tradition	550	80	151
Northern Brewer	44	74	150
Hallertauer Mfr.	210	66	147
Hersbrucker Spät	170	81	147
Spalter Select	124	84	147
Spalter	37	101	113
Other	28	72	133
Bavaria	**3,023**	**74**	**157**

5.2 Tentative trial with various nutrient solutions for initial hop stripping

Initial situation, problem and objective

Hop stripping promotes growth of the trained main shoots and has a phytosanitary effect. It involves removing the hop plant's lower leaves and laterals to a height of about 2 m above the ground, as well as any newly emerging ground shoots. Growers in the Hallertau region mostly use nitrogenous solutions for hop stripping. Adhesives and, if required, micronutrient fertilisers may be added to intensify the effect. The herbicide "Lotus" is added to further reinforce the effectiveness of this mixture and simultaneously control weed growth. As Lotus must not be used in hops exported to the USA, and its use will be prohibited altogether as from 2014, the aim of this tentative trial was to test alternative substances for their ability to increase the effectiveness of fertiliser solutions in a similar manner.

Trial design

The hop stripping performance of the nutrient mixtures listed in the following table was tested on Hallertauer Magnum and Saphir in the hop breeding yard at the Rohrbach location. All spray variants were applied at a dose rate of 400 l/ha. The standard solution consisted of 266 l water and 133 l UAN solution. The cyanamide "Dormex" (also known as Alzodef) produced by AlzChem and a new N fertiliser solution traded under the name of "InnoFert Hopfen flüssig" were tested for their ability to increase the efficacy of the spray mixture. InnoFert Hopfen flüssig is an ammonium nitrate solution with a nutrient content of 7.5% NH_4-N and 7.5% NO_3-N. A new 30% magnesium chloride solution, which is used as a weedkiller by growers of organic potatoes, for example, was also available. Magnesium chloride ($MgCl_2$) is converted into plant-available magnesium chloride (MgO) by a factor of 0.423. The spreading additive Break Thru, which has proved of value for increasing hop-stripping efficacy, was used in all the spray variants except variants II and IX. Solutions VIII and IX additionally contained the micronutrient fertilisers zinc (0.3%) and boron (0.2%). The following table lists the dose rates of the nutrient solutions and indicates the amount of nutrients applied in kg/ha or g/ha.

Tab. 5.4: Trial design showing dose rates and nutrient amounts per ha

Variant	**Dose rate 400 l/ha**							**Nutrients/ha**
I	Untreated							
II	80 ml Lotus	266 l w water	133 l UAN					48 kg N
III		266 l water	133 l UAN	6 l Alzodef (1.5 %)			150 ml Break Thru	48 kg N
IV		266 l water	133 l UAN	8 l Alzodef (2 %)			150 ml Break Thru	48 kg N
V		266 l water	133 l UAN	12 l Alzodef (3 %)			150 ml Break Thru	48 kg N
VI		200 l water	200 l InnoFert	8 l Alzodef (2 %)			150 ml Break Thru	36 kg N
VII		133 l water	133 l UAN	8 l Alzodef< (2 %)	133 l $MgCl_2$ (33 %)		150 ml Break Thru	48 kg N 17 kg MgO
VIII		133 l water	133 l UAN		133 l $MgCl_2$ (33 %)	1.2 kg zinc sulphate 0.8 kg boron salt	150 ml Break Thru	48 kg N 17 kg MgO 209 g Zn 170 g B
IX		133 l water	133 l UAN		133 l $MgCl_2$ (33 %)	1.2 kg zinc sulphate 0.8 kg boron salt	500 ml FCS rapeseed oil	48 kg N 17 kg MgO 209 g Zn 170 g B

Results

A comparison of the stripping efficacy obtained with the different variants shows a similar pattern in both cultivars, although the actual degree of efficacy is much lower in the case of Hallertauer Magnum than in the case of Saphir. Surprisingly, the spray variant containing the herbicide Lotus was unconvincing for both cultivars. In Hallertauer Magnum, none of the variants produced the desired 80% stripping efficacy for leaves or laterals (red line). In Saphir, by contrast, all variants except number IX were highly effective. The advantages of using Break Thru rather than rapeseed oil as a wetting agent in hop-stripping nutrient solutions is evident, as it was in 2011, from the results obtained in plots VIII and IX.

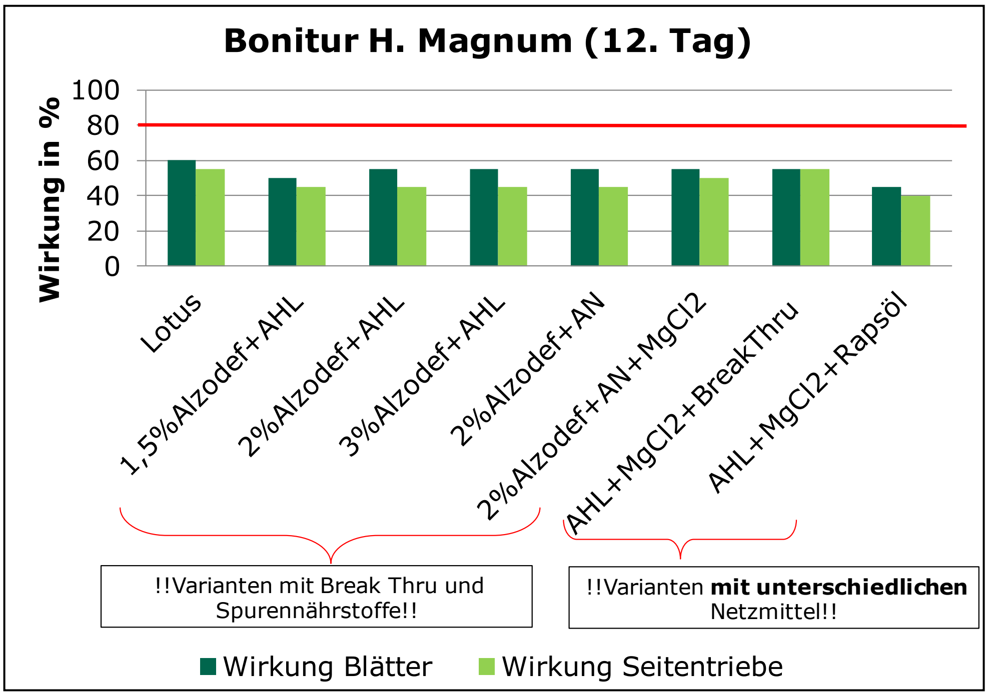

Fig. 5.1: Efficacy in Hallertau Magnum

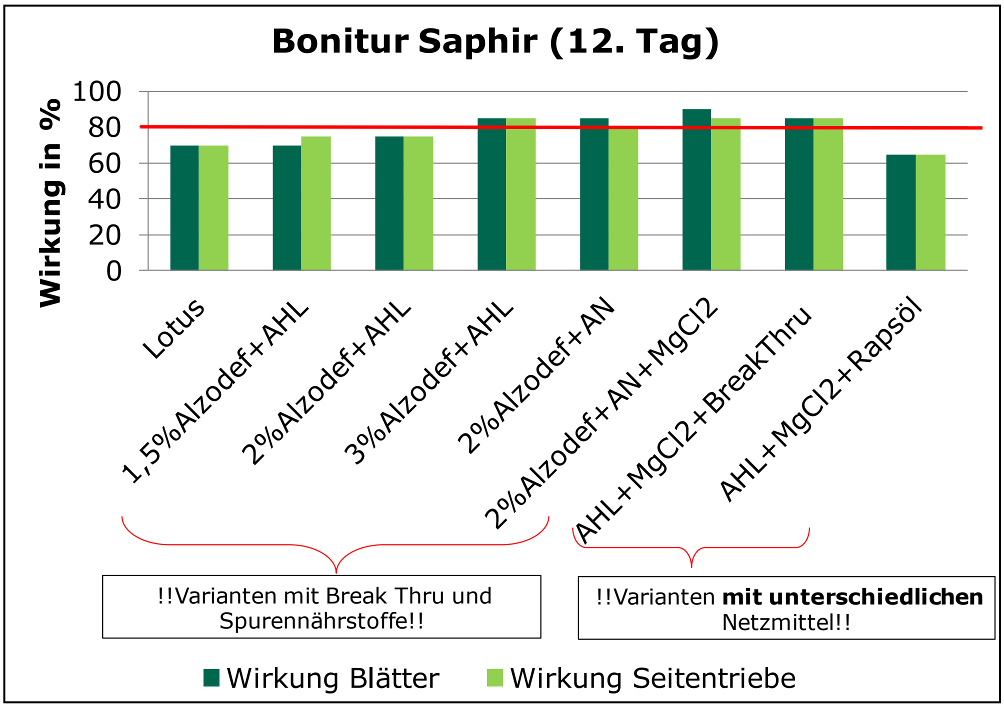

Fig. 5.2: Efficacy in Saphir

Discussion

Initial tentative trials at the Hüll Hop Research Centre have shown that the caustic effect of UAN is intensified by the addition of cyanamide. However, the cyanamide “Dormex”, formerly sold under the name “Alzodef” and used for hop stripping, is not licensed. The new ammonium nitrate solution “Innofert Hopfen flüssig” may prove suitable as an alternative to UAN. The addition of $MgCl_2$ solution intensified the caustic effect, especially at the shoot tips.

The wetting agent with the better results was Break Thru. Good stripping results with spray mixtures containing nutrient solutions can only be achieved if stripping is preceded by rain followed by intense sunshine, with no further rainfall until the spray has taken effect. Experience has shown the necessity of generating a very fine spray in order to obtain uniform wetting of leaves and laterals. The dose rate of 400 l/ha was not enough for Hallertauer Magnum due to its abundant growth. Consequently, wetting and stripping efficacy were unsatisfactory. Further trials will be needed to confirm the finding that increasing the dose rate of nutrient solutions used in hop-stripping also increases stripping efficacy. The plants' nutrient requirement must naturally be borne in mind here.

5.3 Optimisation of hop drying in a belt dryer

Initial situation and objective

It has been shown in trials aimed at optimising hop drying in floor kilns and belt dryers that selecting the correct air speed relative to cone depth and drying temperature has the greatest influence on drying performance in kg dry hops/m² drying surface/h drying time.

In trials conducted on a belt dryer at a commercial hop farm, the basic settings for cone depth and the volumetric flow rate of drying air were optimised over the past few years. Drying performance was thereby increased by approx. 20 % compared with earlier years.

The intention in 2012 was to chart drying performance over the entire harvesting period in order to ascertain the extent to which it can be increased still further with existing heating and blower capacities.

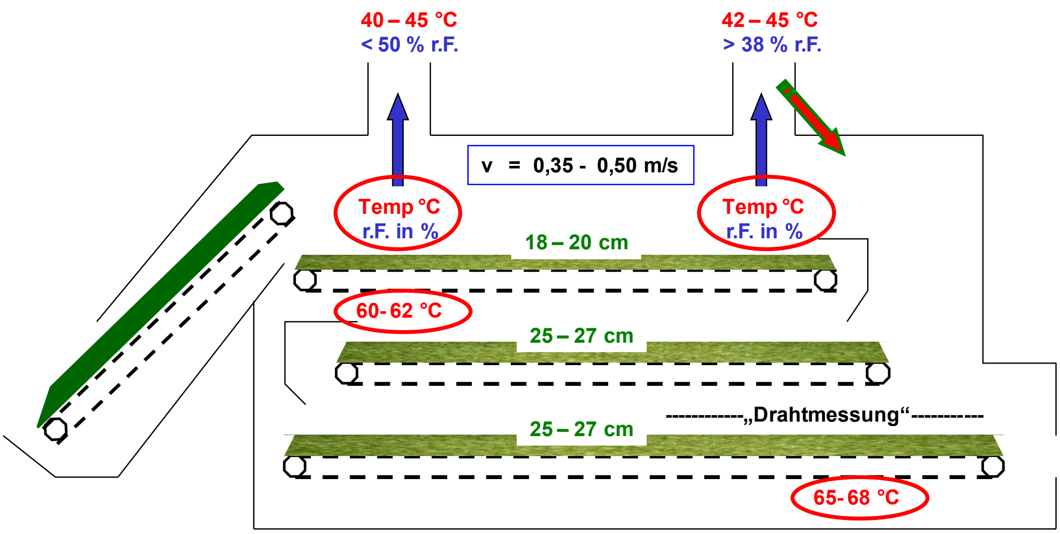

Fig. 5.3: Measuring points and basic settings of the belt dryer on a commercial hop farm

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 25-27 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. Moist air was sucked out of the belt dryer via frequency-controlled extractors in two waste-air flues. Experience with this belt dryer has shown that, for the cone depths and drying temperatures indicated above, drying performance is best if the relative humidity in the first waste-air flue does not exceed 45 %. 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 the optimised operating parameters 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.

Hop drying during the 2012 harvest was performed with the basic settings indicated above. No adjustments were made to temperature, cone depth or the volumetric flow rate of the drying air over the entire drying period.

The dried hops were transported on conveyor belts from the belt drier to two conditioning chambers. Filling time and duration were documented for each individual chamber (K1-K21) in a drying protocol. The conditioned hops were weighed on baling. This permitted drying performance in kg dry hops/m² drying area/h drying/filling time of the relevant conditioning chamber to be determined.

Results

Constant changes in drying performance were observed for the same cone depth and the same fan-intake-port setting, one reason being that the cone weight of green hops and the resultant air speed also vary. Within one and the same variety, cone weight will vary according to weather conditions, ripening time, growing conditions and moisture content.

The intervarietal difference in drying behaviour is also interesting. For the same basic settings, average drying performance for the Hallertauer Tradition and Perle aroma varieties was 5.99 kg in each case and for the Hallertauer Magnum bitter variety 6.83 kg/m² drying area/h drying time. Maximum and minimum drying performances differed by 26% for the aroma varieties and by even more than 50 % for Hallertauer Magnum.

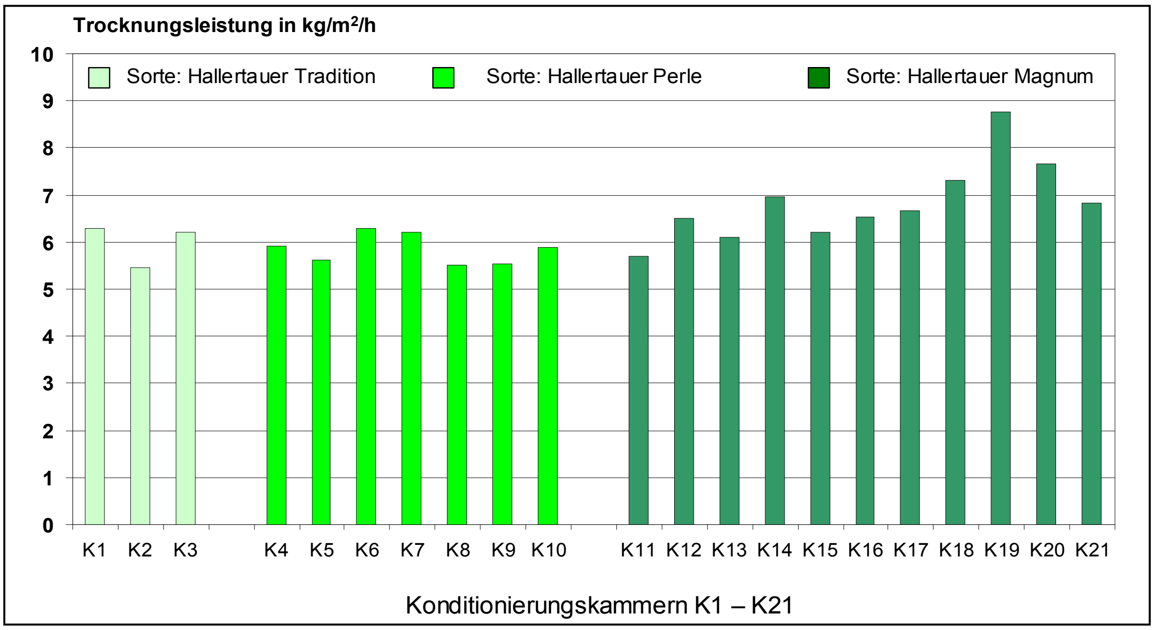

Fig. 5.4: Drying performance of Hallertauer Tradition, Perle and Hallertauer Magnum at constant cone depth and resultant different air speeds in the belt dryer

Implications and outlook

Development and installation of a measuring system to continuously measure the air speed would allow very quick determination of the air speed needed to obtain maximum drying performance. Since the speed of the air flowing through a belt dryer is a function of cone depth, a continuous display of the currrent air speed would enable it to be controlled, simply by adjusting cone depth, so as to ensure optimal drying performance.

5.4 LfL projects within the Production and Quality Initiative

As part of a production and quality campaign on behalf of agriculture in Bavaria, the Bavarian State Research Center for Agriculture has launched 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 2012 results summarized.

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

During the 2012 harvest, 600 freshly harvested hop samples were analysed for alpha-acid content on the day of harvesting. Such daily measurements provide insight into the 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 hop quality in the year in question and point to disease/pest susceptibility, production-related errors or incorrect treatment of harvested hops. Analysis of the data pertaining to 9,133 cone lots from all over Bavaria revealed above-average levels of common spider mite and botrytis infestation. Assessment according to the new NFQ specifications for colour and odour showed 80.9% of the Hallertau lots to be discoloured. The NFQ criteria no longer include tainted, damaged or overdried cones.

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

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

5.4.3 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.

In 2012, trials continued with the index-based thresholds, which had been raised in the preceding years in order to take the distinction between "prior to flowering" and "post flowering" into account.

The 2012 figures showed that, at the Speikern (Hersbruck) trial location, the previous early-warning model recommended only one downy-mildew treatment for both tolerant and susceptible varieties during the entire season. The Adcon model, by contrast, generated three warnings for the susceptible HE cultivar and two for the tolerant HT cultivar. These treatments were carried out. On account of the dry weather and very low level of spore dispersion in the Hersbruck region, a single downy-mildew treatment as recommended by the LfL's early-warning model sufficed for all varieties in 2012. No infestation was observed in any of the trial plots, either in field examinations or the examination of harvested cone samples.

At the Eschenhart trial location, the index threshold (0.22) was only reached once; a warning was generated on 10th July for the Adcon plot, which was treated accordingly. No differences between the trial plots were ascertained on crop evaluation. Both were free of infestation.

For the first time since commencement under the trial in 2008, fewer warnings were generated for the Adcon plot in Aiglsbach than by the LfL's early-warning model. This was due to a 5-week failure in 2012 of the Adcon weather station, which was out of order from July 5th to August 14th.

Consequently, only 4 warnings were generated for susceptible varieties by the Adcon model compared with 6 by the LfL's early-warning model. This failure meant that only one warning was generated for the susceptible HT variety compared with three for the LfL plot. Fortunately, there were no crop-yield or quality losses thanks to the exceptional weather situation in 2012.

Cone samples were collected during harvesting from the thrice-replicated blocks of field-assessed hop plants and examined for cone infestation. In this examination, approx. 500 cones from each sample are classified as slightly, moderately or severely infested with downy mildew. The weighted average is then calculated according to a key specified by the German efficacy test for plant protectives. No measurable downy-mildew infestation was ascertained for either model at any location or in any variety in the 2012 cone assessment.

5.5 Advisory and training activities

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

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

Written information

- The 2012 "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. 2,535 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 62 faxes sent in 2012 (54 for the Hallertau region + 5 for Spalt + 3 for Hersbruck) by the Hop Producers' Ring to 1074 hop growers 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.
- 3,023 soil-test results obtained within the context of the N_{min} nitrogen fertilisation recommendation system were checked for plausibility and approved for issue to hop-growers.
- Advisory notes and specialist articles were published for the hop-growers in 2 Hop Ring /ER-circulars and in 7 monthly issues of the Hopfen Rundschau.
- 253 field records on the 2012 hop harvest were evaluated by two working groups with the "HSK" recording and evaluation program and returned to farmers in written form.

Internet and Intranet

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

Telephone advice and message services

- The downy-mildew warning service, provided jointly by the WG Hop Cultivation/Production Techniques (Wolnzach) and the WG Plant Protection in Hop Growing (Hüll) and updated 80 times during the period from 8.05.2012 to 31.08.2012, was available via the answerphone (Tel. 08442/9257-60 and 61) or via the internet.
- Consultants from the WG Hop Cultivation/Production Techniques answered around 2,500 special questions by telephone or provided advice in one-to-one consultations, some of them on site.

Talks, conferences, guided tours, training sessions and meetings

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

Basic and advanced training

- Setting of a Master's examination topic and assessment of 3 work projects for the examination
- 16 lessons for hop-cultivation students at the Pfaffenhofen School of Agriculture
- 1-day course during the summer semester at the Pfaffenhofen School of Agriculture
- Exam preparation and examination of agricultural trainees focusing on hop cultivation, 2 sessions
- 1 information event for pupils at Pfaffenhofen vocational school
- 6 meetings with the "Business Management for Hop Growers" working group

6 Plant protection in hops

LD Wolfgang Sichelstiel, Dipl.-Ing. agr.

6.1 Pests and diseases in hops

6.1.1 Aphids

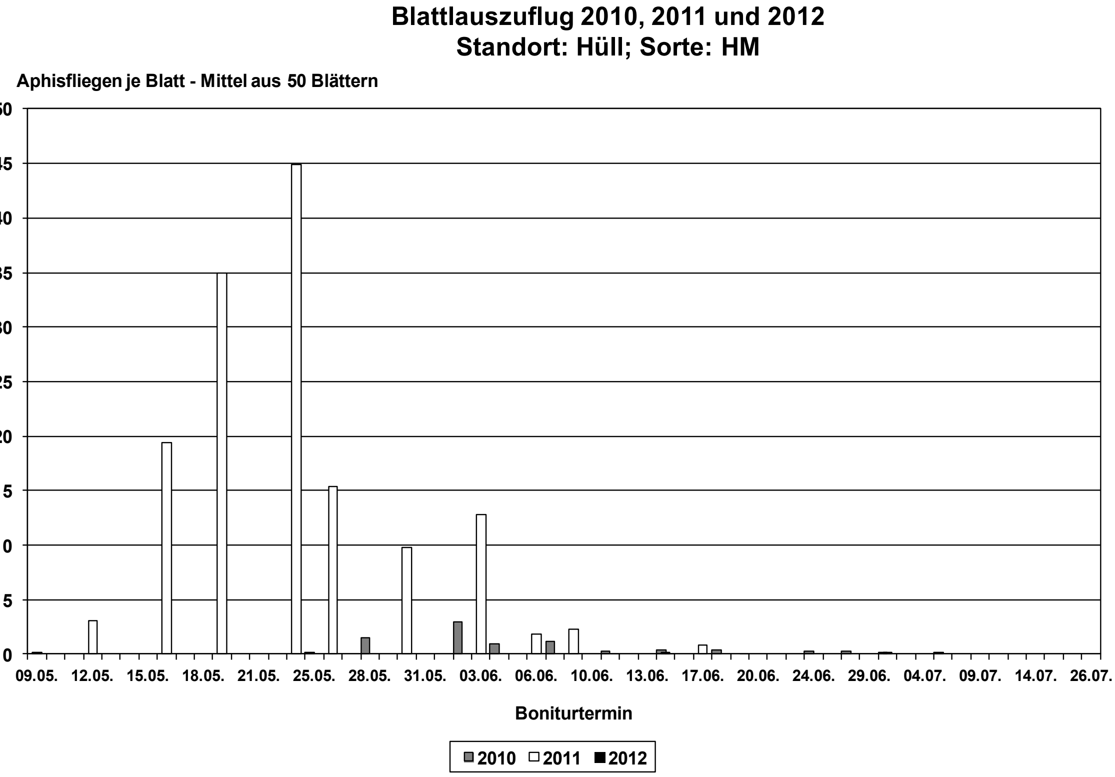

Fig. 6.1: Aphid migration

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

Date	Aphids per leaf			Spider mites per leaf		
	Ø	min.	max.	Ø	min.	max.
04.06.	0,26	0,00	3,52	0,53	0,00	5,57
11.06.	0,22	0,00	3,30	1,19	0,00	11,37
18.06.	0,29	0,00	2,66	0,89	0,00	5,77
25.06.	0,27	0,00	1,92	1,04	0,00	6,03
02.07.	0,19	0,00	1,58	1,62	0,00	11,50
09.07.	0,35	0,00	4,04	1,22	0,00**	11,37*
16.07.	0,08	0,00	1,22	0,24	0,00	4,00
23.07.	0,03	0,00	0,54	0,09	0,00	0,93
	Main spraying dates 04. - 17.07. 21 locations untreated			Main spraying dates 05.06 - 18.07. *control threshold exceeded at 14 locations ** 9 locations		

Hop aphid outbreaks were rare in 2012. Migrations were observed only in isolated cases and were extremely weak. In many cases, it was unnecessary to take any control measures, as two thirds of the hop yards observed within the scope of pest monitoring were completely free of aphids. Low to moderate levels of infestation justifying at least one precautionary treatment were observed on one third of the hop yards.

For the common spider mite, on the other hand, conditions were very favourable in 2012. Infestation was observed at an early stage, making two to three treatments indispensable in many cases.

6.1.2 Downy mildew and powdery mildew

Tab. 6.2: Downy and powdery mildew warning service

Fax-Nr.	Date	Primary downy mildew	Spray warnings			Powdery mildew
			Suscep. cultivars	All cultivars	Late cultivars	
17	10.04	xxx				
22	24.05	xx				
24	31.05.		Spray warning for hail-damaged yards			
26	13.06.			x		Susceptible
29	22.06		x			
31	02.07			x		Susceptible
33	12.07		x			
36	27.07.			x		
38	08.08		x			
42	31.08				x	
No. of spray warnings			3 + 3	3	+1	2

6.2 Extent and importance of organic hop farming in Germany and worldwide

Introduction

Organic hop farming in line with the rules of organic production of the organic farming associations has become firmly established in Germany. And like conventional hop farming, organic hop farming is competing on a global market in the full sense of the word, a market on which the two major hop producer nations, Germany and the USA, vie with one another for supremacy. As the global trend in acreage is becoming increasingly unclear in the wake of a dynamic course of development over the last few years, the IPZ Work Group has been monitoring the global trend in organic hop farming closely and on an ongoing basis since December 2010, with constant efforts being made to obtain the most up-to-date information possible from all hop growing nations for continuous updating in a data base. The situation at the end of 2012 will be outlined below.

The history of organic hop farming worldwide began as recently as the middle of the 1980s, when two farms in the Hallertau region of Bavaria took the lead, soon to be followed by two Franconian farms in what was then known as the 'Hersbruck Mountains' growing region, and switched from conventional to organic hop production. Three of these genuinely pioneering farms are still in operation today.

In the USA, organic hops were first produced in Yakima Valley in crop year 2000 and have experienced rapid growth ever since – with 10 % of the major hop farms in the USA now farming at least part of their hop acreage in accordance with ecological standards. And although the organic hop market is still only a fraction of the size of the total hop market, new, relatively tiny microbreweries producing high-quality beer from organically grown hops are mushrooming in North America, as typified, above all, by the innovative craft brewer scene in the USA. With their enormous range of small, local, strongly hopped beer varieties, these brewers are increasingly competing with globally operating breweries with their mainstream beers. Against this background, the situation with respect to organic hop production in the USA and Canada is becoming increasingly unclear, with small organic farms on an acre (0.4047 ha) or less also frequently growing hops for direct marketing to small local breweries. An economically important market will probably emerge as a result.

A statutory amendment scheduled for 1st January 2013 was expected to lead to a quantum leap in the demand for organic hops in the USA. The amendment, effected only after tremendous public pressure (TURNER et al. 2011), concerned the guidelines of the 'National Organic Standards Board' (NOSB), which had previously allowed beers to be sold under the 'Organic Beer' label in the USA even if they contained a conventionally produced ingredient (with a maximum permissible weight of 5 % of the total weight). The small share of hops in beer is much lower than the above figure, but hops were nevertheless removed from the list of permissible components as of 2013 and beer can now only be sold as organic beer if organic hops are added (GOLDMAN-ARMSTRONG 2011). The American Organic Hop Grower Association (AOHGA) has reacted to the expected increase in demand by tripling the potentially available acreage for growing organic hops over the last three years (AOHGA 2011).

2012 trend in acreage and statistics

In **Germany**, eight hop growers - five in the Hallertau region, two in the Hersbruck region and one in Tettnang – produced certified organic hops in 2012 on a total acreage of 84.16 ha. As compared with 2011, this meant an increase of 3.1 ha in acreage. The most important varieties were Hallertauer Tradition (24.03 ha), Spalter Select (15.82 ha) and Perle (14.45 ha). In general, only aroma varieties are currently grown in Germany.

Britain currently boasts four organic hop farmers, one each in Kent, Cornwall, Hampshire and the West Midlands; they are growing old English varieties such as Fuggle or Golding as well as modern low-trellis varieties such as First Gold or Boadicea on a total certified area of 16.72 ha.

Belgium has one organic hop farmer, who has been growing organic hops in West Flanders for quite some time on 13.93 ha, the most important varieties so far being Challenger and Kent Golding.

In **France**, certified organic hops were harvested for the first time in 2012; they were grown by a farmer in Alsace on a total of 12.33 ha. The most important varieties were Hallertauer Tradition, Strisselspalter and Nugget.

In **Austria,** there are currently two organic hop farmers; they are in the Mühlviertel hop-growing region and in 2012 they grew the Hallertauer Tradition, Spalter Select, Perle and Malling varieties on a total acreage of 7.26 ha. 2012 saw an increase in acreage of 2 ha over the 2011 figure.

The **Czech Republic** boasts three organic hop farmers – two in the Saaz region, one in Tirschitz; in 2012, they grew the 'Saazer' variety on 8.34 ha, certified for the first time. The Hops Research Institute in Žatec is currently also switching to organic production at a

2.25 ha yard with the 'Premiant' variety, with certified hops due to be harvested for the first time in 2014.

Poland currently boasts one certified organic hop farmer, in the Lublin growing region. This farmer is growing the 'Marynka' variety and, as the only organic hop farmer in Europe, the high-alpha variety 'Hallertauer Magnum' on an acreage of 5.56 ha.

The **Netherlands** boasts one organic grower in the province of Limburg, who grew certified organic hops of the 'Hallertauer Tradition' variety for the first time in 2012 for a private brewery.

In **Denmark**, too, there is a connection between a small private brewery on Zealand and a certified hop garden of 0.2 ha, where old Danish clones and a number of modern varieties are being cultivated.

The only European organic hop farmer in a non-EU country is in Solothurn in **Switzerland**, where the 'Perle' variety has been being cultivated for some years on 2.5 ha.

The current situation with respect to organic hop growing in the **USA** is relatively unclear, largely due to the already mentioned change in the law as of 01.01.2013. According to the AOHGA, a total of 27 US farms produced organic hops in 2010 on a total acreage of 51 ha; a further 43 ha of already certified hop acreage remained uncultivated and 45 ha were undergoing a switchover to organic production. In 2011, a total of 125 ha of certified acreage were thus available for cultivation; including a further 22 ha due to be switched over by 2012, this added up to a total acreage of 147 ha potentially available for growing organic hops. The actual acreage used for this purpose in 2011 was probably much smaller, *viz.* just under 60 ha, which nevertheless represents an increase of as much as 9 ha or thereabouts as compared with 2010. With the commencement of 2012, the expected increase in organic acreage took place, with the figure doubling to approx. 120 ha. The AOHGA growers were the only ones to harvest additional acreage, *viz.* just under 54 ha, thereby obtaining a yield of 99 t on a total acreage of 92.3 ha (AOHGA 2012). Unfortunately, it is currently impossible to obtain more precise data, as only 7 out of 27 farms with organic hops in the AOHGA are currently organized, five of them, admittedly, being among the seven 'big players' from the North West. In the USA a wide range of American, British and German varieties are also produced organically; they include a number of high-alpha varieties, in contrast to Germany and most European countries, where this is not the case. As in previous years, by far the most important hop variety grown organically in the USA in 2012 was 'Cascade', followed by 'Citra' and 'Centennial', both of which saw huge acreage expansion (AOHGA 2012).

The situation with respect to organic hop farming in **Canada** is similarly unclear, albeit at a much lower level. In the wake of the complete collapse in the early 1900s of Canadian hop farming, formerly a flourishing industry, this sector has been experiencing a renaissance since the turn of the century. It consists almost solely of small farms, often run by idealists, with hops frequently being grown alongside other crops and sold to local microbreweries. Within the context of this trend, currently very dynamic, 10 farms from among the numerous new hop farms producing organic hops have been researched so far, their total acreage amounting to 4.0 ha. Most of the farms are in the provinces of British Columbia and Ontario. The wide range of varieties is similar to that found in the USA.

So far, the only hop-growing nation in the southern hemisphere where organic hops are also produced is located in **New Zealand**. As New Zealand's hop farms benefit, in general, from exceptional climatic conditions that have hitherto prevented the emergence of fungal diseases and aphids, there is normally hardly any need to take plant protective measures. This is probably the reason why TURNER et al. (2011) cite New Zealand as the main producer of organic hops for the American market. This view is, however, incorrect, as

New Zealand currently boasts only two farms that produce certified organic hops - on a total acreage of about 15 ha. On most other hop yards in New Zealand, weed control is a crucial problem that is combatted with herbicides.

Conclusion

According to our research, certified organic hops are currently not being produced in any of the other hop-growing nations. In the **Ukraine**, initial attempts to grow organic hops commenced some time ago, with certified production possibly on the cards for 2014 at the earliest. In **Slovenia** and **Spain**, small hop yards have been established in research facilities and initial trials with organic hops launched, but certified hops have not yet been produced. To date, data on similar activities in other hop-growing countries of the world have not yet been ascertained.

In conclusion, it can only be repeated that organic hop farming plays a genuinely minimal role within the larger context of global hop production. Organic hop farming accounts for barely 0.4% of the world's total hop-growing area, and the organic hops produced there make up a mere 0.3% of total world hop production. Organic hops thus represent an exciting market segment that is attracting the attention of the hop industry but will nevertheless remain a niche product for a long time to come.

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7 Hop quality and Analytics

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7.1 General

Within the Hops Dept. (IPZ 5) of the Institute for Crop Science and Plant Breeding, the IPZ 5d Work Group (WG Hop Quality and Analytics) performs all analytical studies required to support the experimental work of the other Work Groups, especially Hop Breeding Research. After all, hops are grown for their components, with 95 % of hop output being used by the brewing industry and only 5 % for alternative purposes. Hop analytics is therefore an indispensable prerequisite for successful hop research. The hop plant has three groups of value-determining components: bitter compounds, essential oils and polyphenols, ranked in order of importance. Until now the alpha acids have been regarded as the main quality characteristic of hops, as they are a measure of hop bittering potential and hops are added to beer on the basis of their alpha-acid content (internationally, approx. 4.3 g alpha acid per 100 l beer). They are also becoming increasingly important for hop prices. US craft brewers, in particular, are now paying more attention to the aroma substances (essential oils). They are looking for hops with special aromas, some of them not typical of hops. Such hops are referred to collectively as "special flavour hops". Less interest has so far been taken in the polyphenols, although they make a definite contribution to the taste sensation. They also possess considerable anti-oxidant potential, which helps to improve the taste stability of beer and has health benefits as well. Xanthohumol has anti-carcinogenic properties and has attracted a lot of publicity in recent years. 8-prenylnaringenin, trace elements of which are found in hops, is one of the most powerful phyto-œstrogens and is responsible for the slightly œstrogenic effect of hops.

Currently the breweries face a huge glut of hops, making it very important to tap alternative uses. They can be found 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

The brewing industry, which purchases 95 % of hop output, is still the largest consumer of hops and will remain so in the future, too (Fig. 7.1).

Fig. 7.1 Use of hops

As far as hopping is concerned, breweries follow two extremely different philosophies. The aim of the first approach is to obtain alpha-acids as cheaply as possible, with variety and growing region being irrelevant. The aim of the second is to cultivate beer diversity through a variety of hop additions and products, with importance still being attached to varieties and growing regions and costs playing no role. However, overlaps exist between these two extremes.

The requirements of the brewing and hop industries regarding the composition of the hop components are constantly changing. All parties agree, however, on the need to breed hop varieties with the highest possible α-acid levels that remain as stable as possible from year to year. A low cohumolone content as a quality parameter has declined in significance. For downstream and beyond-brewing products, there is even a demand for high-alpha varieties with a high cohumolone content.

A more comprehensive view of hops can now be discerned, especially as a result of the rapid growth of the craft brewers' scene (Fig. 7.2).

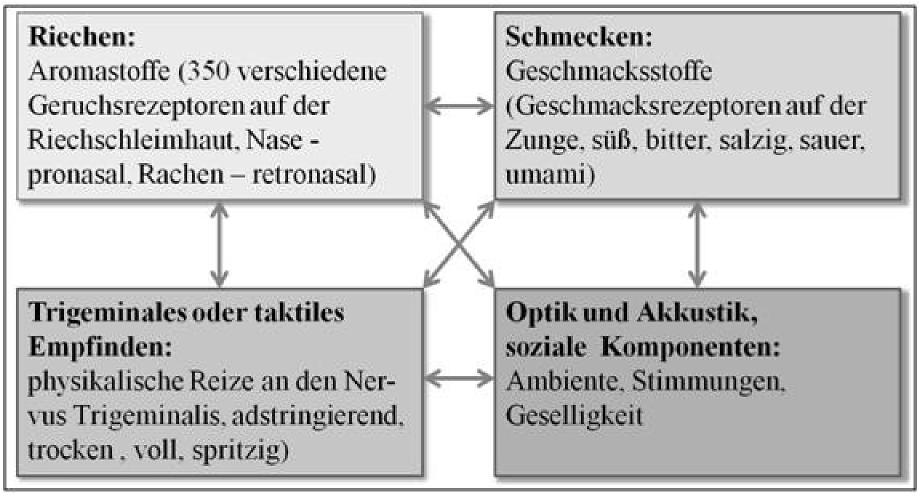


Fig. 7.2: Eating and drinking are a holistic experience

Eating and drinking are a holistic experience, with smell, taste, trigeminal and tactile sensations, as well as optical and acoustic sensations and social components interacting and complementing one another. However, as smell is responsible for 90% of foodstuff recognition, craft brewers attach more importance to the aroma compounds. The essential oils in hops consist of more than 300 different substances. Some substances are perceived more strongly, others cancel each other out. Smell is a subjective impression, in contrast to analytics, which provide objective data. Key substances must be defined, however, so that aroma quality can also be characterised analytically. Substances such as linalool, geraniol, myrcene, esters and sulphur compounds are important for hop aromas. Craft brewers are also interested in purchasing hops with exotic aromas such as mandarin-orange, melon, mango or currant.

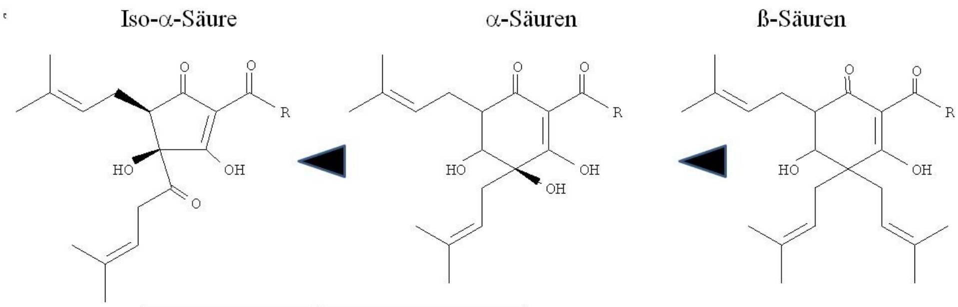
The way in which aroma is imparted to beer is also highly dependent on technological factors. Maximum aroma intensity is achieved through late hopping or, best of all, dry hopping.

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 such as xanthohumol, the prenylflavonoids and phenolic carboxylic acids.

7.2.2 Possible alternative uses

To date, only 5 % of hop output has been put to alternative uses, but it is planned to expand this share. Both the cones and the remainder of the hop plant can be utilised. The shives (woody core of the stem) have good insulating properties and are very stable mechanically; they are thus suitable for use as loose-fill insulation material and in composite thermal-insulation mats. Shive fibres can also be used to make moulded parts such as car door panels. As yet, no large-scale industrial applications exist, however.

As far as the cones are concerned, the antimicrobial properties of the bitter substances are especially suited to alternative uses. Even in catalytic amounts (0.001-0.1 wt. %), the bitter substances have antimicrobial and preservative properties in the following order of importance: iso-α-acids, α-acids, β-acids. (Fig. 7.3).



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

Fig. 7.3: Sequence of anti-microbial activity of iso-α-acids, α-acids and β-acids

They destroy the pH gradient at the cell membranes of bacteria, which can no longer absorb any nutrients and die. The iso-α-acids in beer even provide protection against heliobacter pylori, a bacterium that triggers stomach cancer. The ß-acids are especially effective against bacteria such as listeriae and clostridiae and also have a strong inhibitory effect on the growth of Mycobacterium tuberculosis. This property can be exploited by using the bitter substances in hops as natural biocides wherever bacteria need to be kept under control. In sugar processing and ethanol production, it is already established practice to replace formalin with β-acids. Other potential applications that exploit the antimicrobial activity of hop β-acids include their use as preservatives in the food industry (fish, meat, milk products), the sanitation of biogenic waste (sewage sludge, compost), elimination of mould, improvement of the smell and hygiene of pet litter, control of allergens, and use as an antibiotic in animal food. In future, considerable demand for hops for use in such areas can be expected. Increased β-acid content is therefore one of the breeding goals in Hüll. Currently, the record is about 20 %, and there is even a breeding line that produces β-acids alone and no α-acids.

As the hop plant boasts a wide variety of polyphenolic substances, it is also of great interest for the areas of health, wellness, dietary supplements and functional food. With a polyphenol content of up to 8 %, the hop plant is very rich in these substances. Work is being done on increasing xanthohumol content. A breeding line containing 1.7 % xanthohumol is already available. Other prenylated flavonoids, such as 8-prenylnaringenin, occur only in trace amounts in hops. The oligomeric proanthocyanidins (up to 1.3 %), glycosidically bound quercetin (up to 0.2 %) and kaempferol (up to 0.2 %) are substances with very strong antioxidative potential. 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 in collaboration with Hop Quality and Analytics.

7.3 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. Tab. 7.1 shows the composition of the polyphenols in hops.

Tab. 7.1: Composition of the hop polyphenols and their concentrations in hops

Substances and substance groups	Concentrations
Phenolic carbon acids	
1) Benzoic acid derivatives	< 0.01 %
2) Cinnamic acid derivatives	0.01 – 0.03 %
Flavonoids	
3) Xanthohumol	0.20 – 1.70 %
4) 8,6-prenylnaringenin	< 0.01 %
5) Quercetin glycoside	0.05 – 0.23 %
6) Kämpferol glycoside	0.02 – 0.24 %
7) Catechins and epicatechins	0.03 – 0.30 %
8) Oligomeric proanthocyanidins	0.20 – 1.30 %
9) Acylphloroglucinol derivatives	0.05 – 0.50 %
Higher-molecular substances	
10) Catechin tanning agents and tannins	2.00 – 7.00 %

Polyphenols occur as bioactive substances in almost all plants. They have biological functions as flavour and colouring agents and also help promote plant resistance to disease and pests. In higher-molecular form, they act as tanning agents. Numerous publications attest to the positive health-giving properties of the polyphenols, which act as antioxidants 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. It accumulates in the liver and is thus very effective against liver disease. Xanthohumol levels in blood plasma are relatively low. 8-prenylnaringenin, trace amounts of which are found in hops, is regarded as one of the most potent phyto-œstrogens and is responsible for the slightly œstrogenic effect of hops. Although this effect had been known for centuries, the responsible substance was not discovered until 10 years ago.

Tab. 7.2 shows a comparison of polyphenol levels in hops and other plants. Hops have especially high amounts of quercetin and proanthocyanidins. These groups of substances boast very strong antioxidative potential. Such substances protect cells against oxidative processes and thus against associated diseases such as atherosclerosis and cancer. Our diet should therefore contain lots of foodstuffs that are rich in polyphenols (fruit and vegetables).

Tab. 7.2: Polyphenol content of hops as compared with that of other plants

Plants	**Polyphenol level (total)**	**Quercetin**	**Catechin + epicatechin**	**Proantho-cyanidins**	**Literature**
Hops	2 – 8	50 – 230	30 – 300	320 – 1640	
Apple		2.0 – 44	1.00 – 14.00	128	1, 5
Pear			0.94 – 4.21	42	5
Broccoli		3.0 – 3.7			1
Blackberry		4.5	0.84 – 6.30	23	1, 5
Strawberry			2.52 – 5.47	145	5
Blueberry		7.4 - 15.8	2.07 – 5.58	329	1, 5
Cocoa	6		2200	1573	2
Cherry		3.2	3.46 – 6.37		1, 5
Cranberry			5.53 – 8.59	418	5
Plum			6.38 – 14.94	247	5
Lettuce		0.1 – 9.0			4
Tea	25 – 35	1.4 – 1.7	20000 – 30000		6
Tomato		0.5 – 3.0	0	0	4, 5
Grape		1.5 – 3.7	0.44 – 2.14	81	3, 5
Cinnamon				8108	5
Onion		34.2 – 48.6			1

Total polyphenol level in %, quercetin, catechin, epicatechin, proanthocyanidins in mg/100 g

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7.3.1 Previous methods of differentiating between varieties

Basically, there are four possible ways of differentiating between hop varieties:

- Morphological characteristics
- Composition of the bitter substances
- Composition of the essential oils
- DNA analysis

In some cases, hop cones are very easily distinguished visually on the basis of their morphological characteristics, but this task can also be very difficult. Hop cones have a range of shapes and sizes; their bracts vary greatly in shape and are typical of the variety. These characteristics are absent in pellets and extracts.

In Hüll varietal identification and selection are initially performed via visual examination, after which chemical methods are employed. Every hop variety has its own typical bitter-substance composition. The cohumulone percentage and α-/ß-acid ratio are variety specific. The essential oils supply further information. Once again, some varieties are easy to distinguish and others very difficult. The bitter compounds and essential oils can even be used for varietal differentiation when hop pellets and extracts are involved. DNA analysis is resorted to in special cases (Dr. Seefelder, IPZ 5c). DNA is absent, however, in hop extracts. The aim of this project is to investigate whether the low-molecular polyphenols can also be used to identify varieties.

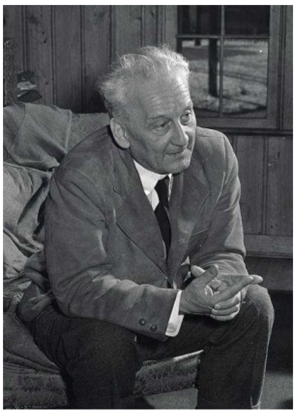
7.3.2 Goal

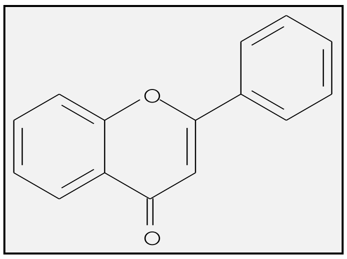
Approximately 80 % of hop polyphenols consist of higher-molecular compounds such as the catechin tanning agents and tannins (tanning agents). About 20 % of the hop polyphenols consist of monomeric substances such as phenolic carboxylic acids like the flavonoids and their glycosides (Tab. 7.1). The low-molecular substances can be analysed via HPLC.

The initial goal of the project was to devise a suitable method for sample preparation and HPLC analysis before proceeding to an analysis of the entire world hop range of crop years 2009, 2010 and 2011 available at Hüll. The second goal was to evaluate the data thus obtained with the help of multivariate statistical methods in order to see whether grouping or classification was possible.

7.3.3 Current status of polyphenol analytics

Flavonoids are a sub-group of polphenols and were discovered by Nobel Prize Winner for Medicine Albert Szent-Györgyi Nagyropolt in the 1930s. Initially, he labelled them 'vitamin P', as they are capable of exerting an influence on the permeability of blood vessels. Later on, they were given the name 'flavonoids', as they are derived from the structure of flavone. (Fig. 7.4) [7]. I. McMurrough and C. F. Sumere [8, 9] were the first scientists to analyse the low-molecular polyphenols in hops via HPLC and to perform basic research on this group of substances. Quercetin and kaempferol do not occur in free form in hops but only in glycosidically bound forms.





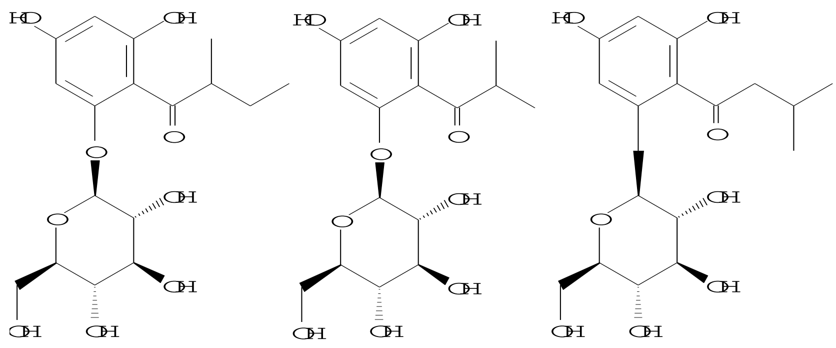
Flavone

Fig. 7.4: Albert Szent-Györgyi Nagyropolt and the structure of flavone

The sugars can be removed via hydrolysis, and quercetin and kaempferol quantitatively determined. This method had already been used to analyse the total world hop range [10]. In this project, however, the glycosides also had to be taken into account.

A further group of substances that are of pharmacological interest due to their anti-inflammatory properties is that of the acylphloroglucinol derivatives (multifidols, [11]).

The term 'multifidols' comes from the tropical plant Jatropha multifida, which contains these compounds in its sap. Fig. 7.5 shows the chemical structures. Multifidol glucoside itself has structure A. Hops mainly contain the B compound, but also A and C in smaller concentrations.



A B C

Fig. 7.5: Chemical structures of the multifidols

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9) Van Sumere, C., F.; VandeCasteele, K; Hutsebaut, M.; Everaet, E.; De Cooman, L.; Meulemann, W.: RP-HPLC Analysis of Flavonoids and the Biochemical Identification of Hop Cultivars, EBC-Monograph XIII, 1987, pp. 146-175

10) Kammhuber, K.: Differenzierung des Welthopfensortiments nach Bitterstoffen and Polyphenolen, Hopfenrundschau International, 2005/2006, pp. 42-46

11) Bohr, G.; Gerhäuser , C.; Knauft, J.; Zapp, J.; Becker, H.: Anti-inflammatory Acylphloroglucinol Derivatives from Hops (Humulus lupulos), J. Nat. Prod., 2005, 68, pp. 1545-1548

The exact chemical names are:

A = 1-(2-methylbutyryl)phloroglucinol-glucopyranoside (multifidol)

B = 1-(2-propanoyl)phloroglucinol-glucopyranoside

C = 1-(3-methylbutyryl)phloroglucinol-glucopyranoside

Until now, total polyphenol content and total proanthocyanidin content has been determined at the Hüll laboratory as per Analytica-EBC methods 9.10 and 9.12 for beer.

7.3.4 Material and methods

World hop range (cultivar yard at Hüll)

There is a cultivar yard at Hüll where almost the entire available world hop range is grown. The bitter compounds and essential oils are analysed there every year, the goal being 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.

The results are published every year in the annual report of the Hop Research Centre. The same samples were used for the polyphenol project. The 2009, 2010 and 2011 crops were taken into account in the analysis.

Sample preparation

Work first focussed on devising a suitable method of sample preparation and optimum HPLC differentiation. For sample preparation purposes, 5 g of ground hops are extracted for 15 min. in an ultrasonic bath and then filtered; the solution is shaken with 50 ml hexane in a separation funnel. The non-polar substances remain in the hexane phase. 1 ml internal standard solution (250 mg flavone in 25 ml acetone) is added to the acetone/water phase. Finally, filtration is performed once again with the help of a syringe filter (Rotilabo, nylon membrane, 0.20 µm) and the solutions filled into analytical vials for HPLC analysis.

HPLC method

The EC 125/2 NUCLEODUR Sphinx RP, 3 µm from Macherey and Nagel has proved very suitable as a separation column. The ACCELA UHPLC system from Thermo Scientific was used for HPLC purposes. The gradient programme in Tab. 7.3 was used to separate the polyphenols. The various detection wavelengths for the individual substance groups are also compiled in Tab. 7.3.

Eluent A: add water to 100 ml methanol and 3 ml 85 % H_3PO_4 to make up 1 l solution

Eluent B: add water to 700 ml methanol and 3 ml 85 % $H3PO_4$ to make up 1 l solution

Eluent C: methanol

Tab. 7.3: Gradient programme and detection wavelengths

Linear gradient:	Detection wavelengths:
0 min.: 100 % A	Benzoic acid derivatives: 250 nm
5 min.: 100 % A	Cinnamic acid derivatives:
30 min.: 70 % A, 30 % B	Catechins:
55 min.: 10 % A, 90 % B	Quercetin glycosides: 350 nm
56 min.: 100 % C	Kaempferol glycosides: 350 nm
60 min.: 100 % C	Multifidol glucosides: 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. Quercetin and the kaempferol glycosides have an absorption maximum at wavelength 350 nm and the multifidol glucosides at 280 nm. The decision was therefore taken to measure at wavelengths 350 nm and 280 nm, in order to obtain maximum selectivity and sensitivity. Fig. 7.6 shows a chromatogram at wavelength 280 nm, which is ideal for measuring the multifidol glucosides. Fig. 7.7 shows the chromatograms of the Opal, Hersbrucker Spät, Herkules and Zeus varieties at wavelength 350 nm; these cultivars differ greatly in their flavonoid composition.

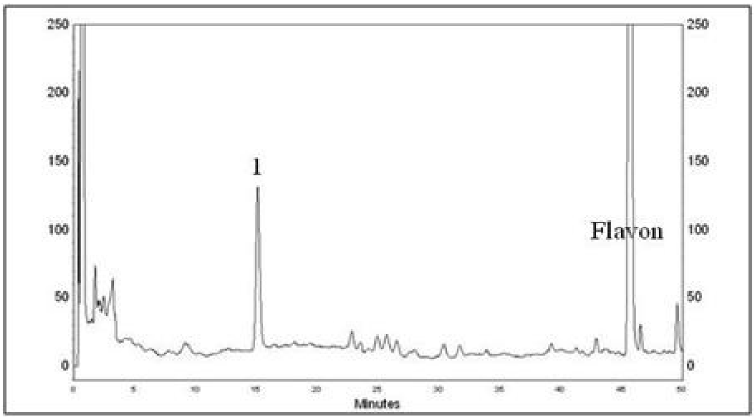


Fig. 7.6: Chromatogram of the flavonoids at wavelength 280 nm

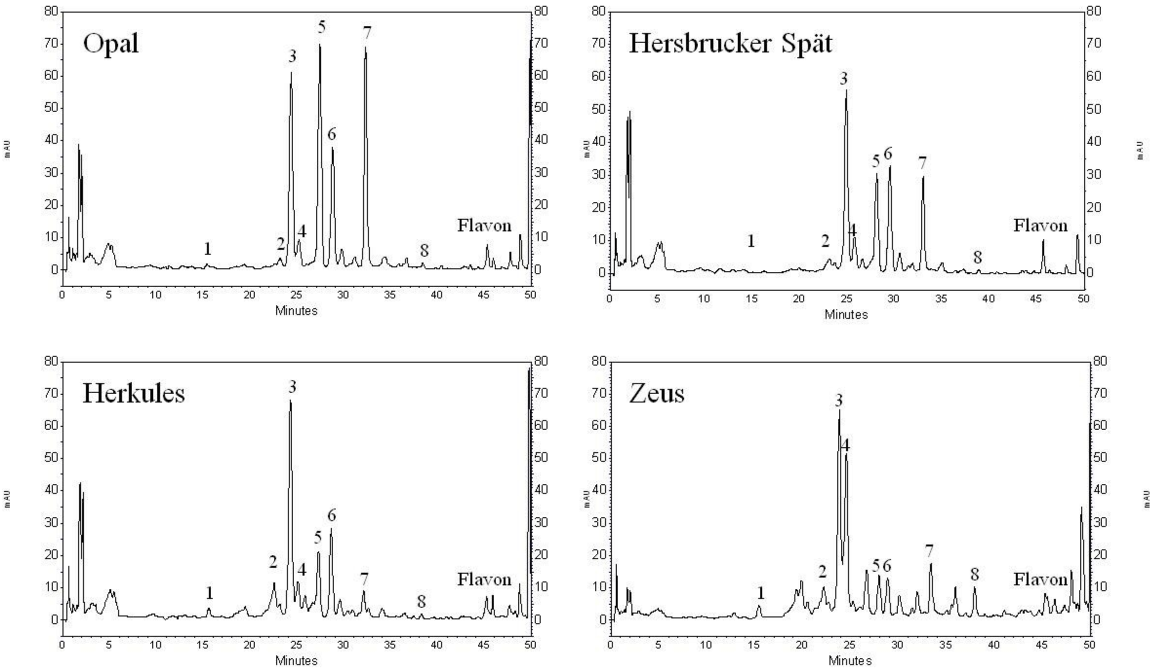


Fig. 7.7: HPLC chromatograms of the flavonoid glycosides of Opal, Hersbrucker Spät Herkules and Zeus at wavelength 350 nm

The substance flavone (Fig. 7.4) serves as the standard, as it does not occur in hops and distinguishes the polar from the non-polar substances. The non-polar bitter substances xanthohumol and the prenylated naringenins are not eluted until after flavone. The main substances of interest in this research work were those that exceeded flavone in polarity.

Identification of individual substances

All main substances were identified in collaboration with Dr. Coelhan of Munich Technical University (TUM). Dr. Coelhan isolated the substances via preparative HPLC and determined the chemical structures via mass spectrometry, although the latter method does not allow the absolute structures to be determined [12].

The substances quercetin-3-galactoside, quercetin-3-glucoside (isoquercitrin) and kaempferol-3-glucoside (astragaline) were also verified with pure substances. Substance 1 was positively identified as 1-(2-methylpropanoyl) phloroglucinol-glucopyranoside. The chemical structures are compiled in Fig. 7.8.

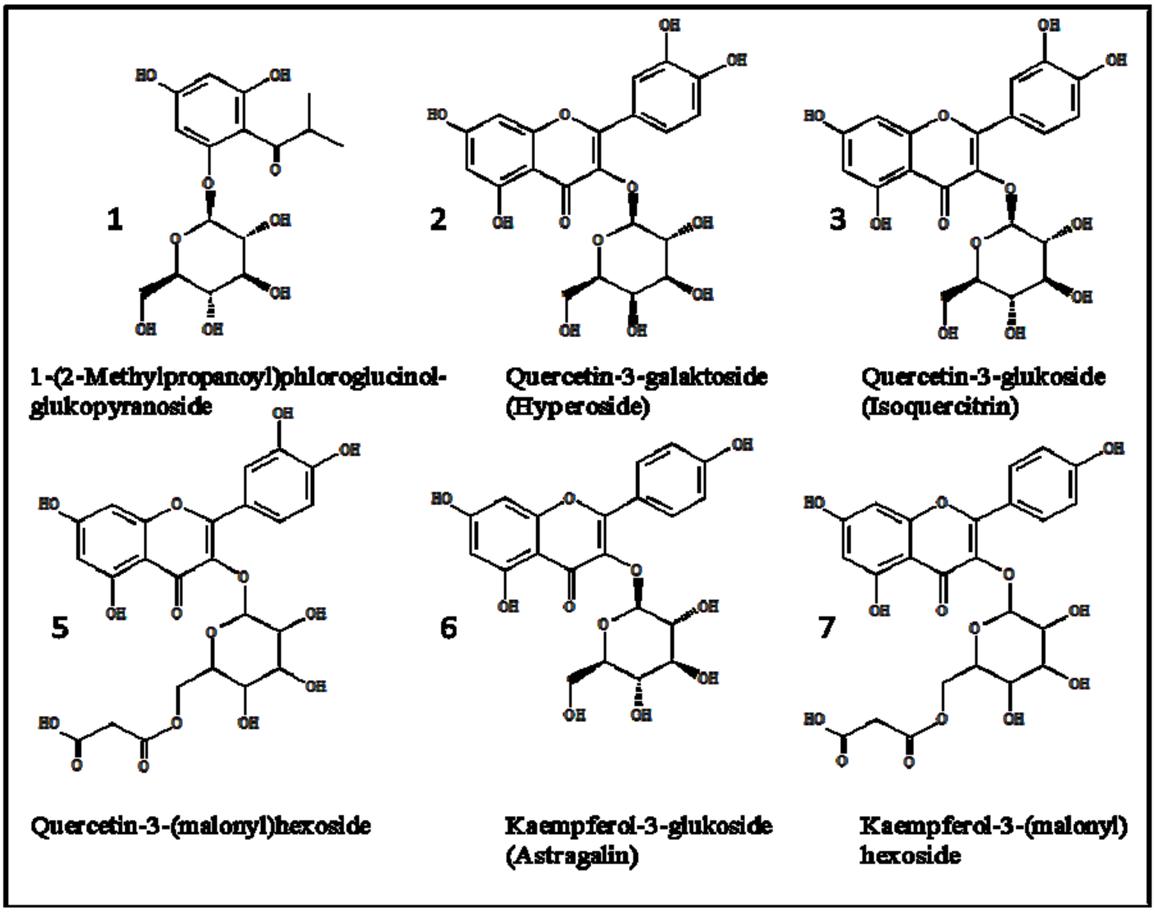


Fig. 7.8 Chemical structures of the identified substances (English designation)

12) Coelhan, M.; Plapperer, R.; Strohmeier, J.; Tischliar, M,: Forschungsbericht über HPLC-MS Identifizierung von Hopfenpolyphenolen, Forschungszentrum Weihenstephan for Brau- and Lebensmittelqualität, November 2011

7.3.5 Results and evaluation

Almost the entire world hop range available in Hüll from crop years 2009, 2010 and 2011 (121 different varieties from 17 countries) was analysed using the methods that had been developed. Tab. 7.4 shows the world hop range and the first three principal components. Flavonoid composition varied only very slightly over the three crop years and samples of the same variety at various locations displayed the same patterns, too. Flavonoid composition is, at all events, genetically determined and thus variety specific.

7.3.6 Principal-component analysis

Method and execution

A principal component analysis was performed on the basis of the seven substances identified in the chromatograms (Fig. 7.7) and their mean values in crop years 2009, 2010 and 2011, in order to visualize similarities and differences. The SAS 9.1 software programme was used and the calculation performed on the basis of the correlation matrix (Table 7.4).

Tab. 7.4: Correlation matrix

	Multifidol	Peak 3	Peak 4	Peak 5	Peak 6	Peak 7	Peak 8
Multifidol	1.0000	-0.5666	-0.1952	-0.3604	-0.6012	-0.2994	0.2393
Peak 3	-0.5666	1.0000	0.3535	-0.3410	0.5770	-0.4710	-0.3000
Peak 4	-0.1952	0.3535	1.0000	-0.5077	-0.0820	-0.4839	-0.0752
Peak 5	-0.3604	-0.3410	-0.5077	1.0000	-0.1380	0.6476	0.0555
Peak 6	-0.6012	0.5770	-0.0820	-0.1380	1.0000	0.0929	-0.2934
Peak 7	-0.2994	-0.4710	-0.4839	0.6476	0.0929	1.0000	-0.1676
Peak 8	0.2393	-0.3000	-0.0752	0.0555	-0.2934	-0.1676	1.0000

In the principal-component analysis, the original data matrix is projected onto smaller matrices, the principal components each accounting for the maximum variance (Tab. 7.5).

Tab. 7.5: Eigenvalues and variances

PCA	Eigen-values	Diffe-rence	Variance in%	Cumulative variance in %
1	2.5327	0.3347	36.2	36.2
2	2.1980	1.3142	31.4	67.6
3	0.8838	0.0748	12.6	80.2
4	0.8090	0.3521	11.6	91.8
5	0.4569	0.3386	6.5	98.3
6	0.1183	0.1169	1.7	100
7	0.0014	0.3347		

The first principal component accounts for 36.2 %, the second for 31.4 % and the third for 12.2 % of total variance. The cumulative variance shows that three principal components account for as much as 80.2 % of total variance. In Tab. 7.6, the entire world hop range is shown with the first three principal components.

Tab. 7.6: World hop range with first three principal components

Variety	Country	PCA 1	PCA 2	PCA 3	Variety	Country	PCA 1	PCA 2	PCA 3
Admiral	England	2.04183	0.94175	1.69449	College Cluster	England	-3.82735	-0.52455	0.76948
Agnus	Czech	2.24785	1.33353	2.28590	Columbus	USA	-0.21336	3.60828	0.47866
Ahil	Slovenia	1.96116	1.52735	-0.22146	Comet	USA	0.65837	1.18686	-0.04438
Alliance	England	-0.38170	-2.72811	0.60409	Crystal	USA	-2.80028	-1.45026	0.18509
Alpharoma	New Zealand	-0.65776	-2.26668	0.84087	Density	England	-2.76180	0.79104	-0.39323
Apolon	Slovenia	1.14272	1.71109	0.77967	Diva	England	-0.19095	-1.28221	-0.77179
Aquila	USA	-0.96231	2.98401	1.52197	Early Choice	England	0.02238	-1.36078	-1.15919
Aromat	Czech	1.10493	-1.11444	-1.36697	Eastern Gold	Japan	-3.32473	2.56387	-0.06658
Atlas	Slovenia	-2.05435	0.72380	-0.48218	Eastwell Golding	England	0.14067	-0.84732	-0.12258
Aurora	Slovenia	0.91023	-1.36435	0.05024	Emerald	Germany	1.54828	1.42179	-2.05440
Backa	Serbia	0.65960	2.18446	0.63811	Eroica	USA	-1.46287	2.46127	-1.14963
Belgischer Spalter	Belgium	0.38071	0.12289	-0.36131	Estera	Poland	-1.43458	-0.48900	-0.25895
Blisk	Slovenia	-0.22409	1.45445	-0.73677	First Gold	England	0.67613	-0.67343	-1.07277
Boadicea	England	-0.93738	-0.31228	-0.53503	Fuggle	England	-0.46297	0.01115	0.80670
Bobek	Slovenia	1.73215	-0.51223	-0.28643	Galena	USA	-0.39551	2.51721	-1.91454
Bor	Czech	0.96097	0.53709	-0.50771	Ging Dao Do Hua	China	-3.52078	2.10132	-0.78549
Bramling Cross	England	-2.99209	0.40742	-0.26983	Glacier	USA	0.37478	-1.38294	0.11672
Braustern	Deutschland	1.28631	-0.38741	-1.11421	Golden Star	Japan	-3.51414	2.03026	-0.69983
Brewers Gold	England	1.34915	1.83555	0.64214	Granit	Ukraine	-0.71857	0.23842	-0.21029
Brewers Stand	England	-2.28517	1.52733	0.77956	Green Bullet	New Zealand	-0.52002	-1.80941	0.43583
Buket	Slovenia	0.75996	-1.49028	0.80786	Hallertauer Gold	Germany	0.86406	-0.63794	-1.03808
Bullion	England	0.14002	1.07304	-0.12315	Hallertauer Magnum	Germany	1.81580	2.98347	1.30195
Cascade	USA	0.22194	0.46694	-1.17152	Hallertauer Merkur	Germany	0.35002	1.35109	-0.06421
Chang Bei 1	China	-0.24690	-1.55693	0.86758	Hallertauer Taurus	Germany	1.13888	2.30451	-0.68785
Chang Bei 2	China	-0.69786	-1.65797	0.18394	Hallertauer Tradition	Germany	2.02716	0.92631	-2.61546

Cont. Table 7.6

Variety	Country	PCA 1	PCA 2	PCA 3	Variety	Country	PCA 1	PCA 2	PCA 3
Hallertauer Mfr.	Germany	1.13477	-1.72671	-0.54764	Northern Brewer	England	1.36296	0.33631	-1.53893
Harmony	Czech	1.18405	0.33871	0.10254	Nugget	USA	-0.47255	-0.79810	1.94991
Herald	England	0.86354	-0.68715	-1.71095	Olympic	USA	-0.90500	-1.55109	0.41600
Herkules	Germany	0.02822	2.12309	-1.33157	Opal	Germany	0.64547	-1.65466	-0.32680
Hersbrucker Pure	Germany	0.90833	-0.93491	0.73297	Orion	Germany	1.12376	0.74199	-1.49551
Hersbrucker Spät	Germany	-2.50516	-1.70103	0.75162	Pacific Gem	New Zealand	-1.93674	-1.17812	1.77690
Horizon	USA	0.21274	-0.91001	1.07888	PCU 280	Polen	1.04204	-0.11165	-0.78807
Hüller Anfang	Germany	0.97139	-1.91889	-0.23639	Perle	Germany	1.97974	1.46174	-2.83497
Hüller Aroma	Germany	0.57925	-1.77810	-0.23225	Phoenix	England	0.46683	-1.13500	0.87954
Hüller Bitter	Germany	-0.71603	-0.40141	-0.07721	Pilgrim	England	0.20876	-0.71615	-0.05841
Hüller Fortschritt	Germany	0.32379	-2.37877	-0.07445	Pilot	England	-1.33190	-1.20248	0.25126
Hüller Start	Germany	1.18480	-2.38164	-0.30232	Pioneer	England	0.37490	-0.52956	-0.93666
Japan C 730	Japan	-0.08667	-0.57252	1.34100	Premiant	Czech	2.98889	3.18519	0.22191
Japan C 845	Japan	0.95844	1.19259	-2.85173	Pride of Kent	England	0.43860	-2.56218	0.74239
Kirin 1	Japan	-3.11898	2.54900	-0.16420	Pride of Ringwood	Australien	-2.25745	-0.36189	0.54530
Kirin 2	Japan	-3.76278	2.26708	-0.67160	Progress	England	-2.46649	1.13049	1.09132
Kitamidori	Japan	0.00573	0.51185	-1.98592	Rubin	Czech	-0.55751	-2.37830	-0.06678
Kumir	Ukraine	1.09074	-0.18612	-0.19151	Saazer	Czech	1.27054	-1.23380	0.82692
Lubelski	Poland	1.62961	-0.33753	-0.70151	Saphir	Germany	0.72312	-1.14376	-0.77558
Malling	Austria	-2.00999	-0.84785	0.57431	Serebrianker	Russia	0.98084	-1.79311	0.74006
Marynka	Poland	-2.58884	0.91816	0.26799	Sirem	Czech	1.41067	-0.49892	-0.82060
Mt. Hood	USA	0.51723	-1.12373	0.63901	Sladek	Czech	0.84689	0.01732	-1.45927
Neoplanta	Yugoslavia	0.29516	-1.67254	1.03211	Smaragd	Germany	0.29672	-2.29612	0.29408
Neptun	Germany	4.13781	3.64201	7.39853	Spalter	Germany	1.56961	-0.46461	-0.70530
New Zealand Hallertauer	New Zealand	-1.56715	-0.24337	0.04939	Spalter Select	Germany	1.80298	-0.61059	0.90013

Cont. Table 7.6

Variety	Country	PCA 1	PCA 2	PCA 3	Variety	Country	PCA 1	PCA 2	PCA 3
Sterling	USA	-0.71120	-1.21306	1.02883	Williamette	USA	-2.31667	-0.63407	0.41347
Sticklebrackt	New Zealand	-2.90578	-0.54805	0.59901	Wye Northdown	England	1.02772	0.20647	-1.16152
Strisselspalter	France	-3.00219	-1.34995	0.62767	Wye Target	England	2.11202	1.77136	1.66728
Super Alpha	New Zealand	-1.60742	-0.69886	0.45123	Wye Viking	England	0.40314	-0.67542	0.25007
Talisman	USA	1.44274	0.28638	-0.85607	Yeoman	England	0.50739	-0.76036	-0.22969
Tettnanger	Germany	1.54564	-0.86445	0.37306	Zatecki	Czech	-1.26367	-0.03387	0.10788
Toyomidori	Japan	1.73308	1.75889	-0.61351	Zenith	England	0.27764	-1.89752	0.19763
Urozani	Russia	0.71110	-0.65709	0.69946	Zeus	USA	-0.61988	3.46674	0.62154
USDA 21055	USA	-3.27366	1.92294	0.31517	Zitic	Ukraine	1.41942	1.08282	-1.39901
Vojvodina	Yugoslavia	0.74209	-1.59669	0.68526	Zlatan	Czech	1.74055	-0.42084	0.01360
WFG	England	1.69272	-0.18858	-0.73742					

Fig. 7.9 shows a graph of the first two principal components.

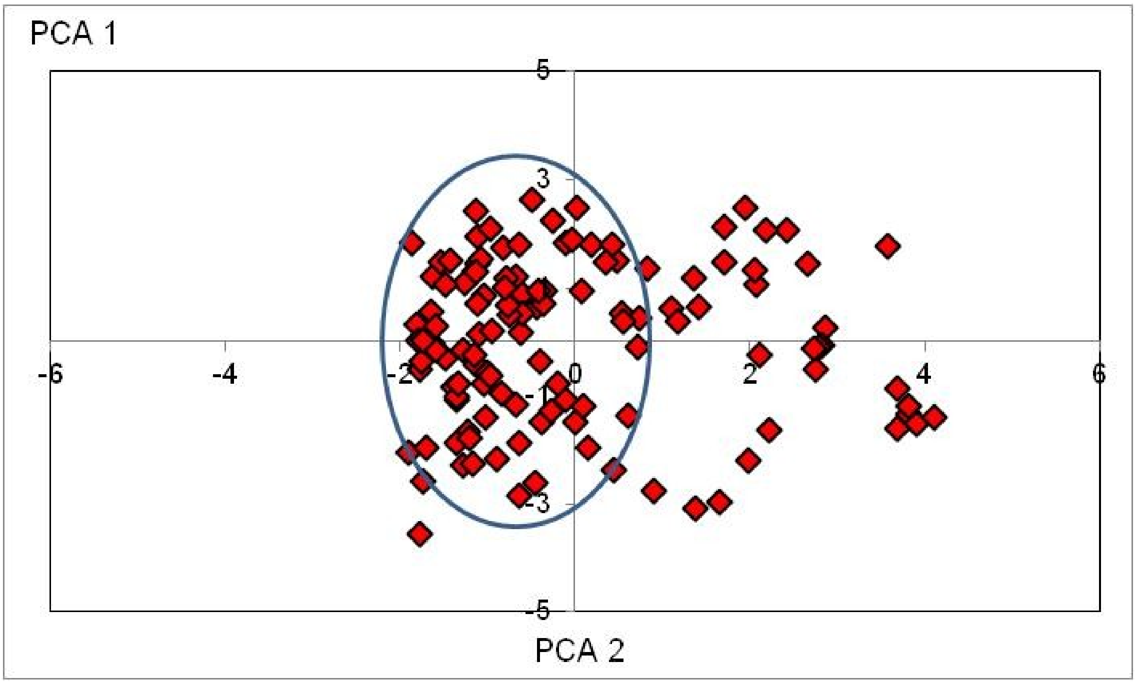
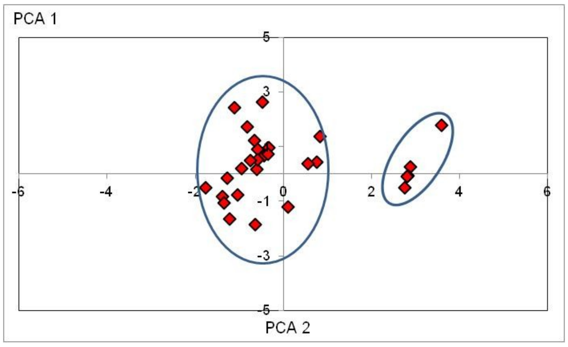


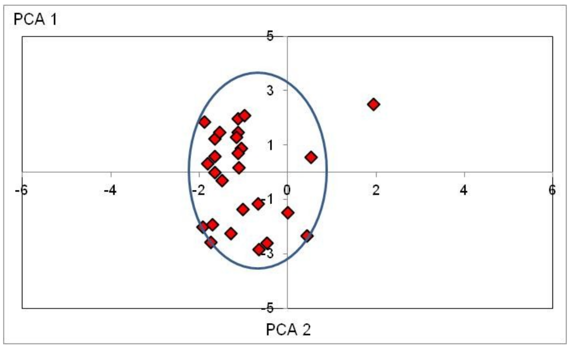
Fig. 7.9: Cluster diagram of the first two principal components of the world hop range

Each point in the graph represents a hop variety. The closer the points are clustered together, the greater the similarity between the varieties, and the further apart they are, the more they differ. Most varieties lie within the plotted ellipse.

Figs. 7.10 to 7.12 show the principal component diagrams by country. They are shown initially in descending order by number of varieties per country and then, in Tab. 7.7, alphabetically.

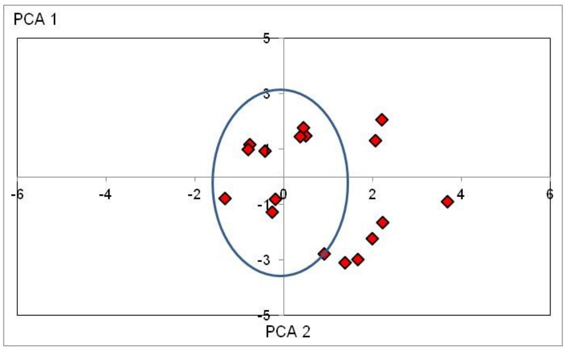


England (28)

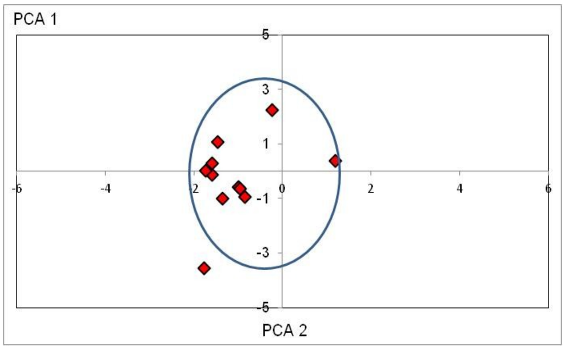


Germany (26)

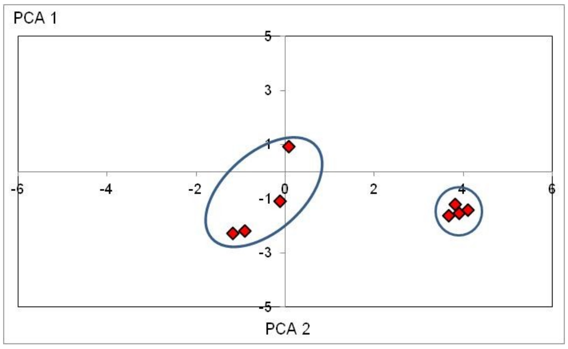
Fig. 7.10: Cluster diagrams of the principal components of the world hop range by country (Part 1)



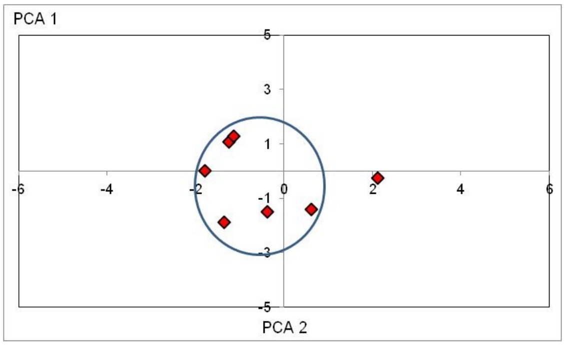
USA (17)



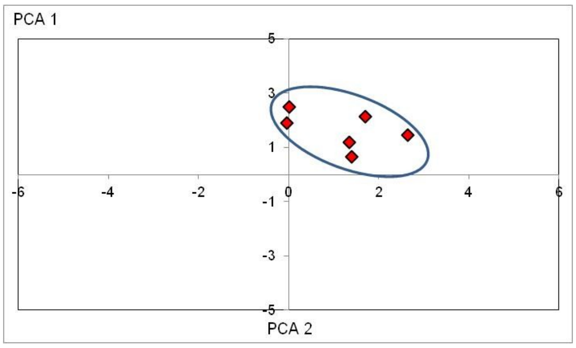
Czech Republic (11)



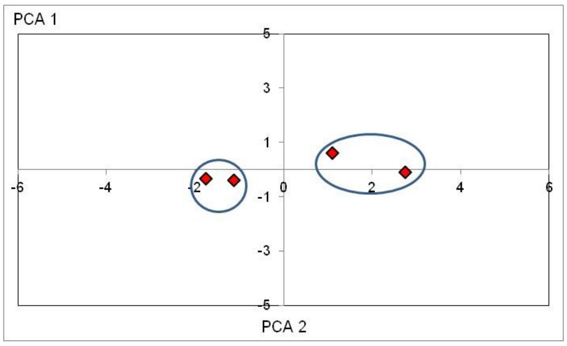
Japan (8)



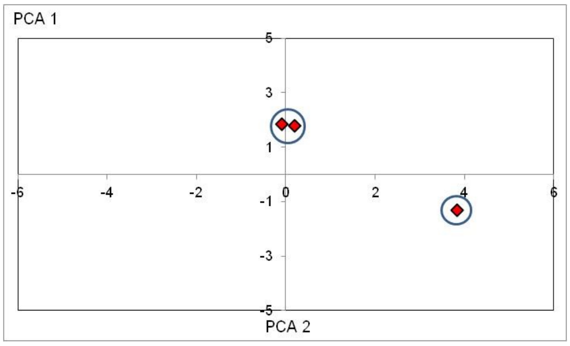
Slovenia (7)



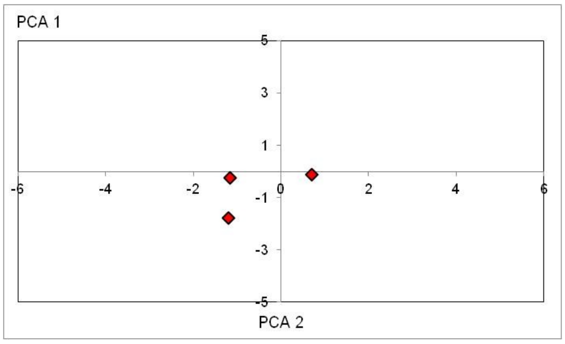
New Zealand (6)



Poland (4)

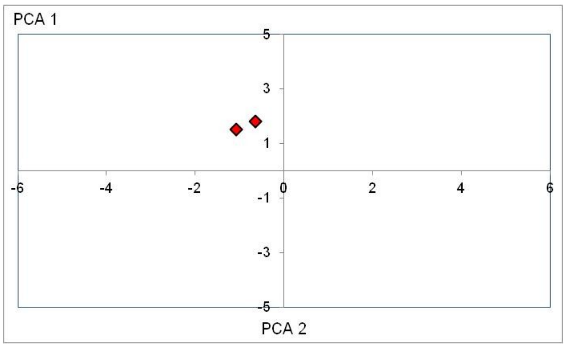


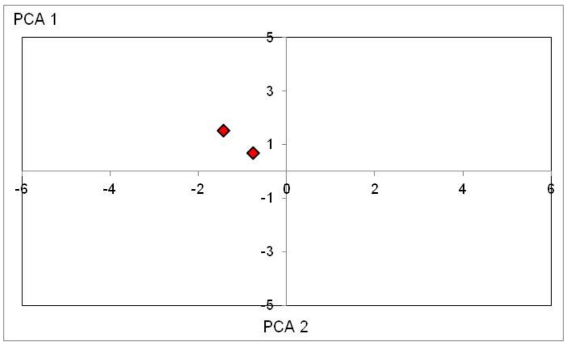
China (3)



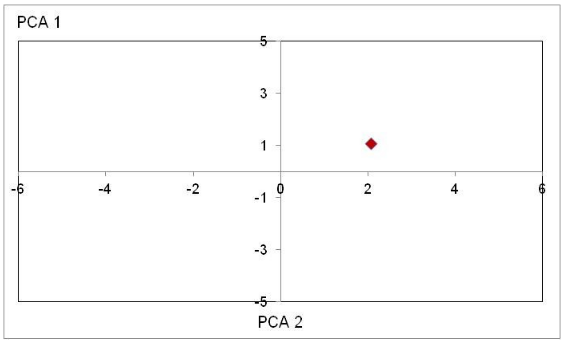
Ukraine (3)

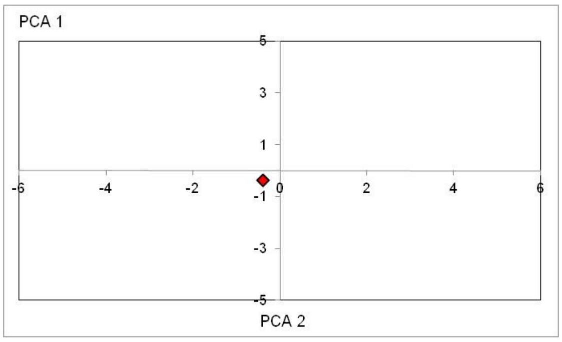
Fig. 7.11: Cluster diagrams of the principal components of the world hop range by country (Part 2)



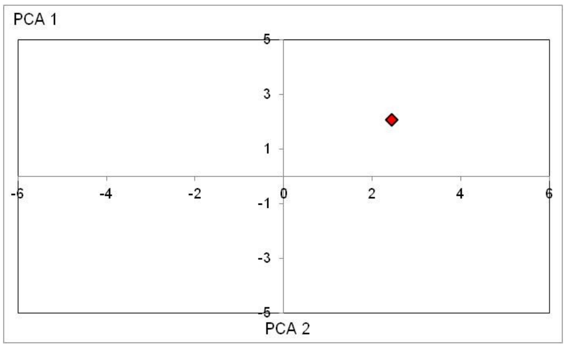


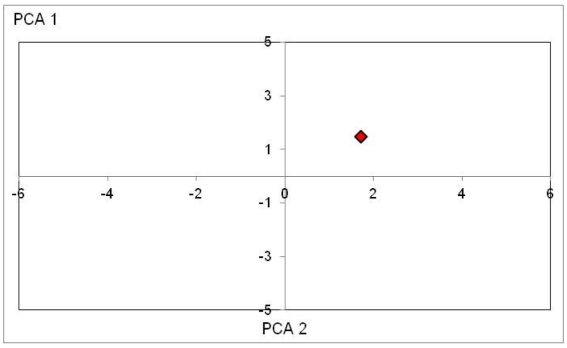
Yugoslavia (2) Russia (2)



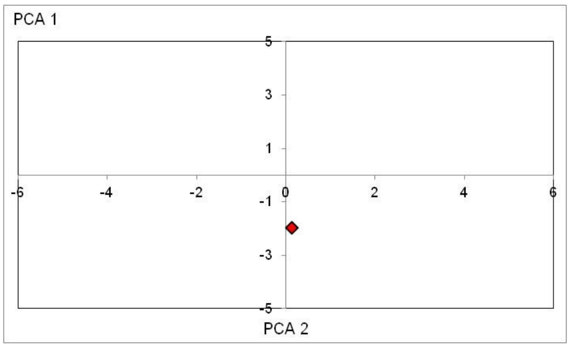


Australia (1) Belgium (1)





France (1) Austria (1)



Serbia (1)

Fig. 7.12: Cluster diagrams of the principal components of the world hop range by country (Part 3)

Discussion and interpretation of data

In this project, the first of its kind, the flavonoid compositions of almost all varieties of the world hop range were studied over a period of three years. The results were surprising, as many varieties proved, after all, to be very similar in their flavonoid structure. Most varieties have a structure similar to that of Opal (Fig. 7.7), which also corresponds to that of the old European landrace varieties. As can be clearly seen from Fig. 7.9, the majority of the varieties lie within the plotted ellipse. A number of varieties, however, have a very typical, individual flavonoid composition, which also makes it easy to distinguish between them. These varieties are located outside of the ellipse and include, among others, the Zeus and Herkules varieties.

Grouping according to country also reveals a number of new and important findings. With 28 varieties, the UK takes the lead, followed by Germany with 26 varieties. The English varieties can be divided up into two groups. Most of the English varieties can be assigned to European landrace varieties, but four of them form their own separate group (Fig. 7.10). The German varieties correspond to European landrace varieties. The cultivars from the USA are somewhat more varied (Fig. 7.11). Here, too, many varieties have the same structure as European landrace varieties, which can be traced back to the fact that European breeding material has also been bred into these varieties. The Czech Republic and Slovenia are traditional European hop-growing countries and the varieties from these countries are of the European type. The eight Japanese varieties can be divided up into two groups that are relatively far apart from one another. Some of the six varieties from New Zealand are slightly outside the ellipse and very similar to one another. The four varieties from Poland consist of two pairs. Hüll also boasts three varieties from China, two of them very similar and the third quite different. Only one to a maximum of three varieties (Ukraine) are available from each of the remaining countries. Fig. 7.12 shows their position on the chart.

7.3.7 Cluster analysis

Step-by-step cluster analysis is another method used to arrange objects on the basis of their degree of similarity, with hierarchical or non-hierarchical clusters being formed as a result. Similarities between objects are expressed in terms of distance measures. The smaller the distance, the more similar the objects. A cluster describes a group of objects that are more similar to one another than to objects outside the group.

Clusters are formed by aggregating objects on the basis of their distance measure. In this project, the world hop range was assigned to 20 clusters. The choice of clusters is arbitrary; 10 or 30 clusters could also be chosen. In Tab. 7.7, the individual varieties are assigned to the various clusters.

Most varieties can be found in clusters 1 and 2, corresponding to the typical patterns of the landrace varieties. Only one variety has been assigned to each of clusters 15-20. These varieties possess the already-mentioned typical individual flavonoid pattern. Fig. 7.13 shows cluster dendograms of the results of the principal-component analysis. The diagram also shows the relationships between the clusters.

Tab. 7.7: *Assignment of the world hop range to 20 clusters (similarity of flavonoid composition)*

Cluster 1	**Cluster 2**	Golden Star	Japan C 730	**Cluster 10**	**Cluster 14**
Aromat	Admiral	Kirin 1	Mt. Hood	Alliance	Columbus
Aurora	Agnus	Kirin 2	Neoplanta	Alpharoma	Eroica
Buket	Belgischer Spalter		Nugget	Green Bullet	Galena
Diva	Bobek	**Cluster 4**	Olympic	Pride of Kent	Zeus
Early Choice	Bor	Boadicea	Phoenix	Rubin	
Eastwell Golding	Braustern	Estera	Serebrianker	Zenith	**Cluster 15**
Glacier	First Gold	Fuggle	Sterling		Atlas
Hallertauer Mfr.	Hallertauer Gold	Hüller Bitter		**Cluster 11**	
Hersbrucker Pure	Harmony	New Zealand Hallertauer	**Cluster 7**	Emerald	**Cluster 16**
Hüller Anfang	Herald	Pilot	Ahil	Hallertauer Tradition	USDA 21055
Hüller Aroma	Kumir	Zatecki	Blisk	Japan C 845	
Hüller Fortschritt	Lubelski		Hallertauer Taurus	Perle	**Cluster 17**
Hüller Start	Northern Brewer	**Cluster 5**	Herkules	Premiant	Apolon
Opal	PCU 280	College Cluster	Kitamidori		
Pilgrim	Pioneer	Crystal	Orion	**Cluster 12**	**Cluster 18**
Saazer	Sirem	Hersbrucker Spät	Toyomidori	Pride of Ringwood	Aquila
Saphir	Sladek	Malling	Zitic	Super Alpha	
Smaragd	Spalter	Pacific Gem			**Cluster 19**
Spalter Select	Talisman	Sticklebract	**Cluster 8**	**Cluster 13**	Granit
Tettnanger	WFG	Strisselspalter	Brewers Stand	Backa	
Urozani	Wye Northdown	Williamette	Progress	Brewers Gold	**Cluster 20**
Vojvodina	Wye Target			Bullion	Neptun
Wye Viking		**Cluster 6**	**Cluster 9**	Cascade	
Yeoman	**Cluster 3**	Chang Bei 1	Bramling Cross	Comet	
Zlatan	Eastern Gold	Chang Bei 2	Density	Hallertauer Magnum	
	Ging Dao Do Hua	Horizon	Maryanka	Hallertauer Merkur	

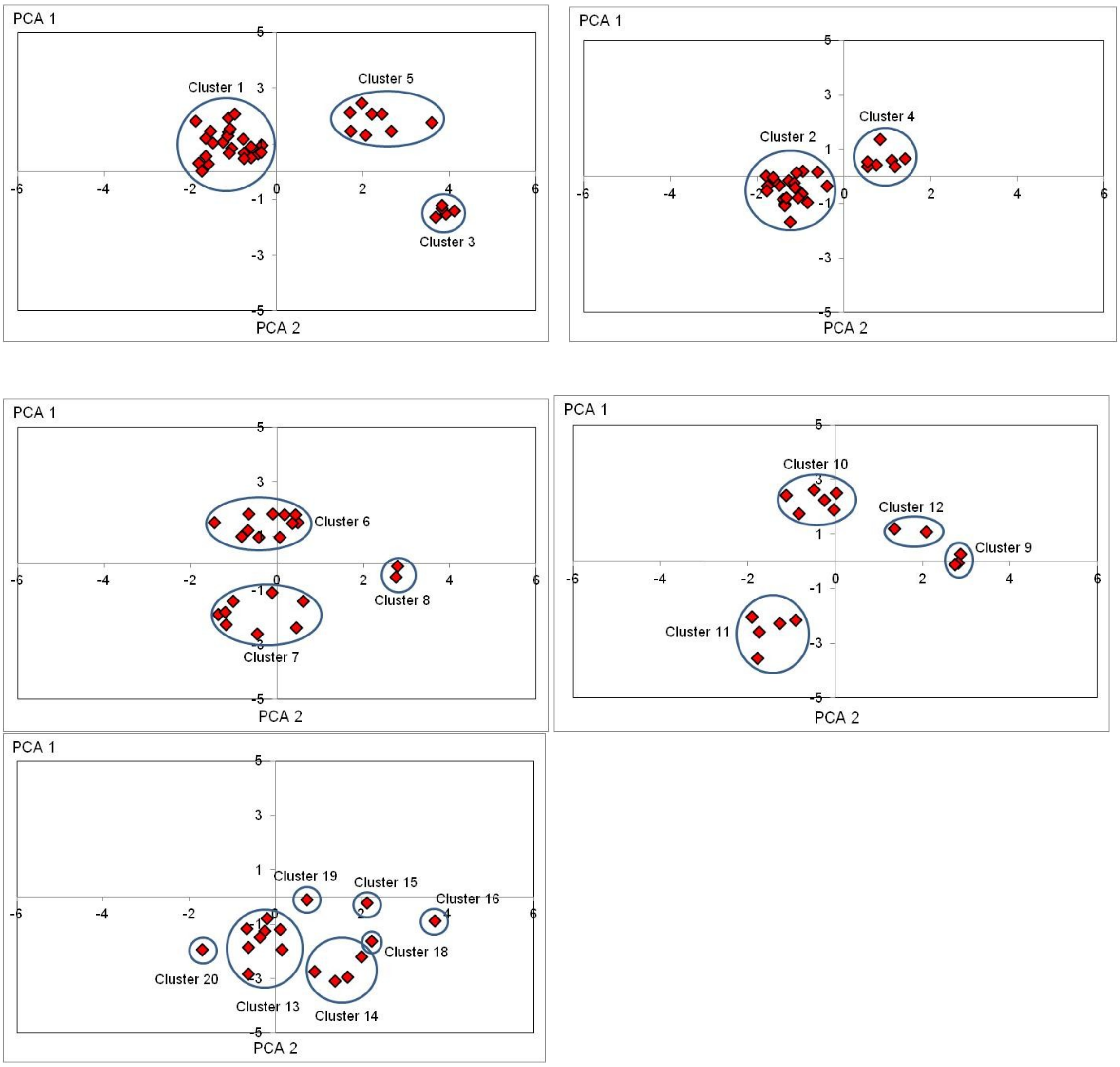


Fig. 7.13: Cluster diagram in principal-component analysis

7.4 World hop range (2011 crop)

Oil analyses of the world hop range are also performed every year via headspace gas chromatography and the bitter compounds analysed via HPLC. Tab. 7.8 shows the results for the 2011 harvest. The findings can be helpful in classifying unknown hop varieties.

Tab. 7.8: World hop range 2011

Variety	Myrcene	2-M.-iso butyrate	Sub. 14b	Sub. 15	Linalool	Aromadendrene	Undecanon	Humulene	Farnesene	γ-Muurolene	ß-Selinene	α-Selinene	Cadinene	Selinadien	Geraniol	α-acids	ß-acids	ß/α	Cohumulone	Colupulone
Admiral	3304	290	4	21	26	0	6	285	5	8	5	2	18	0	0	15.0	6.7	0.45	39.9	60.6
Agnus	1660	29	1	4	7	1	2	127	0	7	6	6	14	0	1	12.0	8.1	0.67	37.4	53.1
Ahil	7696	338	7	4	16	2	8	172	119	6	10	9	13	0	3	9.6	4.5	0.47	37.7	59.0
Alliance	862	91	1	2	15	0	5	289	2	9	5	3	18	0	0	7.2	3.6	0.51	29.7	56.5
Alpharoma	2865	310	20	13	20	0	10	286	20	9	5	2	19	0	2	10.3	2.6	0.25	27.3	62.0
Apollo	2329	60	8	31	4	5	4	182	0	6	3	2	13	0	2	16.8	8.6	0.51	28.2	52.2
Apolon	7586	63	7	11	26	0	1	184	119	6	10	8	14	0	4	7.0	3.8	0.54	29.7	56.5
Aquila	4110	62	4	121	23	32	15	18	0	8	58	60	10	75	5	7.7	3.8	0.49	45.5	76.8
Aromat	727	18	1	3	26	0	16	334	5	12	9	4	23	0	0	4.6	5.2	1.13	29.3	45.3
Atlas	4123	444	8	7	18	0	1	169	63	6	13	11	13	0	5	7.2	3.8	0.52	35.3	61.7
Aurora	5095	91	2	50	35	0	25	274	38	8	7	3	17	0	1	10.3	4.2	0.41	21.3	47.4
Backa	1633	371	1	8	27	0	7	268	10	9	7	4	19	0	0	8.6	5.8	0.67	40.2	59.2
Belgisch Spalter	818	41	1	5	16	13	10	175	0	11	33	34	17	50	0	8.1	4.8	0.60	28.4	51.0
Blisk	5645	193	12	8	25	0	3	182	117	7	10	9	14	0	3	10.6	4.4	0.41	32.4	59.9
Boadicea	1768	61	1	9	4	2	2	117	13	5	6	6	12	0	1	7.3	4.8	0.65	19.6	39.2
Bobek	10939	207	8	140	56	0	17	241	57	7	6	5	15	0	2	8.0	5.9	0.74	24.5	46.0
Bor	2077	55	1	33	8	0	7	289	0	7	5	3	16	0	1	14.2	5.8	0.41	24.8	51.2
Bramling Cross	1001	135	5	5	37	0	13	290	0	9	10	5	19	0	2	7.0	4.4	0.64	35.6	55.1
Braustern	1268	49	1	21	7	0	6	256	0	9	5	3	17	0	1	13.4	7.5	0.56	27.4	48.4
Bravo	6375	140	23	12	12	4	4	138	0	14	11	9	30	14	5	15.7	4.5	0.29	35.2	56.7
Brewers Gold	2118	137	7	10	11	0	1	141	0	6	9	9	13	0	2	9.4	5.2	0.56	41.3	66.0

Cont. Table 7.8

Variety	Myr cene	2-M.-iso butyrate	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendrene	Unde-canon	Humu-lene	Farne-senε	γ-Muu-rolene	ß-Seli-nenε	α-Seli-nene	Cadi-nene	Selina-dien	Gera-niol	α-acids	ß-acids	ß/α	Cohu-mulone	Colu-pulone
Brewers Stand	11778	453	17	38	64	26	22	41	0	65	102	94	111	130	9	8.4	4.0	0.48	24.7	50.7
Buket	2698	133	2	63	21	0	11	239	18	8	5	2	17	0	1	11.2	6.5	0.58	25.1	46.5
Bullion	2705	97	7	23	12	0	2	133	0	6	10	9	13	0	1	9.6	6.9	0.72	37.9	54.3
Cascade	4741	195	13	10	17	0	7	224	26	8	16	12	18	0	2	6.8	5.4	0.80	35.3	52.2
Chang bei 1	1685	4	3	5	31	0	14	234	13	9	23	22	18	30	0	5.7	6.0	1.05	24.5	43.3
Chang bei 2	1322	4	2	2	29	0	16	236	9	9	24	23	18	32	0	5.8	5.7	0.98	25.6	44.0
College Cluster	811	72	6	10	5	0	4	132	0	4	7	7	9	0	1	8.7	3.3	0.38	25.8	53.2
Columbus	3881	117	11	9	12	1	3	135	0	17	13	9	34	15	1	17.0	5.9	0.35	28.1	52.3
Comet	1999	29	4	47	9	0	2	6	0	2	36	40	3	14	1	10.9	4.5	0.41	37.8	59.1
Crystal	1382	50	1	20	33	35	10	185	0	12	43	43	18	60	0	3.8	5.8	1.54	20.1	42.7
Density	1106	137	5	7	38	0	16	302	0	9	10	4	19	0	0	6.7	4.1	0.62	36.4	57.0
Diva	4487	142	4	22	40	0	25	274	7	11	114	126	18	0	2	7.6	5.4	0.71	24.8	47.1
Early Choice	892	59	0	13	5	0	5	277	0	9	73	77	21	0	0	5.0	3.1	0.63	27.1	51.7
Eastwell Golding	1017	46	1	7	12	0	5	287	0	8	6	5	17	0	1	7.4	4.4	0.59	28.8	53.0
Emerald	888	31	3	8	6	0	6	301	0	8	5	3	16	0	1	8.8	6.2	0.71	28.6	47.7
Eroica	2614	280	11	56	6	6	5	161	0	6	10	10	13	0	1	8.7	8.4	0.98	40.2	61.7
Estera	1294	86	1	5	21	0	6	277	7	8	6	4	18	0	0	4.9	4.5	0.92	28.9	47.8
First Gold	4527	421	2	13	29	4	12	276	10	9	105	119	21	0	1	10.7	4.2	0.39	26.7	57.4
Fuggle	1403	87	1	7	18	0	6	256	8	9	5	2	17	0	0	5.1	3.7	0.71	27.5	46.6
Galena	4020	295	18	97	6	9	5	162	0	7	9	8	14	0	1	10.1	9.2	0.91	39.7	62.3

Cont. Table 7.8

Variety	Myr cene	2-M.-iso butyrate	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendrene	Unde-canon	Humu-lene	Farne-sene	γ-Muu-rolene	ß-Seli-nene	α-Seli-nene	Cadi-nene	Selina-dien	Gera-niol	α-acids	ß-acids	ß/α	Cohu-mulone	Colu-pulone
Ging Dao Do Hua	2450	438	1	3	21	0	9	244	0	14	43	48	29	0	3	8.4	5.2	0.61	42.8	63.7
Glacier	2624	29	2	5	35	0	9	282	0	8	6	4	17	0	1	6.9	8.2	1.19	11.7	35.8
Golden Star	2612	433	1	4	24	0	12	242	0	14	40	39	29	0	4	7.8	4.4	0.56	43.0	65.5
Granit	1146	45	3	6	6	3	12	190	0	6	11	10	13	0	1	9.7	5.9	0.61	28.5	48.7
Hallertauer Gold	1399	65	14	4	26	0	7	301	0	11	7	4	20	0	1	6.7	6.0	0.91	23.6	43.9
Hallertauer Magnum	4230	77	26	20	8	3	4	278	0	6	4	2	14	0	1	16.1	7.1	0.44	28.7	48.9
Hallertauer Merkur	2341	96	7	4	16	3	4	277	0	8	5	3	17	0	0	12.6	6.2	0.50	18.6	40.9
Hallertauer Mfr.	350	60	1	1	23	0	9	334	0	13	6	3	23	0	0	3.9	4.3	1.09	19.1	37.0
Hallertauer Taurus	10098	91	8	20	45	0	10	263	0	8	63	73	19	0	1	18.5	5.8	0.31	22.8	45.4
Hallertauer Tradition	650	63	7	3	30	0	11	316	0	10	11	8	0	0	0	6.2	5.0	0.80	21.5	42.4
Harmony	2673	18	3	12	25	0	14	257	0	9	76	86	16	0	1	9.7	6.5	0.67	17.4	35.1
Herald	4623	275	3	88	11	0	18	200	0	7	31	33	16	0	2	11.7	4.7	0.40	34.1	56.2
Herkules	6092	200	32	69	11	0	8	286	0	7	5	3	16	0	2	16.9	5.7	0.34	35.7	53.6
Hersbrucker Pure	1986	46	2	7	26	18	13	209	0	11	32	32	17	50	0	5.9	3.2	0.55	21.8	41.7
Hersbrucker Spät	1501	41	1	11	40	36	10	167	0	13	50	49	16	68	1	2.7	8.0	2.93	15.7	40.3
Hüller Anfang	345	60	6	1	15	0	8	322	0	12	6	3	21	0	0	4.3	5.5	1.3	23.6	41.9
Hüller Aroma	440	47	2	1	21	0	8	333	0	12	7	3	22	0	0	4.5	5.2	1.14	25.3	45.2
Hüller Bitter	3048	107	24	4	30	13	9	160	0	40	51	48	68	68	2	7.0	6.6	0.95	26.7	46.1
Hüller Fortschritt	673	26	7	2	22	0	9	317	0	11	7	4	21	0	0	4.5	6.0	1.32	27.5	43.9
Hüller Start	253	32	1	1	9	0	10	348	0	12	7	3	22	0	0	3.9	5.0	1.27	24.0	42.7

Cont. Table 7.8

Variety	Myr cene	2-M.-iso butyrate	Sub. 14b	Sub. 15	Lina- lool	Aroma- dendrene	Unde- canon	Humu- lene	Farne- sene	γ-Muu- rolene	ß-Seli- nene	α-Seli- nene	Cadi- nene	Selina- dien	Gera- niol	α-acids	ß-acids	ß/α	Cohu- mulone	Colu- pulone
Jap. C 730	340	9	5	13	6	0	4	194	10	6	6	5	13	0	1	5.6	2.9	0.53	28.5	49.8
Jap. C 845	1279	15	4	17	5	0	4	284	23	8	4	3	16	0	1	10.8	4.9	0.45	22.3	39.5
Kirin 1	1783	399	1	3	21	0	9	230	0	16	42	47	33	0	4	6.9	4.4	0.63	45.4	65.8
Kirin 2	2272	473	1	3	20	0	9	230	0	17	48	55	33	0	3	7.5	4.7	0.62	43.1	63.7
Kumir	1826	57	2	10	18	0	8	287	5	8	5	3	16	0	1	11.1	5.6	0.50	24.8	48.4
Late Cluster	14918	343	23	48	52	34	20	43	0	57	86	1	105	108	5	8.9	5.1	0.58	27.0	49.0
Lubelski	1324	9	1	4	21	0	14	320	15	8	7	4	18	0	0	6.5	6.9	1.06	26.3	43.4
Malling	866	39	1	3	21	0	8	271	6	10	7	5	19	0	0	5.7	4.7	0.83	33.1	51.6
Marynka	2429	129	2	20	6	5	5	147	85	5	9	8	12	0	2	10.7	6.7	0.63	26.3	47.2
Mt. Hood	458	30	8	4	12	0	5	230	0	12	5	3	21	0	1	5.0	4.4	0.89	19.2	44.6
Neoplanta	1151	44	1	16	4	0	4	210	13	8	4	2	16	0	0	11.8	5.2	0.44	33.5	62.1
Neptun	2227	105	20	5	15	0	3	208	0	8	5	3	17	0	0	12.9	5.0	0.39	22.8	41.9
Northern Brewer	1661	45	1	26	7	0	6	260	0	8	5	2	16	0	1	10.2	5.4	0.53	24.6	45.1
Nugget	2389	70	2	14	17	3	4	166	0	5	9	9	11	0	0	13.6	4.9	0.36	27.7	54.7
NZ Hallertauer	2745	107	1	19	29	6	6	156	9	9	23	22	15	33	2	8.2	9.0	1.10	36.4	48.9
Olympic	2414	75	1	20	15	2	2	160	0	5	10	9	10	0	1	15.4	5.5	0.36	27.8	53.4
Opal	2453	33	9	23	24	0	7	231	0	7	5	5	16	13	1	9.5	5.9	0.62	13.7	31.3
Orion	675	70	3	3	15	0	5	216	0	10	5	3	20	0	0	7.7	5.9	0.76	30.1	47.9
PCU 280	564	19	0	5	3	0	4	293	0	8	4	3	16	0	0	9.5	5.5	0.58	29.3	51.9
Perle	1035	68	2	15	5	0	4	265	0	8	4	2	16	0	0	8.3	5.1	0.61	31.0	53.7

Cont. Table 7.8

Variety	Myr cene	2-M.-iso butyrate	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendrene	Unde-canon	Humu-lene	Farne-sene	γ-Muu-rolene	ß-Seli-nene	α-Seli-nene	Cadi-nene	Selina-dien	Gera-niol	α-acids	ß-acids	ß/α	Cohu-mulone	Colu-pulone
Phoenix	2052	132	2	8	5	0	6	263	8	8	61	68	19	0	1	11.9	6.3	0.53	24.5	44.9
Pilgrim	6480	436	6	115	14	0	17	279	0	8	81	94	15	0	3	9.3	4.5	0.48	35.0	57.9
Pilot	11405	779	17	128	87	22	52	57	0	12	439	503	29	0	6	8.1	4.1	0.50	36.9	59.3
Pioneer	4317	368	3	148	10	3	18	208	0	7	31	29	16	0	3	11.6	4.7	0.41	31.1	59.3
Premiant	1541	65	3	6	24	0	9	294	2	9	5	3	17	0	0	10.0	4.9	0.49	28.2	52.4
Pride of Kent	1254	28	1	3	24	0	6	295	0	8	6	3	17	0	0	7.7	3.7	0.48	30.2	55.4
Progress	13679	365	22	44	52	32	17	36	0	64	95	91	115	133	4	10.1	5.0	0.49	26.8	50.7
Rubin	3070	76	15	8	10	0	4	239	0	10	69	73	21	0	2	14.3	4.8	0.33	31.1	50.1
Saazer	1110	10	1	5	23	0	18	338	13	10	9	5	21	0	2	3.4	4.4	1.32	23.2	40.1
Saphir	2295	29	4	22	25	14	19	197	0	8	19	16	15	26	0	4.9	7.7	1.57	12.9	41.3
Serebrianker	213	47	1	1	23	0	8	216	0	14	44	41	26	0	1	2.9	5.4	1.85	32.8	43.8
Sirem	936	12	2	4	26	0	18	303	8	11	9	5	22	0	0	6.0	6.4	1.05	30.1	45.3
Sladek	1615	43	2	9	19	0	9	290	3	8	5	3	17	0	1	13.1	5.6	0.42	25.3	50.7
Smaragd	2088	29	8	21	31	0	9	272	0	8	8	7	18	25	2	7.0	5.4	0.76	16.7	39.3
Spalter	1552	8	1	5	25	0	18	331	20	10	9	4	20	0	3	3.4	4.9	1.46	24.0	41.8
Spalter Select	4800	47	15	10	76	26	17	194	62	11	33	30	17	51	0	5.6	5.6	1.00	21.2	42.2
Sterling	2645	86	2	26	16	3	4	161	0	5	10	9	10	0	0	14.7	5.6	0.38	26.8	51.8
Strisselspalter	1925	39	2	12	30	29	10	192	0	11	42	43	16	49	1	5.4	6.3	1.17	17.5	35.7
Super Alpha	3860	236	9	15	41	0	11	288	0	7	6	3	16	0	2	9.5	4.3	0.45	32.9	62.4
Super Galena	2527	163	20	57	6	4	4	172	0	7	4	2	14	0	2	10.8	9.1	0.85	40.4	61.1

Cont. Table 7.8

Variety	Myr cene	2-M.-iso butyrate	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendrene	Unde-canon	Humu-lene	Farne-sen	γ-Muu-rolene	ß-Seli-nen	α-Seli-nene	Cadi-nene	Selina-dien	Gera-niol	α-acids	ß-acids	ß/α	Cohu-mulone	Colu-pulone
Talisman	1742	48	1	20	7	0	5	247	0	8	6	4	16	0	1	11.7	6.3	0.54	27.2	49.6
Tettnanger	1199	7	2	5	23	0	20	340	16	11	8	3	22	0	3	3.4	4.4	1.27	22.7	40.8
Toyomidori	1694	184	6	97	13	0	14	196	0	23	19	12	44	16	2	11.1	5.4	0.48	32.4	56.2
Urozani	1280	16	2	4	37	0	11	233	11	10	22	20	20	26	0	5.8	7.8	1.34	27.3	43.7
USDA 21055	3225	304	2	151	7	0	3	107	38	6	14	14	13	0	1	11.8	3.1	0.26	35.5	77.7
Vojvodina	2787	86	1	26	10	0	8	237	2	7	6	4	15	0	0	9.3	5.0	0.53	28.9	53.0
WFG	870	19	1	3	23	0	14	304	6	10	10	6	20	4	1	5.8	5.9	1.02	27.2	45.0
Willamette	972	72	1	4	16	0	4	248	6	8	6	4	16	0	1	4.1	3.6	0.89	34.5	52.9
Wye Challenger	4294	220	3	33	31	0	14	263	6	9	59	66	19	0	0	7.0	4.9	0.7	23.5	45.3
Wye Northdown	1589	47	1	13	10	0	5	246	0	8	5	2	16	0	1	11.4	6.5	0.57	29.2	50.3
Wye Target	2728	134	3	13	23	3	9	149	0	15	12	8	31	10	1	11.7	5.7	0.49	32.8	55.4
Wye Viking	1458	74	2	17	13	0	20	241	24	8	40	39	18	0	0	6.5	4.9	0.76	26.2	45.6
Yeoman	2207	160	8	10	7	0	4	222	0	7	46	50	17	0	1	15.7	6.8	0.43	27.6	49.4
Zatecki	1324	88	1	9	22	0	6	269	8	9	6	4	18	0	0	5.0	4.5	0.90	27.6	47.1
Zenith	1817	52	1	13	18	0	7	276	0	9	91	103	21	0	0	10.9	4.8	0.44	25.1	49.0
Zeus	3744	77	9	8	9	0	3	136	0	17	13	9	35	14	1	16.3	5.2	0.32	31.8	55.4
Zitic	1820	3	1	10	9	4	8	291	4	8	5	3	17	0	3	7.6	6.3	0.82	28.2	46.7
Zlatan	1276	16	3	6	39	0	26	337	12	11	10	3	22	0	0	5.2	6.1	1.18	32.7	46.7

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

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

7.5.1 Ring analyses of the 2012 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 what is termed a 'neutral' range. If it is above or below this range, the price is marked up or down, respectively. The specification compiled by the working group for hop analysis (AHA) describes precisely how samples are to be treated (sample division and storage), lays down which laboratories carry out post-analyses and defines the tolerance ranges permissible for the analysis results. In 2012, the IPZ 5d Work Group once again assumed responsibility for organizing and evaluating the ring analyses used to verify the quality of the alpha-acid analyses.

The following laboratories took part in the 2012 ring analyses:

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

The ring analyses commenced on 4th September 2012 and ended on 2nd November 2012, as this was the period during which most of the hop lots were examined in the laboratories. In all, the ring test was performed nine times (nine weeks). Sample material was kindly provided by Mr. Hörmansperger (Hopfenring e.V.). To ensure maximum homogeneity, each sample was drawn from a single bale. Every Monday, the samples were ground with a hammer mill in Hüll, divided up with a sample divider, vacuum-packed and taken to the various laboratories. The laboratories then analysed one sample daily on each of the following weekdays. A week later, the results were sent back to Hüll for evaluation. A total of 34 samples were analysed in 2012.

The evaluations were passed on to the individual laboratories as quickly as possible. Fig. 7.14 shows a sample evaluation serving as a model example of a ring test. The laboratory numbers (1-7) do not correspond to the above list. The outlier test was calculated as per DIN ISO 5725. Cochran's test was applied for intra-laboratory assessment and Grubb's test for inter-laboratory assessment.

No. 5: HSR (11.09.2012)

Labor-atory	KW		Mean	s	cvr
1	4.93	4.93	4.93	0.000	0.0
2	4.87	4.78	4.83	0.064	1.3
3	4.95	4.94	4.95	0.007	0.1
4	4.85	4.91	4.88	0.042	0.9
5	4.99	4.96	4.98	0.021	0.4
6	4.81	4.87	4.84	0.042	0.9
7	4.77	4.85	4.81	0.057	1.2

Mean	4.89
sr	0.040
sL	0.058
sR	0.071
vkr	0.82
vkR	1.44
r	0.11
R	0.20
Min	4.77
Max	4.99

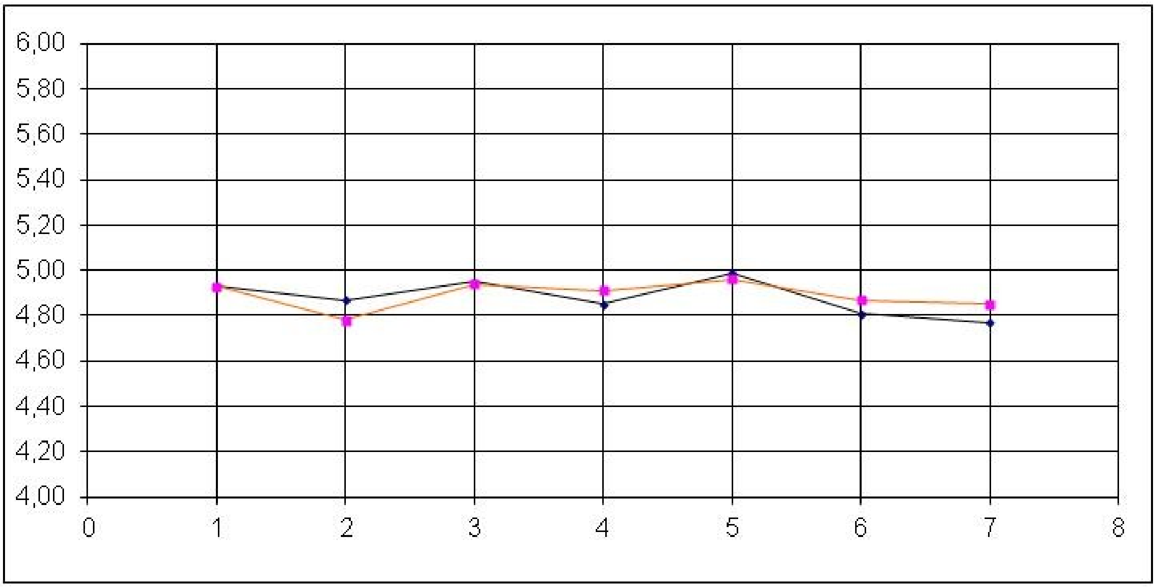


Fig. 7.14: Ring-test evaluation

The outliers in 2012 are compiled in Tab. 7.9.

Tab. 7.9: 2012 outliers

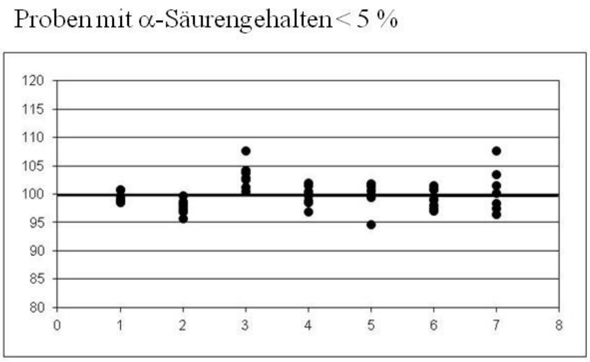
	Cochran		**Grubbs**	
Sample	α = 0.01	α = 0.05	α = 0.01	α = 0.05
27	0	0	0	1
31	0	0	0	1
34	0	0	0	1
Total:	**0**	**0**	**0**	**3**

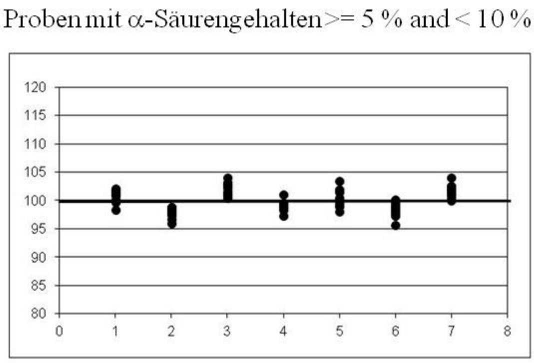
Tab. 7.10 shows the tolerance limits (critical difference values (CD), Schmidt, R., NATECO$_2$, Wolnzach) derived from the Analytica-ECB of the European Brewery Convention (EBC 7.4, conductometric titration) and outliers from 2000 to 2012.

Tab. 7.10: Tolerance limits set by EBC 7.4 method and outliers from 2000 to 2012

	Up to 6.2 %	6.3 % - 9.4 %	9.5 % - 11.3 %	From 11.4 %
Critical difference	+/-0.3	+/-0.4	+/-0.5	+/-0.6
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 2011	1	0	0	1
in 2012	0	0	0	1

In 2012, one result exceeded the permissible tolerance limits. Fig. 7.15 shows all the analysis results for each laboratory as relative deviations from the mean (= 100 %), differentiated according to alpha-acid levels of <5 %, ≥ 5 % and <10 %, and also ≥ 10 %. The chart clearly shows whether a laboratory tends to arrive at values that are too high or too low.





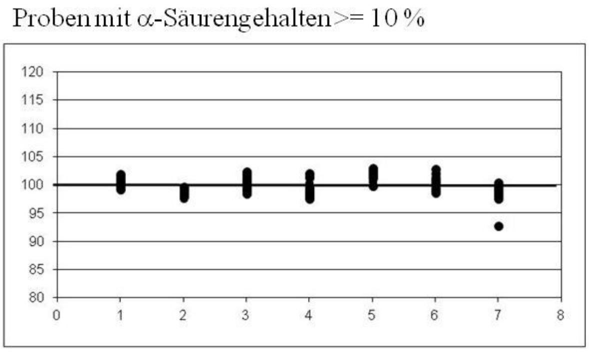


Fig.. 7.15: Analysis results of laboratories relative to the mean

The Hüll laboratory is number 5.

7.5.2 Evaluation of post-analyses

Since 2005, post-analyses have been performed in addition to the ring tests. The post-analyses are evaluated by the IPZ 5d Work Group, which passes on the results to the participating laboratories, the German Hop Growers' Association and the German Hop Trading Association. Three samples per week are selected by an initial test laboratory and these samples are subsequently analysed by three other laboratories according to the AHA specification. The result of the initial test is confirmed if the post-analysis mean and initial test result are within the tolerance limits (Tab. 7.11). Tab. 7.11 shows the 2012 results. Since 2005, all initial test results have been confirmed.

Tab. 7.11: 2012 post-analyses

Sample	Initial test	Initial	Post-analysis			Mean	Result
designation	laboratory	test	1	2	3	value	confirmed
KW 36 HPE	HHV Au	7.2	7.3	7.3	7.6	7.40	ja
KW 36 HNB	HHV Au	9.9	9.7	9.9	10.2	9.93	ja
KW 36 HHM	HHV Au	15.0	14.7	14.9	15.0	14.87	ja
HPE	NATECO2 Wolnzach	8.1	7.7	7.7	8.0	7.80	ja
HHT 1	NATECO2 Wolnzach	6.2	5.8	5.9	6.1	5.93	ja
HHT 2	NATECO2 Wolnzach	6.2	5.8	5.9	6.2	5.97	ja
HPE1-KW 38	HVG Mainburg	9.7	9.5	9.5	9.8	9.60	ja
HPE2-KW 38	HVG Mainburg	10.0	10.0	10.1	10.2	10.10	ja
HTU-KW 38	HVG Mainburg	15.8	15.3	15.4	15.5	15.40	ja
KW 39 HPE	HHV Au	8.0	8.2	8.2	8.3	8.23	ja
KW 39 HHM	HHV Au	13.9	13.9	14.0	14.1	14.00	ja
KW 39 HHS	HHV Au	16.0	16.0	16.3	16.3	16.20	ja
HTU	NATECO2 Wolnzach	16.7	16.3	16.6	16.7	16.53	ja
HHS 1	NATECO2 Wolnzach	17.5	17.5	17.7	17.9	17.70	ja
HHS 2	NATECO2 Wolnzach	15.1	14.7	15.1	15.2	15.00	ja
EHM 1 - KW 41	HVG Mainburg	13.4	12.8	13.0	13.1	12.97	ja
EHM 1 - KW 41	HVG Mainburg	12.1	11.6	11.8	11.8	11.73	ja
HHS.- KW 41	HVG Mainburg	15.8	15.6	15.7	16.0	15.77	ja
KW 42 HNU	HHV Au	11.6	11.5	11.7	11.9	11.70	ja
KW 42 HNB	HHV Au	9.1	8.9	9.1	9.3	9.10	ja
KW 42 HHS	HHV Au	16.8	16.4	16.7	16.8	16.63	ja
HNB	NATECO2 Wolnzach	9.2	8.8	8.8	9.0	8.87	ja
HNU	NATECO2 Wolnzach	11.0	10.7	10.7	10.9	10.77	ja
HHM	NATECO2 Wolnzach	13.5	13.4	13.4	13.5	13.43	ja
HHS – KW 44	HVG Mainburg	15.9	15.4	15.6	15.6	15.53	ja
HHT – KW 44	HVG Mainburg	7.1	6.9	7.2	7.3	7.13	ja
HPE – KW 44	HVG Mainburg	8.5	8.2	8.4	8.5	8.37	ja

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

In the autumn of 2010, the AHA working group introduced the international calibration extract ICE 3. It was the task of the Hüll laboratory to produce the ultra-pure α-acids (>98 %) required for calibrating and monitoring the extract as a standard. The stability of the calibration extract is checked twice a year by the AHA laboratories. The orthophenylenediamine complex is first prepared from a CO_2 hop extract with a high α-acid content by reaction with orthophenylenediamine (Fig. 7.16).

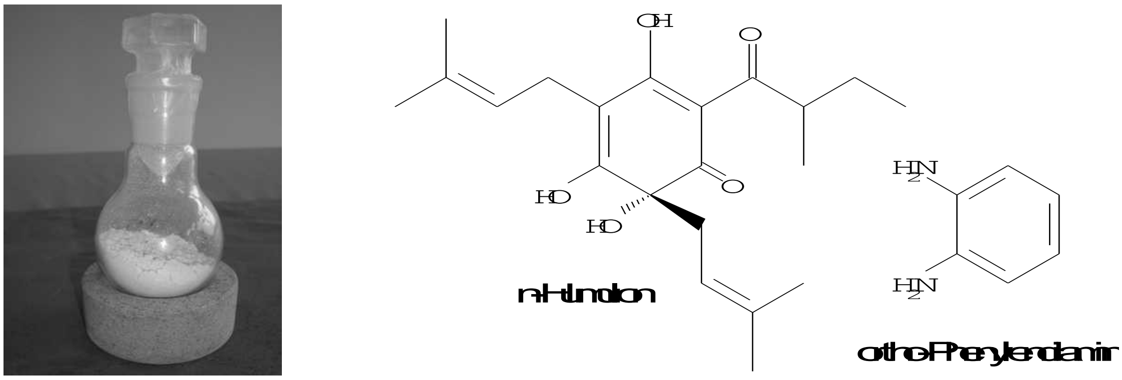


Fig. 7.16.: Ortho-phenylenediamine complex and its chemical structure

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

7.7 Hüll Special Flavor Hops

7.7.1 Biogenesis of the essential oils

Total essential-oil content and composition are much more dependent on the time of harvesting than is the case with the alpha acids (Fig. 7.17 and Fig. 7.18).

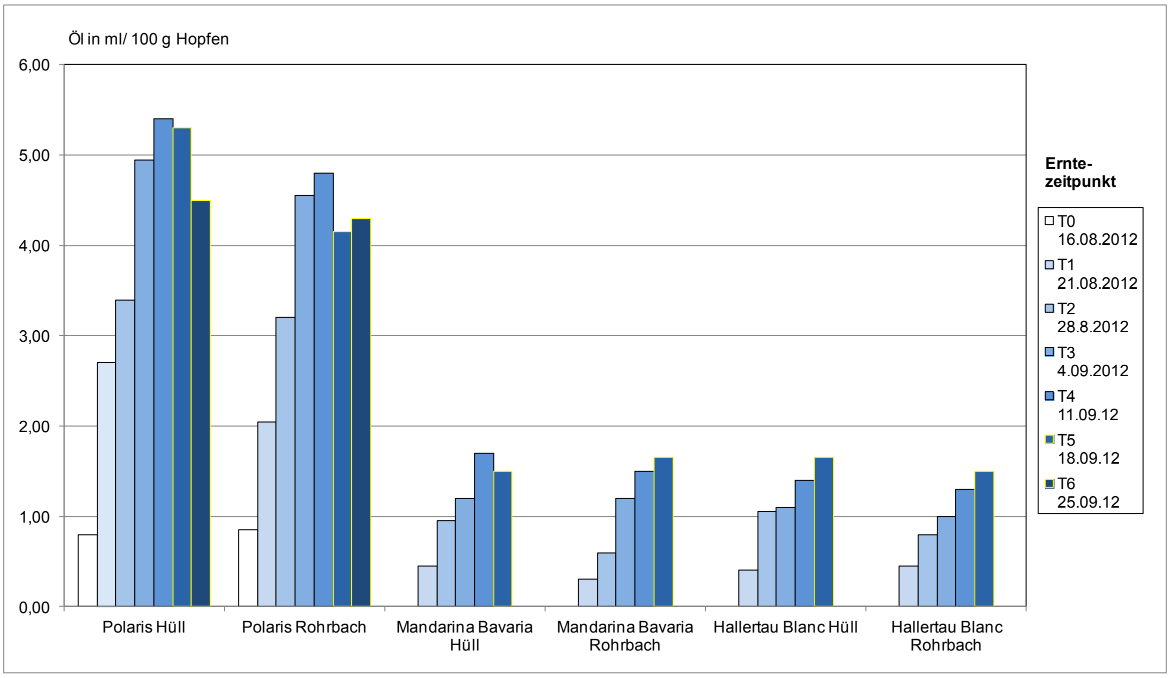


Fig. 7.17: Biogenesis of total oil content of the new Hüll Special Flavor Hops

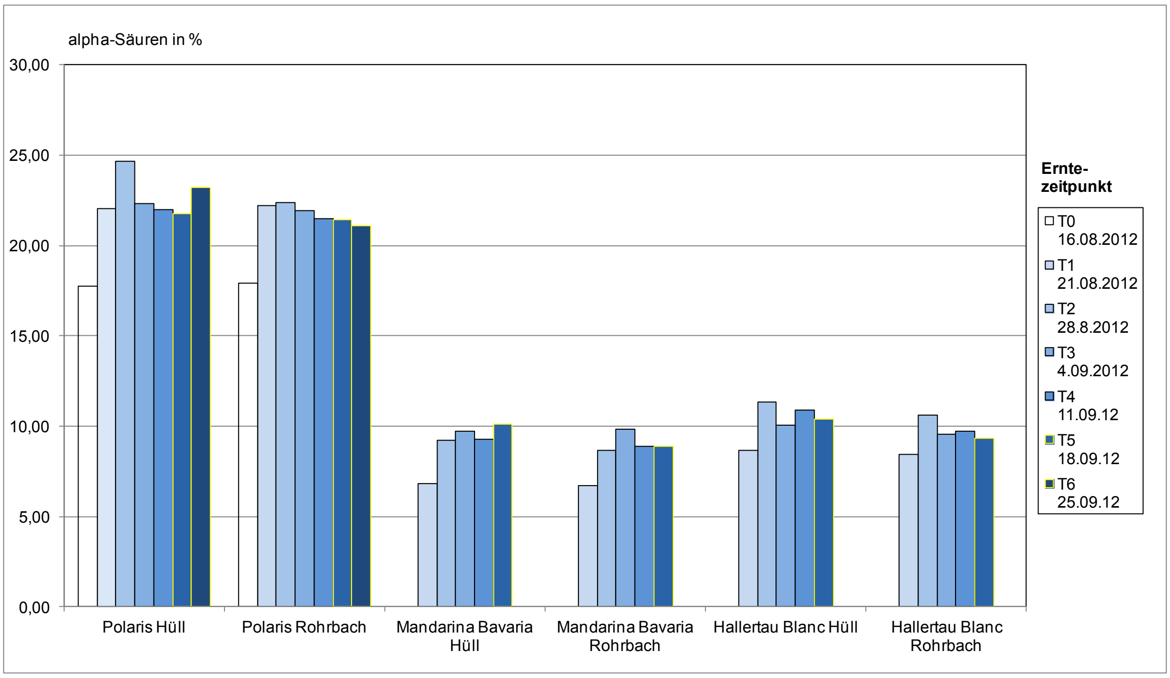


Fig. 7.18: Biogenesis of alpha-acid content of the new Hüll Special Flavor Hops

Myrcene levels rise more strongly than those of the other oil components. Fig. 7.19 illustrates this using the Polaris cultivar by way of example. The other cultivars show a similar pattern.

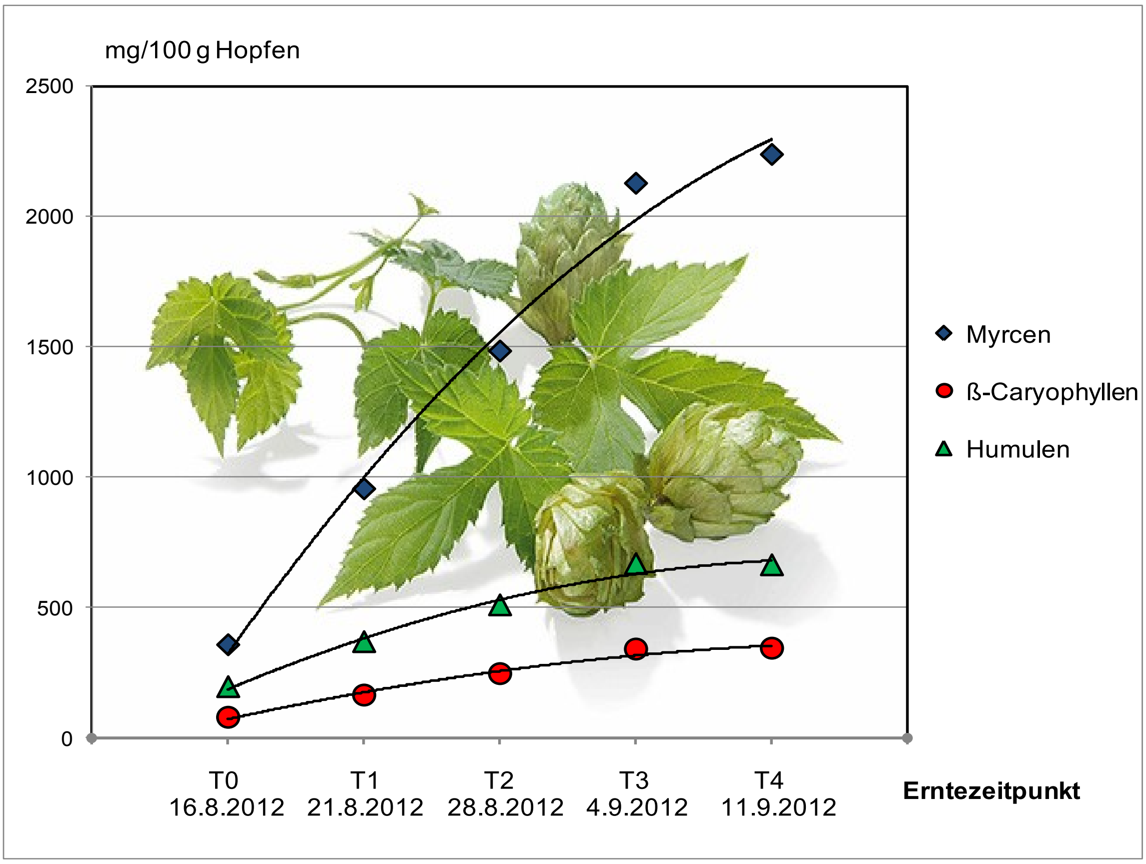


Fig. 7.19: Biogenesis of various oil components in the Polaris cultivar

7.7.2 Improving aroma characterisation

This project is being conducted in conjunction with the Technical University of Munich (WZW, Centre of Life and Food Sciences, Research Centre Weihenstephan for Brewing and Food Quality, Dr. M. Coelhan) and receiving financial support from the HVG Hop Producers' Group; its aim is to improve and refine aroma characterisation in order to create a better basis for the further breeding of flavour hops.

The following work programme has been determined and has already been initiated:

- Identification of unknown substances via GC-MS
- Identification of aroma-active substances via GC sniffing
- Initial exploratory investigations regarding sulphur compounds

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

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

Leonorus japonicus: 32 duplicate determinations of total flavonoid content (spectral photometric method);

Saposhnikova divaricata: 32 determinations of extract content (hot-ethanol extract) and 32 determinations of prim-O-glucosylcimifugin and 4'-O-beta-D-glucosyl-5-O-methyl-visamminol (HPLC).

7.9 Monitoring of varietal authenticity

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

Varietal authenticity checks for German food authorities (District Administrator’s Offices)	19
Of which, complaints	0

8 Publications and specialist information

8.1 Overview of PR activities

	Number		Number
Practice-relevant information and scientific articles	43	Guided tours	68
LfL publications	4	Exhibitions and posters	6
Press releases	-	Basic and advanced training sessions	10
Radio and TV broadcasts	6	Final-year university degree theses	-
Conferences, trade events and seminars	12	Participation in working groups	36
Talks	71	Foreign guests	151

8.2 Publications

8.2.1 Practice-relevant information and scientific articles

Kammhuber, K. (2012): 'Differentiation of the World Hop Collection by Means of the Low Weight Molecular Polyphenols', Brewing Science, Vol. 65, Brewing Science-Monatsschrift für Brauwissenschaft, P. 16 - 23, Fachverlag Hans Carl

Kammhuber, K. (2012): 'Ergebnisse von Kontroll- und Nachuntersuchungen für Alphaverträge der Ernte 2011', Hopfenrundschau, No. 9, P. 288; Publ.: Verband deutscher Hopfenpflanzer e.V. Hopfen-Rundschau

Lutz, A. (2012): 'Hopfensorten', Brauwelt Wissen , Hopfen - Vom Anbau bis zum Bier, P. 118 - 134, Fachverlag Hans Carl, ISBN: 978-3-418-00808-0

Lutz, A., Kammhuber, K, Ehrenstraßer, O., Hainzlmaier, M., Kneidl, J., Petzina, C., Pflügl, U., Wyschkon, B., Suchostawski, Ch. (2012): 'Bonitierung und Ergebnisse für die Deutsche Hopfenausstellung 2012', Hopfen Rundschau, No. 11, P. 353 – 356; Publ.: Verband Deutscher Hopfenpflanzer e.V., Hopfen-Rundschau

Lutz, A., Seigner, E., Kammhuber, K. (2012): 'Neuer Trend in der Hüller Hopfenzüchtung - New German Special Flavor Hops from Hüll', Hopfenrundschau - International Edition of the German Hop Growers' Magazine 2012/2013, 40 – 49; Publ.: Verband deutscher Hopfenpflanzer

Münsterer, J. (2012): 'Untersuchung möglicher Methoden zur Steuerung der Tröpfchenbewässerung', Hopfen-Rundschau 63 (6), 162 - 16

Münsterer, J. (2012): 'Erste Untersuchungen zur Optimierung von Bandtrocknern', Hopfen-Rundschau 63 (7), 200 - 201

Münsterer, J. (2012): 'Hinweise für eine optimale Konditionierung des Hopfens', Hopfen-Rundschau 63 (8), 232 - 234

Niedermeier, E. (2012): 'Pflanzenstandsbericht April 2012', Hopfen-Rundschau 63 (5), 148 - 149

Niedermeier, E. (2012): 'Pflanzenstandsbericht Mai 2012', Hopfen-Rundschau 63 (6), 182

Niedermeier, E. (2012): 'Pflanzenstandsbericht Juni 2012', Hopfen-Rundschau 63 (7), 209

Niedermeier, E. (2012): 'Hygienisierung von Hopfenrebenhäcksel durch Heißrotte', Hopfen-Rundschau 63 (8), 239 - 240

Niedermeier, E. (2012): 'Pflanzenstandsbericht Juli 2012', Hopfen-Rundschau 63 (8), 254

Niedermeier, E. (2012): 'Pflanzenstandsbericht August 2012', Hopfen-Rundschau 63 (9), 285

Niedermeier, E., Dr. Weihrauch, F. (2012): 'Hopfenforschungszentrum Hüll präsentierte sich auf der "Woche der Umwelt" in Berlin', Hopfen-Rundschau 63 (10), 318-319

Oberhollenzer, K., Seigner, E., Eichmann, R., Hückelhoven, R. (2012): 'Technique for Functional Analysis of Genes Associated with Powdery Mildew Resistance in Hops', Book of Abstracts, 3rd ISHS International Humulus Symposium, P. 26 – 26: Publ.: International Society for Horticultural Sciences, Hop Research Institute Co. Ltd. Zatec

Portner, J. (2012): 'Aktuelle Hopfenbauhinweise und Warndienstmeldungen. Hopfenbau-Ringfax No. 3, 4, 6, 7, 10, 12, 13, 15-22, 24, 26-27, 29-33, 35-40, 42-43, 47, 51, 53

Portner, J. (2012): 'Nmin-Untersuchung in Hopfen und erste Empfehlung zur Stickstoffdüngung 2012', Hopfen-Rundschau 63 (4), 114

Portner, J. (2012): 'Gezielte Stickstoffdüngung des Hopfens nach DSN (Nmin)', Hopfen-Rundschau 63 (4), 121

Portner, J. (2012): 'Hinweise zur Rodung von Hopfenflächen', Hopfen-Rundschau 63 (4), 122

Portner, J., Brummer, A. (2012): 'Nmin-Untersuchung 2012', Hopfen-Rundschau 63 (5), 138 - 139

Portner, J. (2012): 'Zwischenfruchteinsaat im Hopfen für KuLaP-Betriebe spätestens bis 30. Juni vornehmen!', Hopfen-Rundschau 63 (6), 164

Portner, J. (2012): 'Peronosporabekämpfung - Planen Sie Ihren Mitteleinsatz', Hopfen-Rundschau 63 (6), 185

Portner, J. (2012): 'Kostenfreie Rücknahme von Pflanzenschutzverpackungen - PAMIRA 2012', Hopfen-Rundschau 63 (8), 234

Portner, J. (2012): 'Rebenhäcksel bald möglichst ausbringen!', Hopfen-Rundschau 63 (8), 251

Portner, J. (2012): 'Hopfenkolloquium 2012 in Niedergoseln und Wermsdorf', Hopfen-Rundschau 63 (9), 284 - 285

Portner, J. (2012): 'Fachkritik zur 125. Moosburger Hopfenschau 2012', Hopfen-Rundschau 63 (10), 305 - 307

Portner, J., Dr. Gobor, Z., Dr. Fröhlich, G. (2012): 'Europäischer Innovationspreis für die Veröffentlichung über das Drahtaufhängegerät der Fa. Soller', Hopfen-Rundschau 63 (10), 310 - 311

Portner, J. (2012): 'Aktuelles zum Pflanzenschutz und Termine', Hopfenring-Information, 31.07.2012

Portner, J. (2012): 'Fortbildungsveranstaltungen; KuLaP-Hinweise; Flächenzu- und -abgänge melden', Hopfenring-Information, 30.11.2012

Portner, J. (2012): 'Hopfen', Bayerischer Agrarbericht

Schwarz, J., Weihrauch, F., (2012): 'Versuche zur Reduzierung kupferhaltiger Pflanzenschutzmittel im ökologischen Hopfenbau', LfL-Schriftenreihe 4/2012, Angewandte Forschung und Beratung für den ökologischen Landbau in Bayern. Öko-Landbau-Tag 2012 on 29. March 2012 in Freising-Weihenstephan, P. 107 – 113; Publ.: Bayerische Landesanstalt für Landwirtschaft (LfL), ISSN: 1611-4159

Seigner, E. (2012): 'Welthopfensortenliste des Internationalen Hopfenbaubüros 2011', Hopfenrundschau 63 (1), 12 - 20

Seigner, E., Lutz, A., Kammhuber, K., (2012): 'New Trend in Hop Breeding at the Hop Research Center Huell', BrewingScience 65, Monatsschrift für Brauwissenschaft, P. 24 - 32, Fachverlag Hans Carl

Seigner, E., Lutz, A., Kammhuber, K. (2012): 'Breeding for New Aroma Impressions in Hops', 10th International Trends in Brewing, P. 34; Publ.: KaHo Sint-Lieven, Gent

Seigner, E.; Lutz, A. (2012): 'Züchtung von resistenten Hopfen mit besonderer Eignung für den Anbau in Niedriggerüstanlagen', Deutsche Forschungsberichte, Edition: F 12 B 2104, P. 1 – 1; Publ.: Technische Informationsbibliothek Hannover

Weihrauch, F., Schwarz, J., (2012): 'Versuche zur Reduzierung kupferhaltiger Pflanzenschutzmittel im ökologischen Hopfenbau.', Berichte aus dem Julius Kühn-Institut, Nr. 164, P. 46 – 51; Publ.: Kühne, S., Friedrich, B., Röhrig, P. , JKI Braunschweig, ISSN: 1866-590X

Weihrauch, F. (2012): 'The significance of Brown and Green Lacewings as aphid predators in the special crop hops (Neuroptera: Hemerobiidae, Chrysopidae)', Mitteilung der Deutschen Gesellschaft für allgemeine und

angewandte Entomologie 18, 587 – 590; Publ.: Deutsche Gesellschaft für allgemeine und angewandte Entomologie (DGaaE), ISSN: 0344-9084

Weihrauch, F. (2012): 'The arthropod fauna of hop cones, with specific consideration of the Neuroptera', DGaaE-Nachrichten 26 (1), 47 – 48; Publ.: Deutsche Gesellschaft für allgemeine und angewandte Entomologie (DGaaE), ISSN: 0931-4873

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Weihrauch, F. (2012): 'The arthropod fauna of hop cones, with specific consideration of the Neuroptera ', Journal of Plant Diseases and Protection 119, Report on the 30th Annual Meeting of the Working Group 'Beneficial Arthropods an Entomopathogenic Nematodes'; Publ.: Herz, A., Ehlers, R.-U.

Weihrauch, F., Baumgartner, A., Felsl, M., Kammhuber, K., Lutz, A., (2012): 'The influence of aphid infestation during the hop growing season on the quality of harvested cones', BrewingScience 65 (4), 83 - 90

Weihrauch, F., Baumgartner, A., Felsl, M., Kneidl, J., Lutz, A. (2012): 'Simple is Beautiful: A New Biotest for the Aphid Tolerance Assessment of Different Hop Genotypes', Book of Abstracts, 3rd ISHS International Humulus Symposium, P. 40 – 40; Publ.: Hop Research Institute Co.Ltd., Žatec

8.2.2 LfL publications

Name	Work Group	LfL-publications	Title
Kammhuber, K., Lutz, A., Portner, J., Schwarz, J., Seefelder, S., Seigner, E., Sichelstiel, W., Weihrauch, F.	IPZ 5	LfL-Information (LfL publication)	Annual Report 2012 Special Crop: Hops
Portner, J.	IPZ 5a	“Grünes Heft” (“Green Leaflet”)	Hops 2012
Schwarz, J., Weihrauch, F.	IPZ 5b	LfL-Schriftenreihe (LfL publication series)	Versuche zur Reduzierung kupferhaltiger Pflanzenschutzmittel im ökologischen Hopfenbau (Trials aimed at reducing copper-containing protectives in organic hop farming)
Weihrauch, F., Meier, H.,	IPZ 5b	LfL-Schriftenreihe (LfL publication series)	Marktanalyse Öko-Hopfen 2012 - Deutschland, Europa, Welt (Market analysis, organic hops 2012 – Germany, Europe, world)

8.2.3 Radio and TV broadcasts

Name/WG	Date of broadcast	Topic	Title of programme	Station
Lutz Anton IPZ 5c	27.03.2012	Beer tastes of melon or mandarin-orange	Regionalnachrichten Teleschau	IN-TV
Lutz Anton IPZ 5c	03.04.2012	New Hüll hop cultivars with special aromas	Nachrichten Bayern	Radio Charivari
Lutz, A. IPZ 5c	16.08.2012	Hops in vogue	Aus Schwaben und Altbayern	Bavarian TV

Name/WG	Date of broadcast	Topic	Title of programme	Station
Lutz, A. IPZ 5c	21.09.2012		Unser Land	Bavarian TV
Lutz, A. IPZ 5c	15.10.2012	Well, then - cheers! Talking of hops, malt and lots more	Future Trend Reportage	RTL
Lutz, A.; Seigner, E. IPZ 5c	22.04.2012	Mandarin-orange and glacier mint – new hop varieties	Aus Schwaben und Altbayern	Bavarian TV

8.3 Conferences, talks, guided tours and exhibitions

8.3.1 Conferences, trade events and seminars

Organised by	Topic	Participants	Date/Venue
Doleschel, P., IPZ-L	Licence agreement for new hop varieties	Society of Hop Research; Hop Growers' Assoc.	10.01.12 Hüll
Doleschel, P., IPZ-L	Guided hop tour through the Hallertau region	Politicians, incl. Bavarian State Minister Brunner; hop industry; Fed. Ministry of Consumer Protection and Food Safety (BVL)	30.08.12 Wolnzach/Hüll
Münsterer, J., IPZ 5a	Workshop: Optimising drip irrigation in hop growing	Hop growers with irrigation equipment	07.03.12 Wolnzach
Münsterer, J., IPZ 5a	Seminar: Optimising hop drying	Hop growers in the Hallertau growing area	19.07.12 Wolnzach
Münsterer, J., IPZ 5a	Workshop: Measuring systems for optimising belt dryers for hops	Hop growers with belt dryers	23.08.12 Lobsing
Portner, J., IPZ 5a	Working group: "Hop farm management"	Hop growers (working group members)	01.01.12 Various venues
Portner, J., IPZ 5a	"Green Leaflet" discussion	Hop research and consultancy colleagues in Germany	01.03.12 Hüll
Portner, J., IPZ 5a	Hop congress	Hop researchers in Germany; experts from state research centers and agencies; ministerial consultants and advisors from the authorities	09.-11.08.12 Niedergoseln and Wermsdorf
Portner, J., IPZ 5a	Hop assessment	Hop experts; barley growers' association	18.09.12 Moosburg
Sichelstiel, W., IPZ 5b	Expert Working Group (EWG) Minor Uses - Hops	Hop experts; LfL; Julius Kühn Institut (JKI); Association of German Hop Growers	26.-27.09.12 Wolnzach/Hüll
Lutz, A., IPZ 5c, Kammhuber, K., IPZ 5d	Hop assessment for the VLB exhibition in Berlin	Hop experts	02.10.12 Hüll
Seefelder, S., IPZ 5c, Niedermeier, E., IPZ 5a	Workshop: *Verticillium* wilt in hops	Affected hop growers	31.01.12 Wolnzach

8.3.2 Talks

WG	Name	Topic/Title	Organizer/ Attendees	Date/ Venue
IPZ 5a	Fuß, S.	Registration of hop plant protectives in 2012	LfL + national office for food, agriculture and forestry (AELF) Pfaffenhofen/Ilm / 45 hop growers	07.02.12 Lindach
IPZ 5a	Fuß, S.	Registration of hop plant protectives	LfL + AELF Erding / 70 hop growers	09.02.12 Osseltshausen
IPZ 5a	Fuß, S.	Hop stripping trials and latest update on plant protection	LfL / 17 employees of Joh. Barth & Sohn	06.06.12 Rohrbach
IPZ 5a	Fuß, S.	Hop stripping trials and latest update on plant protection	IGN / 27 members	06.06.12 Rohrbach
IPZ 5a	Graf, T.	Presentation on irrigation-control trials in hop growing	Joh. Barth & Sohn GmbH & Co. KG / 20 hop growers	12.11.12 Mainburg
IPZ 5a	Graf, T.	Project presentation on drip irrigation	Elbe-Saale Hop Growers' Assoc. / 95 hop growers	05.12.2012 Höfen/Grimma
IPZ 5a	Münsterer, J.	LfL drip-irrigation trials	Joh. Barth & Sohn GmbH & Co. KG /22 hop growers	07.03.12 Bad Gögging
IPZ 5a	Münsterer, J.	Hop-card-index evaluation	LfL - IPZ 5a / 16 members of the hop-card-index working group	24.05.12 Wolnzach
IPZ 5a	Münsterer, J.	New findings concerning the optimisation of hop belt dryers	Elbe-Saale Hop Growers' Assoc. / 95 hop growers	05.12.12 Höfgen/ Grimma
IPZ 5a	Niedermeier, E.	Wilt: research status and control measures	LfL + AELF Pfaffenhofen/Ilm 45 hop growers	07.02.2012 Lindach
IPZ 5a	Niedermeier, E.	Wilt: research status and control measures	LfL + AELF Pfaffenhofen/Ilm 90 hop growers	08.02.2012 Niederlauter-bach
IPZ 5a	Niedermeier, E.	Wilt: research status and control measures	LfL + AELF Erding / 70 hop growers	09.02.2012 Osseltshausen
IPZ 5a	Niedermeier, E.	Wilt: research status and control measures	LfL + AELF Landshut / 40 hop growers	10.02.2012 Oberhatz-kofen
IPZ 5a	Niedermeier, E.	Wilt: research status and control measures	LfL + AELF Roth / 18 hop growers	13.02.12 Hedersdorf
IPZ 5a	Niedermeier, E.	Wilt: research status and control measures	LfL + AELF Roth / 30 hop growers	13.02.12 Spalt
IPZ 5a	Niedermeier, E.	Wilt: research status and control measures	BayWa / 30 BayWa employees	13.02.12 Mainburg
IPZ 5a	Niedermeier, E.	Wilt: research status and control measures	LfL + AELF Abensberg 55 hop growers	14.02.12 Biburg
IPZ 5a	Niedermeier, E.	Wilt: research status and control measures	LfL + AELF Abensberg 110 hop growers	15.02.12 Mainburg

WG	Name	Topic/Title	Organizer/ Attendees	Date/ Venue
IPZ 5a	Niedermeier, E.	Wilt: research status and control measures	LfL + AELF Ingolstadt 35 hop growers	17.02.12 Tettenwang
IPZ 5a	Niedermeier, E.	Hops: plant protection update	Wolnzach Hop Growers' Assoc. / 9 hop growers	19.04.2012 Wolnzach
IPZ 5a	Portner, J.	Is corrective action necessary at IGN for the future ?	IGN / 25 members	11.01.12 Niederlauter-bach
IPZ 5a	Portner, J.	Current plant protection problems and possible solutions in hop growing	Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) / 16 representatives from ministries, the authorities and hop organisations	31.01.12 Bonn
IPZ 5a	Portner, J.	Registration procedure for plant protectives as per the new plant protectives legislation	LfL + AELF Pfaffenhofen/Ilm 45 hop growers	07.02.2012 Lindach
IPZ 5a	Portner, J.	Registration procedure for plant protectives as per the new plant protectives legislation	LfL + AELF Pfaffenhofen/Ilm 90 hop growers	08.02.2012 Niederlauter-bach
IPZ 5a	Portner, J.	Registration procedure for plant protectives as per the new plant protectives legislation	LfL + AELF Erding / 70 hop growers	09.02.2012 Osseltshausen
IPZ 5a	Portner, J.	Registration procedure for plant protectives as per the new plant protectives legislation	LfL + AELF Landshut / 40 hop growers	10.02.2012 Oberhatz-kofen
IPZ 5a	Portner, J.	Registration procedure for plant protectives as per the new plant protectives legislation	LfL + AELF Roth / 18 hop growers	13.02.12 Hedersdorf
IPZ 5a	Portner, J.	Registration procedure for plant protectives as per the new plant protectives legislation	LfL + AELF Roth / 30 hop growers	13.02.12 Spalt
IPZ 5a	Portner, J.	Registration procedure for plant protectives as per the new plant protectives legislation	LfL + AELF Abensberg / 55 hop growers	14.02.12 Biburg
IPZ 5a	Portner, J.	Registration procedure for plant protectives as per the new plant protectives legislation	LfL + AELF Abensberg / 110 hop growers	15.02.12 Mainburg
IPZ 5a	Portner, J.	Registration procedure for plant protectives as per the new plant protectives legislation	LfL + AELF Ingolstadt / 35 hop growers	17.02.12 Tettenwang

WG	Name	Topic/Title	Organizer/ Attendees	Date/ Venue
IPZ 5a	Portner, J.	Cutting hop plant-protectives consumption through use of sensors	Julius Kühn Institute (JKI) 25 consultants	06.03.12 Xanten
IPZ 5a	Portner, J.	Deliberations concerning refinement of the neutral quality assessment procedure (NQF)	20 members of the NQF work group plus Agrolab employees	08.03.12 Mainburg
IPZ 5a	Portner, J.	News and amendments concerning hop plant protection	LfL / 15 members of the working group	08.03.12 Haunsbach
IPZ 5a	Portner, J.	Registration procedure for plant protectives as per the new plant protectives legislation	BayWa / 30 BayWa employees	13.03.12 Mainburg
IPZ 5a	Portner, J.	Cutting hop plant-protectives consumption through use of sensors	GfH / 35 members of the GfH's technical scientific committee (TWA)	17.03.12 Wolnzach
IPZ 5a	Portner, J.	The global hop situation and the "Haus des Hopfens"	6 ATEF.ONE and Nordluft employees	14.06.12 Wolnzach
IPZ 5a	Portner, J.	Mitigation of pesticide run-off in hops	LfL / 10 members of the Prowadis WG; AELF Landshut	18.06.12 Freising
IPZ 5a	Portner, J.	Update on plant protection	AELF / 40 hop growers	13.07.12 Spalt
IPZ 5a	Portner, J.	125th anniversary of the Moosburg hop show in 2012:	Town of Moosburg a. d. Isar / 150 guests	20.09.12 Moosburg
IPZ 5a	Portner, J.	Cutting hop plant-protectives consumption through use of sensors	LfL / 12 members of the Application Techniques working group	28.09.12 Freising
IPZ 5a	Portner, J.	Cutting hop plant-protectives consumption through use of sensors	LfL / 25 LfL employees	11.12.12 Freising
IPZ 5a	Portner, J.	Erosion protection in hop growing	AELF PAF and LfL / 70 hop growers	12.12.12 Niederlauter-bach
IPZ 5b	Schwarz, J.	Trials aimed at reducing copper-containing plant protectives in organic hop farming	LfL / 60 scientists, associations	29.03.12 Freising
IPZ 5b	Schwarz, J.	Use of predatory mites to control the common spider mite in hop farming	German Phytomedical Society (DPG) and German Soc. for General and Applied Entomology (DGaaE) / 35 scientists, federal and state authorities	28.11.12 Erfurt

WG	Name	Topic/Title	Organizer/ Attendees	Date/ Venue
IPZ 5b	Schwarz, J. und Weihrauch, F.	Development of integrated plant protection methods against the alfafa snout beetle *Otiorhynchus ligustici* in hop farming	JKI / 50 scientists, federal and state authorities	07.02.12 Braunschweig
IPZ 5b	Sichelstiel, W.	Update on plant protection in hops, 2012	Assoc. of German Hop Growers / 28 attendees	19.07.12 Tettnang
IPZ 5b	Sichelstiel, W.	Current plant protection problems and possible solutions in hop growing	Assoc. of German Hop Growers / 60 representatives from the registration authorities, trade, advisory services and associations	30.08.12 Wolnzach
IPZ 5b	Weihrauch, F.	Reducing copper in hops - 2011 results of a BLE (Federal Agency for Agriculture and Food) project	Bioland / 25 hop farmers	09.02.12 Plankstetten
IPZ 5b	Weihrauch, F.	2012 market analysis, organic hops – Germany, Europe, world	LfL / 45 members of the "Markets for Organic Foods" working group	29.03.12 Freising
IPZ 5b	Weihrauch, F.	Organic hop farming in Germany and the world: general conditions, scope and importance	Assoc. of German Hop Growers / 68 brewers and farmers	21.09.12 Wernesgrün
IPZ 5b	Weihrauch, F.	2012 trials aimed at minimizing copper in organic hop farming	JKI and BÖLW (Organic Food Industry Federation) / 85 representatives from federal authorities, associations and plant protection companies	07.12.12 Berlin
IPZ 5b	Weihrauch, F.	Simple is beautiful: A new biotest for the aphid tolerance assessment of different hop genotypes	International Society for Horticultural Science / 65 scientists, internal hop research	11.09.12 Žatec (Czech Republic)
IPZ 5c	Lutz, A.	Flavor hops – new hop-breeding trend at Huell	Jura hop support group / 30 hop growers	30.01.12 Hiendorf
IPZ 5c	Lutz, A.	Hop resistance breeding	Bioland conference / 25 attendees	09.02.12 Plankstetten
IPZ 5c	Lutz, A.	New hop-breeding trends: novel aroma and bitter qualities in hops	Bavarian Brewers' Federation / 55 attendees	13.03.12 Wolnzach
IPZ 5c	Lutz, A.	New hop-breeding trends: novel aroma and bitter qualities in hops	Tettnang Hop Growers' Association / 120 attendees	29.03.12 Tettnang
IPZ 5c	Lutz, A.	New hop-breeding trends: novel aroma and bitter qualities in hops	Technical scientific committee of the GfH / 30 attendees	17.04.12 Wolnzach

WG	Name	Topic/Title	Organizer/ Attendees	Date/ Venue
IPZ 5c	Lutz, A.	Hüll flavor hops	IGN Niederlauterbach/ 50 hop growers and brewers	23.08.2012 Untermetten-bach
IPZ 5c	Lutz, A.	New German flavors	German Hops Growers' Association / 68 representatives from the hop and brewing industries	21.09.2012 Wernesgrün
IPZ 5c	Lutz, A.	Hop cultivars and assessment of their aromas	"Alt-Weihenstephaner Brauerbund" / 35 brewing students	05.11.2012 Freising
IPZ 5c	Lutz, A.	Plant variety rights and testing of new cultiivars	Society of Hop Research / 12 society board members	29.11.2012 Hüll
IPZ 5c	Maurer, K.	Development of a rapid molecular in planta test for the detection of Verticillium pathotypes in hops and strategies for prevention of wilt	Graz Technical University / 20 attendees	26.04.2012 Graz
IPZ 5c	Maurer, K.	Development of a rapid molecular in planta test for the detection of Verticillium pathotypes in hops and strategies for prevention of wilt	Graz Technical University / 20 attendees	10.08.2012 Graz
IPZ 5c	Oberhollenzer, K.	Characterisation of defence reactions to *Podosphaera macularis* and *Erysiphe cichoracearum* in resistant hop genotypes	Munich Technical University, Centre of Food and Life Sciences, Chair of Phytopathology / 20 attendees	30.01.12 Freising
IPZ 5c	Oberhollenzer, K.	Hop powdery miildew: microscopic investigations of defence mechanisms and development of a transient assay for identifying resistance genes	HVG Hop Processing Cooperative / 25 attendees	15.03.12 Wolnzach
IPZ 5c	Seigner, E.	Brewing for new aroma impressions in hops	KaHO Sint-Lieven, Heriot Watt University, Berlin Technical University / 300 attendees from the hop and brewing industries	03.04.12 Gent
IPZ 5c	Seigner, E.	New trend in hop breeding – flavor hops	German Brewers' Federation / 25 attendees	23.08.2012 Hüll
IPZ 5c	Seigner, E.	Flavor hops – commencement of breeding and genetic background	IGN Niederlauterbach 50 hop growers and brewers	23.08.2012 Untermettenbac h
IPZ 5c	Seigner, E.	New trend in hop breeding - Hüll flavor hops	Society of Hop Research / 13 attendees	30.08.2012 Hüll
IPZ 5d	Kammhuber, K.	Aroma analytics and sensory assessment of hop samples	Society of Hop Research / 35 attendees	17.04.2012 Wolnzach

8.3.3 Guided tours

(NP = Number of participants)

WG	Name	Date	Topic/Title	Guest organisation	NP
IPZ 5	Doleschel, P.; Kammhuber, K., Seigner, E.; Weihrauch, F.	16.03.12	Hop research	The Greens, press representatives	6
IPZ 5	Doleschel, P., Seigner, E.	16.05.12	Hop farming and hop breeding	GIZ International Leadership Training	11
IPZ 5	Doleschel, P., Seigner, E., Kammhuber, K., Weihrauch, F.	21.06.12	Hop Research Center Huell - hop breeding, integrated plant protection, chemical analysis, hop production	VLB Berlin, Intern. Brewmaster Course	54
IPZ 5	Doleschel, P., Lutz, A., Portner, J., Niedermaier, E.	30.08.12	Guided bus tour: current hop-growing issues in the Hallertau area	Politicians, incl. Bavarian state minister Brunner, hop industry, BVL	200
IPZ 5	Doleschel, P.	12.10.12	Hop research at the LfL, hop breeding, flavor hops	Kirin Brewery	7
IPZ 5	Lutz, A.; Kammhuber, K., Seigner, E.	16.04.12	Hop research: novel Hüll flavor hops	Neue Züricher Zeitung, Frau Lahrtz	1
IPZ 5	Portner, J., Lutz, A., Schwarz, J.	02.08.12	Flavor hops, use of beneficial organisms in low-trellis hop-growing, aphid problems	Assoc. of agricultural college graduates (VlF)	60
IPZ 5	Portner, J., Lutz, A., Sichelstiel, W.	03.08.12	Flavor hops, hop-growing on low-trellis systems, aphid control	Assoc. of agricultural college graduates (VlF)	18
IPZ 5	Portner, J., Lutz, A., Sichelstiel, W.	07.08.12	Flavor hops, cultivation on low-trellis systems, aphid control	Assoc. of agricultural college graduates (VlF)	50
IPZ 5	Portner, J., Lutz, A.	06.08.12	Flavor hops	Young Hop Growers' Assocociation	90
IPZ 5	Schätzl, H., Lutz, A., Portner, J.	15.06.12	Insight into hop research, overview of hop growing, plant protection and breeding	Vocational-school pupils	15
IPZ 5	Seigner, E., Kammhuber, K.	05.06.12	Hop Research Center Hüll	Royal Unibrew, Mr. Möller	2
IPZ 5	Seigner, E., Lutz, A., Kammhuber, K.	19.01.12	Hop Research Center Hüll	Estonian Research Institute of Agriculture	6
IPZ 5	Seigner, E., Portner, J.	29.05.12	Hop farming, production technology, plant protection, breeding	Christian-Albrechts-Univ. Kiel, Faculty of Agricul- and Nutritional Sciences, crop ecology; students, Prof. Kage and Dr. Sieling	26
IPZ 5	Seigner, E.	12.07.12	Hop research – breeding, plant protection, chemical analytics, hop farming	Munich Technical Univ., Institute of Brewing and Beverage Technology, Dr. Zarnkow and students	48

WG	Name	Date	Topic/Title	Guest organisation	NP
IPZ 5	Weihrauch, F., Lutz, A.	24.07.12	Flavor hops, hop-growing on low-trellis systems, use of predatory mites, new copper formulations, etc.	Bioland, growers and consultants	26
IPZ 5a	Schätzl, J.	11.06.12	Farmland walkthrough, current plant protection, defoliation trials in Rohrbach	Hop growers	16
IPZ 5a	Schätzl, J.	27.06.12	Farmland walkthrough in Hersbruck, update on plant protection	Hop growers and guests	14
IPZ 5a	Schätzl, J.	09.07.12	Current plant protection, walkthrough in Hirnkirchen/Nandlstadt	Hop growers	9
IPZ 5a	Schätzl J.	27.07.12	Diseases and pests, current plant protection measures, downy-mildew early warning service	Agricultural school students – practical semester	9
IPZ 5a	Schätzl, J.	16.08.12	Guided hop tour in Simonshofen	Hop growers and guests	28
IPZ 5c	Lutz, A.	26.01.12	Hop breeding – basics and cultivars	Barth Haas Group	2
IPZ 5c	Lutz, A.	01.02.12	Hüll flavor hops	Veltins brewery, hop grower	2
IPZ 5c	Lutz, A.	02.02.12	Flavor hop cultivars	BayWa	2
IPZ 5c	Lutz, A.	03.02.12	Flavor hops	Brewer	1
IPZ 5c	Lutz, A.	04.04.12	Hop breeding: novel Hüll flavor hops	Freisinger Tagblatt, Mr. Eser	1
IPZ 5c	Lutz, A.	27.04.12	Hop breeding: novel Hüll flavor hops	Velo Group, Italy - Dipl.-Braumeister Matthias Möller	1
IPZ 5c	Lutz, A., Seigner, E.	23.05.12	Flavor hops, breeding, hop research	Kopp, S. – journalist and beer sommelier	1
IPZ 5c	Lutz, A.	20.06.12	LfL hop research; focus on hop breeding and culti-vation; Hüll flavor hops	Freising/Erding Farmers' Association	50
IPZ 5c	Lutz, A.	26.06.12	Low-trellis systems, hop breeding	Hop trellis builders	2
IPZ 5c	Lutz, A.	27.06.12	Hop breeding, flavor hops, Hop market	J. Froschmeir, Bavarian Cooperative Union	1
IPZ 5c	Lutz, A., Seigner, E.	04.07.12	Breeding, seedling production	Slovenian Hop Research Institute	4
IPZ 5c	Lutz, A.	05.07.12	Hop research	Suntory, Beer Prod. Dep.	3
IPZ 5c	Lutz, A.	12.07.12	Flavor hops	Birrificio Antoniano, Brauwirtschaft	2
IPZ 5c	Lutz, A., Seigner, E.	13.07.12	Hop Storage Index (HSI), beers with new hop cultivars	Hopsteiner	3

WG	Name	Date	Topic/Title	Guest organisation	NP
IPZ 5c	Lutz, A.	30.07.12	Flavor hops, breeding	SKW Asia; BayWa	3
IPZ 5c	Lutz, A.	30.07.12	Flavor hops	Barth-Haas Group	4
IPZ 5c	Lutz, A.	30.07.12	Hop breeding and production	Augsburger Allgemeine, Mr. Zimmermann	1
IPZ 5c	Lutz, A.	13.08.12	Hüll flavor hops	Hop growers	10
IPZ 5c	Lutz, A.	14.08.12	Flavor hops, hop breeding	Growers' advisory board, Barth-Haas Group	10
IPZ 5c	Lutz, A., Doleschel, P., Seigner, E.	16.08.12	Hüll flavor hops, new breeding yard in Stadlhof	Society of Hop Research's hop growers	75
IPZ 5c	Lutz, A.	24.08.12	New cultivars, flavor hops, DUS testing in the EU	Federal Plant Variety Office	2
IPZ 5c	Lutz, A., Seigner, E.	30.08.12	Hüll flavor hops	Advisory Board of the Society of Hop Research	9
IPZ 5c	Lutz, A., Seigner, E.	30.08.12	Hop breeding at Hüll, Hüll flavor hops	Politicians, incl. Bavarian State Minister Brunner, federal authorities	200
IPZ 5c	Lutz, A.	05.09.12	Flavor hops, aroma and harvesting time	Barth-Haas Group	4
IPZ 5c	Lutz, A.	07.09.12	Hüll flavor hops, hop research at the LfL	AB-InBev, S. Muench	1
IPZ 5c	Lutz, A.	08.09.12	Hop research at the LfL	Fellow-student reunion	40
IPZ 5c	Lutz, A.	14.09.12	New Hüll flavor-hop breeding	AB-Inbev	2
IPZ 5c	Lutz, A.	17.09.12	Hüll flavor hops	US-Craft brewer D. Carey; Dr. V. Peacock	2
IPZ 5c	Lutz, A.	17.09.12	Hüll flavor hops	Hopsteiner	1
IPZ 5c	Lutz, A.	17.09.12	Hüll flavor hops	Spalt hop producers' group and Young Hop Growers' Assoc.	4
IPZ 5c	Lutz, A.	18.09.12	Hop research at the LfL; flavor hops	Fokus TV	3
IPZ 5c	Lutz, A.	24.09.12	Hop research at the LfL; flavor hops	Wolnzach trade association	20
IPZ 5c	Lutz, A.	17.10.12	Hop breeding, flavor hops	AB-InBev	2
IPZ 5c	Lutz, A.	12.11.12	Hop research at the LfL, flavor hops	US-Hopfenpflanzer und Firma Wolf	2
IPZ 5c	Lutz, A., Seigner, E., Kammhuber, K., Kneidl, J.	27.11.12	Presentation of Hüll flavor hops and new aroma breeding lines	Members of the Society of Hop Research	90
IPZ 5c	Lutz, A., Seigner, E., Kammhuber, K.	10.12.12	Presentation of Hüll flavor hops and new breeding lines	Advisory board of the Hallertau Hop Growers' Association	25

WG	Name	Date	Topic/Title	Guest organisation	NP
IPZ 5c	Lutz, A.	13.12.12	New special-flavor hop cultivars and breeding lines	Elbe-Saale hop growers	10
IPZ 5c	Lutz, A.	19.12.12	Overview of hop research at the LfL, with a focus on breeding and flavor hops	Wolnzach hop museum	12
IPZ 5c	Seigner, E.	24.08.12	Hop research at the LfL	Visitors to Hallertau Hop Weeks	31
IPZ 5c	Seigner, E., Kammhuber, K.	05.09.12	Hüll Hop Research Center - applied research for the hop and brewing industries; Hüll flavor hops	US craft brewers, brewer from Polar	3
IPZ 5c	Seigner, E.	06.09.12	Hop research at the LfL, flavor hops	Board members of the Upper Bavarian association of Sparkasse (savings) banks	54
IPZ 5c	Seigner, E., Kammhuber, K.	17.09.12	Hop research	Asahi-Brauerei, Dr. Kishimoto	1
IPZ 5c	Seigner, E., Seefelder, S.	17.09.12	Hop research, Hull flavor hops	SAB-Miller, Ms. Joseph	1
IPZ 5c	Seigner, E., Kammhuber, K.	19.09.12	Hop Research, Hüll flavor hops	Hite Brewery	3
IPZ 5c	Seigner, E.	30.09.12	Hüll Hop Research Center	AB-Inbev Vertrieb	42
IPZ 5c	Seigner, E.	30.11.12	Hop research – projects and tasks	Representatives from the BLE, the European Commission and the HVG hop producer group	12
IPZ 5c	Seigner, E., Lutz, A.	10.12.12	Hop breeding, flavor hops	AB-InBev, US brewers	3

8.3.4 Exhibitions and posters

Name of the exhibition	Exhibition items/projects and topics/posters	Organised by	Duration	WG
Environment Week, Schloss Bellevue, Berlin	"On the trail of aphids in hops"/ "Hüll Hop Research Centre presents itself in Berlin"	Deutsche Bundesstiftung Umwelt (DBU) and the Federal German President	05.-07.06.12	IPZ 5a IPZ 5b
Scientific colloquium for Ph.D. students, Graz, Austria	Development of a rapid molecular in planta test for the detection of Verticillium pathotypes in hops	University of Graz	26.04.2012 and 10.08.2012	IPZ 5c
Craft Brewers Conference, San Diego	New German flavors - Polaris	US Brewers Association	03.05.2012	IPZ 5c
Guided hop tour 2012	Beer specialities brewed with Hüll Special Flavor Hops	Association of German Hop Growers	30.08.2012	IPZ 5c
ISHS Humulus symposium in Zatec, Czech Republik	Technique for the assessment of gene function in hop (Humulus lupulus L.) - powdery mildew interactions	International Society of Horticultural Science	10.09.2012	IPZ 5c

Name of the exhibition	Exhibition items/projects and topics/posters	Organised by	Duration	WG
Central Bavarian Agricultural Festival (ZLF), Munich	BMELV hops booth – erection and manning of the booth	Bavarian Farmers' Association (BBV)	22.- 23.09.12	IPZ 5c IPZ 5a

8.4 Basic and advanced training

Name, work group	Topic	Target group
Münsterer, J., Schätzl, J., IPZ 5a	Final professional-farming examination, 18.07.2012	Trainee farmers
Portner, J., IPZ 5a	Masters' examination – hop-growing work projects, 01.01.2012	3 master-diploma candidates
Portner, J., IPZ 5a	Hop-growing instruction (2 h), 11.01.2012	Agricultural-school students
Portner, J., IPZ 5a	Hop-growing instruction (14 h), 15.10.2012	Students from the Pfaffenhofen and Landshut Schools of Agriculture
Schätzl, J., IPZ 5a	Latest update on plant protection - outlook, 06.06.2012	61 hop growers
Schätzl, J., IPZ 5a	Information pooling, 05.07.2012	13 Ring consultants and Ring experts
Schätzl, J., IPZ 5a	Final professional-farming examination, 17.07.2012	Examination candidates from the Freising district
Schätzl, J., IPZ 5a	Information pooling, 31.07.2012	12 Ring consultants and Ring experts
Schätzl, J., IPZ 5a	Annual review of the 2012 consulting season 2012, 14.12.2012	8 Ring consultants and Ring experts
Schätzl, J., IPZ 5a Lutz, A., IPZ 5c	Pfaffenhofen School of Agriculture, 27.07.2012	Students from the Pfaffenhofen School of Agriculture

8.5 Participation in work groups, memberships

Name	Memberships
Doleschel, P.	• Committee member of the Landeskuratorium für pflanzliche Erzeugung in Bayern e.V. (LKP) • Advisory Board member of the Bayerische Pflanzenzuchtgesellschaft • Chairman of the seed-potato test panel in Bavaria • Steering committee member of the Arbeitsgemeinschaft für Krankheitsbekämpfung und Resistenzzüchtung • Member of the Deutsche Landwirtschaftsgesellschaft (DLG) • Member of the Society of Hop Research • Member of the Gesellschaft für Informatik in der Land-, Forst- und Ernährungswirtschaft (GIL) • Member of the Gesellschaft für Pflanzenzüchtung • Member of the Gesellschaft für Pflanzenbauwissenschaften
Fuß, S.	• Member of the professional-farmer exam. committee at the Landshut training centre
Kammhuber, K.	• Member of the Analysis Committee of the European Brewery Convention (Hops Sub-Committee) • Member of the working group for hop analysis (AHA)
Münsterer, J.	• Member of the professional-farmer exam. committee at the Landshut training centre
Portner, J.	• Member of the Expert Committee on the Approval Procedure for Plant Protection Equipment, Julius Kühn Institute (JKI) • Member of the master-farmer exam. committees of Lower Bavaria, eastern Upper Bavaria and western Upper Bavaria
Schätzl, J.	• Member of the professional-farmer exam. committee at the Landshut training centre • Member of the professional-farmer exam. committee at the Erding/Freising training centre
Seefelder, S.	• Member of the Society of Hop Research • Member of the LfL's public relations team
Seigner, E.	• Chairman and secretary of the Scientific Commission of the International Hop Growers' Convention • Member of the International Society of Horticultural Science (ISHS) • Member of the Society of Hop Research • Member of the Gesellschaft für Pflanzenzüchtung
Sichelstiel, W.	• Chairman of the EU Commodity Expert Group "Minor Uses Hops" • Member of the German Phytomedical Society (DPG)
Weihrauch, F.	• Member of the German Society for Opthopterology (DgfO) • Member of the Arbeitsgemeinschaft Bayerischer Entomologen e.V. • Member of the German Society for General and Applied Entomologie (DgaaE) • Member of the DgaaE's working group "Useful Arthropods and Entomopathogenic Nematodes" • (DgaaE) – responsible for bibliography • Member of the German Phytomedical Society (DPG) • Member of the Society for Tropical Ecology • Member of the Münchner Entomologische Gesellschaft e.V • Secretary of the executive board of the Society of German-Speaking Odonatologists • Member of the British Dragonfly Society • Editorial board member of the Worldwide Dragonfly Society

9 Current research projects financed by third parties

WG Project manager	Project	Dur-ation	Sponsor	Cooperation
IPZ 5a, J. Portner	Development and optimisation of an automatic hop-picking machine	2011-2013	Bundesanstalt für Landwirtschaft und Ernährung (BLE) *(Federal Agency for Agriculture and Food)*	ILT, Freising; Fuß Fahrzeug- und Maschinenbau GmbH & Co. KG, Schkölen
IPZ 5a, J. Portner	Studies to investigate the structural design of hop trellis systems	2009-2012	Erzeugergemeinschaft Hopfen HVG *(HVG hop producer group)*	Bauplanungs- und Ingenieurbüro S. Maier, Wolnzach
IPZ 5a, J. Portner	Optimisation of irrigation management in hop growing	2011-2014	Deutsche Bundesstiftung Umwelt (DBU)	Dr. Michael Beck - HSWT - FA Gartenbau; Prof. Urs Schmidhalter - Munich Tech. Univ.; Pflanzenernährung Christian Euringer - ATEF.ONE GmbH; Dr. Erich Lehmair - HVG, Wolnzach
IPZ 5b, Dr. F. Weihrauch	Reducing or replacing copper-containing plant protectives in organic hop farming	2010-2014	Bundesanstalt für Landwirtschaft und Ernährung (BLE)	Organic hop farm
IPZ 5c, A. Lutz	The HSI (Hop Storage Index) and its importance for different hop varieties	2011-2012	Barth Haas Grant	
IPZ 5c A. Lutz	HSI development with regard to harvesting time and associated factors	2011-2012	Hopsteiner	S. Cocuzza, Munich Tech. Univ., Chair of Brewing and Beverage Technology
IPZ 5c, A. Lutz, Dr. E. Seigner	Continuation of the “Special Flavor Hops” breeding programme	2012-2013	Erzeugergemeinschaft Hopfen e.G. (HVG)	
IPZ 5c, A. Lutz, Dr. E. Seigner	Cross-breeding with the landrace Tettnanger	2011-2014	Ministerium für Ländlichen Raum, Ernährung und Verbraucherschutz *(Ministry of Land and Resources),* Baden-Württemberg; Hopfenpflanzerverband Tettnang *(Tettnang Hop Growers' Assoc.)*; Erzeugergemeinschaft Hopfen e.G. (HVG); Society of Hop Research (GfH)	Versuchsgut Straß, Franz Wöllhaf
IPZ 5c, Dr. S Seefelder	Genotyping of Verticillium pathotypes in the Hallertau	2008-2013	Wissenschaftsförderung der Deutschen Brauwirtschaft e.V. (Wifö) *(Scientific promotion of the German Brewing Industry e.V.);* Erzeugergemeinschaft Hopfen HVG	

WG Project manager	Project	Dur-ation	Sponsor	Cooperation
IPZ 5c, Dr. E. Seigner	Characterisation of hop/hop powdery mildew interaction at cell level and functional analysis of defence-related genes	2008-2012	HVG - Erzeugergemeinschaft Hopfen e.G.	Munich Techgnical University, Chair of Phytopathology, Prof. R. Hückelhoven, Dr. R. Eichmann
IPZ 5c, Dr. E. Seigner A. Lutz	PM isolates and their use in breeding PM-resistant hops	2006-2013	HVG - Erzeugergemeinschaft Hopfen e.G. and Society of Hop Research	EpiLogic GmbH, Freising
IPZ 5c, Dr. E. Seigner A. Lutz and IPS 2c, Dr. L. Seigner	Monitoring of dangerous viroid and viral hop infections in Ger-many	2012-2013	Wissenschaftliche Station für Brauerei in München e.V. *(Scientific Station for Brewing in Munich)*	Wissenschaftliche Station für Brauerei in München e.V.; Hop-growing consultants
IPZ 5d, Dr. K. Kammhuber	Differentiating and classifying the world hop range with the help of low-molecular plyphe-nols	2010-2012	StMELF - Bayerisches Staatsministerium für Ernährung, Landwirt-schaft und Forsten *(Bavarian State Ministry for Food, Agric. and Forestry)*	Dr. M. Coelhan, Munich Tech. University, Weihenstephan Research Center for Brewing and Food Quality
IPZ 5d, Dr. K. Kammhuber	Improving aroma characterisation of the new Hüll Special Flavor Hops	2012-2013	HVG - Erzeugergemeinschaft Hopfen e.G.	Dr. M. Coelhan, Munich Technical University

10 Main research areas

WG	Project	Dur-ation	Cooperation
5a	Testing of various nutrient solutions and additives for hop stripping	2011-2012	
5a	Optimisation of drying performance in belt dryers by selecting the correct cone depth and air speed	2012	Fa. ATEF.ONE GmbH, Forchheim
5a	Evaluation of downy mildew forecasting models and preparation of information for the warning service	2003-2012	
5a	Evaluation of the specific water requirements of different hop varieties irrigated as a function of soil moisture tension	2012-2014	
5a	Testing and establishing technical aids for optimising the drying and conditioning of hops	2003-2015	
5a	Verious fertilisation trials aimed at optimising nutrient supply in hop growing	2003-2015	
5a	Testing of the Adcon weather model for the downy-mildew warning service	2008-2013	Hopfenring e.V., Wolnzach
5a	Hallertauer model for resource-saving hop cultivation	2010-2014	Landesamt für Wald- und Forstwirtschaft; Landesamt für Umwelt; Fa. Ecozept

WG	Project	Dur-ation	Cooperation
5a	Reaction of various cultivars to reduced trellis height (6 m)	2012-2014	
5a	Variation in cover-crop sowing and incorporation times in hop-growing	2012-2014	IAB
5a	Influence of nitrolime on *Verticillium albo-atrum*	2012-2014	
5a	Influence of Plasma Soil on *Verticillium albo-atrum*	2012-2014	
5a	Compilation of a database for business management calculations	2006-2015	
5b	Documentation of the wolrdwide organic hop-growing situation	2011-	Joh. Barth & Sohn GmbH & Co. KG, Nuremberg
5b	PM forecasting - development of an innovative forecasting model for the control of powdery mildew (*Podosphaera macularis*) in hops (*Humulus lupulus*)	2007-2012	IPZ 5 d; Bundesanstalt für Landwirtschaft und Ernährung (BLE); HVG Hop Processing Cooperative
5b	Develop. of integrated methods of plant protection against the Lucerne weevil (*Otiorhynchus ligustici*) in hops	2008-2012	
5b	Monitoring and diagnosis of click beetles (Elateridae) in Hallertau hop yards	2010-	Julius Kühn Institute, Braunschweig; Syngenta Agro GmbH, Maintal
5c	Brewing trials with Special Flavor Hops	2011-	IPZ 5d; hop-trading companies; Assoc. of German Hop Growers; Munich Technical University, Chair of Brewing and Beverage Technology; Lehrstuhl Brau- und Getränketechnologie; breweries worldwide
5c	In-situ maintenance and expansion of the Bavarian hop gene pool	2001-2025	
5c	Breeding of PM-resistant hop cultivars	1999-	
5c	Breeding of hops with special brewing qualities	2003-2015	
5c	Breeding of hop cultivars showing increased resistance/tolerance towards pests and diseases	2003-	IPZ 5b and 5d; EpiLogic GmbH, Agrarbiolog. Forschung und Beratung
5c	Breeding of hop cultivars particularly suited to low-trellis cultivation	2012-2020	IPZ 5b und 5d
5c	Breeding of high-quality cultivars with increased levels of health-promoting, antioxidative and microbial substances, also for areas of application other than the brewing industry	2003-	IPZ 5d
5c	Promoting quality through the use of molecular techniques to differentiate between hop varieties	2007-	Propagation facility; hop trade

WG	Project	Dur-ation	Cooperation
5c	Breeding of hops with special components	2006-	IPZ 5d; Anheuser Busch InBev - Wilfried Lossignol, Dr. Willy Buholzer; BayWa, Dr. Dietmar Kaltner; Schönram brewery, Eric Toft; Hopfenveredlung St. Johann, Andreas Gahr; HVG Hop Processing Cooperative; Hopsteiner, Dr. Martin Biendl; Barth-Haas Group, Dr. Christina Schönberger; Städtische Berufsschule für das Hotel-, Gaststätten- und Braugewerbe, Munich, Detlev Stegbauer
5c	Meristem cultures for producing healthy hop planting stock	2008-2016	IPS 2c - Seigner, L. and team; IPZ 5b - Ehrenstraßer, O.
5c	Use of molecular markers in hop breeding	1997-2012	
5c	Development of a leaf-selection system for testing for downy-mildew tolerance in hops	2012-2013	Prof. Dr. Thomas Ebertseder, Weihenstephan-Triesdorf University, Department of Agriculture and Food Economy
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, flavonoids and individual substances such as quercetin and kaempferol) based on HPLC	2007-open-ended	AHA working group
5d	Production of pure alpha acids and their ortho-phenylenediamine complexes for monitoring and calibrating the ICE 2 and ICE 3 calibration extracts	Ongoing	AHA working group
5d	Ring tests for checking and standardising important analytical parameters within the AHA laboratory (e.g. linalool, nitrate, HSI)	Ongoing	AHA working group
5d	Development of an NIRS calibration model for al-pha-acid content based on HPLC data	2000-open-ended	
5d	Organisation and evaluation of ring analyses for alpha-acid determination for the hop supply contracts	2000-open-ended	AHA working group
5d	Varietal authenticity checks for the food control au-thorities	Ongoing	Landratsämter (Lebensmittel-überwachung) (*District food control authorities*)

11 Personnel at IPZ 5 – Hops Department

The following staff members were employed at the Bavarian State Research Centre for Agriculture, Institute for Crop Science and Plant Breeding, at Hüll, Wolnzach and Freising in 2012 (WG = Work Group):

IPZ 5

Coordinator:
Director at the LfL Dr. Peter Doleschel (provisionally)

- Hertwig Alexandra
- Krenauer Birgit

IPZ 5a

WG Hop Cultivation/Production Techniques
LD Portner Johann

- Fischer Elke
- LA Fuß Stefan
- Dipl.-Biol. (Univ.) Graf Tobias
- LA Münsterer Jakob
- LAR Niedermeier Erich
- LR Schätzl Johann

IPZ 5b

WG Plant Protection in Hop Growing
LD Portner Johann (provisionally as of 31.03.2012)
LD Wolfgang Sichelstiel (as of 01.04.2012)

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

IPZ 5c

WG Hop Breeding Research
RD Dr. Seigner Elisabeth

Dandl Maximilian
CTA Forster Brigitte
CTA Hager Petra
LTA Haugg Brigitte
Hock Elfriede
Agr.-Techn. Ismann Daniel
LTA Kneidl Jutta
LAR Lutz Anton
Maier Margret
Mauermeier Michael
Dipl.-Ing. (Univ.) Maurer Katja (née Drofenigg)
Dipl.-Biol. (Univ.) Oberhollenzer Kathrin (until 30.04.2012)
Pflügl Ursula
Presl Irmgard
BL Püschel Carolyn (until 14.10.2012)
B.Sc. Schmid Helena (as of 15.11.2012)
ORR Dr. Seefelder Stefan
Suchostawski Christa

IPZ 5d

WG Hop Quality and Analytics
ORR Dr. Kammhuber Klaus

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