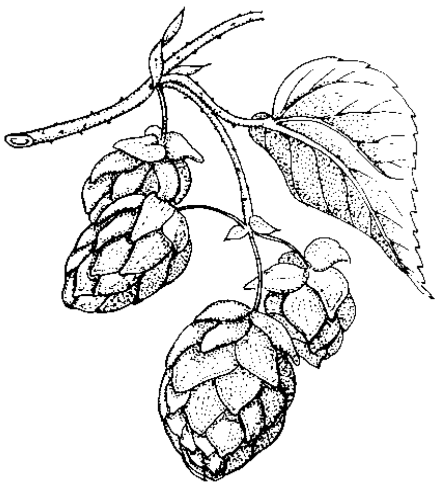
Bayerische Landesanstalt für Landwirtschaft

Gesellschaft für Hopfenforschung e.V.

Annual Report 2015

Special Crop: Hops



Bavarian State Research Center for Agriculture

- Institute for Crop Science and Plant Breeding -

and

Society of Hop Research e.V.

March 2016

LfL-Information

Published by:	Bayerische Landesanstalt für Landwirtschaft (LfL) *Bavarian State Research Center for Agriculture* Vöttinger Straße 38, 85354 Freising-Weihenstephan Internet: http://www.LfL.bayern.de
Edited by:	Institut für Pflanzenbau und Pflanzenzüchtung, Arbeitsbereich Hopfen *Institute for Crop Science and Plant Breeding, Hops Department* Hüll 5 1/3, 85283 Wolnzach E-mail: Hopfenforschungszentrum@LfL.bayern.de Tel.: +49 84 42/92 57-0
Translated by:	Patricia Ziegler B.A. Hons. (London)
First edition:	March 2016
Nominal fee:	5,-- €

Foreword

90 Years of Hop Research – continuity and new horizons

For 90 years since 1926, Hüll, a small place near Wolnzach in the Hallertau region, has been the centre of research into hop in Germany. When the hitherto unknown disease downy mildew (*Pseudoperonospora humuli*) first appeared on the scene, it threatened in equal measure both the survival of hop cultivation in Bavaria and the security of supply of raw materials to the breweries. It was primarily the brewers, who, because of their worries concerning the sustainability of hop supplies, founded the Gesellschaft für Hopfenforschung (*Society for Hop Research*), a private association which has always stood for research into everything relating to hop.

Today, the Free State of Bavaria, the Institut für Pflanzenbau und Pflanzenzüchtung der LfL (*LfL Institute for Crop Science and Plant Breeding*) and the Gesellschaft für Hopfenforschung all work collaboratively in a long-standing public/private partnership which focuses on finding solutions to the pressing problems and issues in the field of hop cultivation.

The serious challenges posed by diseases and pests in hop growing remain unchanged, owing to the emergence of novel or modified pests and infections and the loss of tried and tested plant protection agents. The integrated research work done at Hüll takes the ideal approach to dealing with these challenges. Production techniques, plant protection management, hop breeding, quality research and the transfer of knowledge all come from a single source and are translated into practical applications without the inefficiencies and tensions that can often arise. Test results and research findings are promptly put into practice on the hop growing farms.

2015 was the second dry year in three in the Hallertau region. The challenges due to climate change now facing hop cultivation and hop research are ever more evident, and it is becoming increasingly imperative to devise new ways of adapting cultivation methods, plant protection management and breeding efforts to suit the changing situation. Projects that look into areas like establishing irrigation methods, reducing energy requirements during drying, improving disease prognoses, integrating pest prevention, keeping the application of plant protection agents down to a minimum, and developing healthy and hardy hops that meet the market requirements – all these are contributing to the process of adjustment.

The present market situation for hop also presents a major challenge for its cultivation and breeding. Beer output is declining worldwide, but, at the same time, the call for aroma hops, and Special Flavor hops in particular, has grown considerably, thanks to the demand for these from craft brewers. A further contributing factor is the withdrawal of US hop growers from the bittering hop sector, creating pressure on the hop community to adjust. A crucial factor in maintaining competitiveness in hop growing in Germany is the development of new breeds to add to and enhance the hop portfolio. At the same time, however, breeding efforts must not lose sight of key elements of interest such as crop yield, plant health and location suitability.

The latest trial, research and advisory projects presented in this report have been prompted by the need to prepare for what the future might bring. However, success is never guaranteed, and no success in hop research would be possible without the commitment, hard work and creative energy of the staff at Hüll, Wolnzach and Freising, to whom we take this opportunity to express our sincere thanks.

Dr. Michael Möller
Vorsitzender des Vorstandes der
Gesellschaft für Hopfenforschung
Chief Executive of the Society of Hop Research

Dr. Peter Doleschel
Leiter des Instituts für
Pflanzenbau und Pflanzenzüchtung
Head of the Institute for Crop Science and Plant Breeding

Contents

Page

1 Research Projects and Key Research Priorities, Hops Department

1.1 Current research projects

Increasing drying rates and improving hop quality in a belt dryer (ID 5382)

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung (*Bavarian State Center for Agriculture, Institute for Crop Science and Plant Breeding*)
Funding:	Erzeugergemeinschaft HVG e.G (*HVG Hop Producer Group*)
Project lead:	J. Portner
Project staff:	J. Münsterer
Collaboration:	Ingenieurbüro Dipl.-Ing. Christian Euringer, Geisenfeld-Gaden
	Hop farms in the Hallertau region
Scheduled to run:	2015-2017

Objective

To achieve a significant increase in the drying rate of the belt dryer through well-directed control of air velocity and drying temperature in the front third of the top drying belt, and thus to eliminate frequently occurring problems affecting quality. This will involve technical refits and optimization of the air flow systems on an existing belt dryer.

First, the aim is to reproduce the prevailing air conditions in the belt dryer during the drying process, using an air flow simulator.

Method

HTCO GmbH in Freiburg was commissioned to use flow simulation to establish what kind of flow conditions prevail in the belt dryers typically used. The work was based on technical drawings of original plans and data the firm itself collected. It was also necessary to include details of the installed heating capacity and fan power and of the drying behaviour of hops on the individual belts.

Results

Using the flow simulation, it was possible to show clearly how air velocities were distributed on the different levels in the dryer. The increased air velocities of the drying air as it enters are clearly visible. As suspected, the velocities in the front third of the top drying belt are markedly lower. As a result of this information, action will now be taken to devise new methods and develop new modules to ensure a better distribution of air in belt dryers.

Model Project: Demonstration Farms - Integrated Plant Protection, sub-project: Hop Growing in Bavaria (ID 5108)

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung (*Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding)*
Funding:	Bundesministerium für Ernährung und Landwirtschaft (BMEL) über die Bundesanstalt für Landwirtschaft und Ernährung (BLE) *(Federal Ministry of Food and Agriculture (BMEL), managed by the Federal Institute for Food and Agriculture (BLE))*
Project lead:	J. Portner
Project staff:	M. Lutz
Collaboration:	Julius Kühn-Institut (JKI) Zentralstelle der Länder für EDV-gestützte Entscheidungshilfen und Programme im Pflanzenschutz (ZEPP) 5 Demonstration farms (growing hops) in the Hallertau region
Scheduled to run:	01.03.2014 – 31.12.2018

Objective

As part of the national plan of action to promote the sustainable use of plant protection products, the ongoing nationwide model project *Demonstration Farms - Integrated Plant Protection* was expanded to include hop growing, and, in 2014, a sub-project entitled *Hop Growing in Bavaria* was set up in the Hallertau region.

Its objective is to minimize deployment of plant protective chemicals on hop through regular crop inspections and detailed recommendations. At the same time, the fundamentals of integrated plant protection must be adhered to and non-chemical plant protection measures given preference – inasfar as these are available and their use is practicable.

Method

Three demonstration stands of hops, with average acreages of 1 – 2 hectares, were managed on each of five conventionally run hop farms in the Hallertau region (locations: Geibenstetten, Buch, Einthal, Dietrichsdorf and Mießling). The cultivars chosen were HA, HE, HM, HS, HT, PE and SR. Each stand underwent a weekly assessment during the growing season in which the precise extent of disease and pest infestation was ascertained. If necessary, the incidence of infection or infestation was examined separately in sub-plots. The project staff member in charge based her recommendations regarding control measures on damage thresholds, information from warning services, and forecasting models. If non-chemical treatments were available as possible alternatives to chemical pesticides, these were the preferred choice. The assessment data gathered, the time requirement and the protective measures employed are recorded on a special app or collected in programs and then sent on to the JKI Institute for evaluation.

In an effort to cut back on the use of plant protection agents, the following non-chemical measures were carried out: sensor technology was implemented in the early stages of plant development to aid more accurate application and prevent spray losses during row treatment; *Trico* – sheep-fat based animal repellent was applied to keep deer off; stripping was carried out after hop plants were treated with fertilizer solutions, or was done mechanically, by hand, or using defoliation equipment (leaf blower); to eradicate couch grass, the weeds around the outermost poles were dug out by hand; to protect against two-spotted spider mites, bines were manually cleaned of leaves and then coated with insect glue.

Two field days were organized for interested hop growers, directed at presenting the measures used in integrated plant protection. The complete range of mechanical and chemical hop defoliating methods was demonstrated and elucidated, extending from defoliating devices and nutrient solutions through to herbicide use. At the same time, integrated plant protection practices, especially with regard to spider mite control, were warmly promoted. Special attention was drawn to Dr. Weihrauch's infestation threshold model, non-chemical control methods like glue coating or deployment of predator mites as biological control agents were presented, and the best approach to acaricide application explained.

The plant protection management conference held every year at the onset of the harvest, for representatives from the plant protection industry, hop organizations and specialist bodies and licensing authorities, took place last year on one of the demonstration farms. Using a fixed induction hopper, it was shown how users can be better protected when working with plant protection agents.

Results

It was obvious that damage caused by deer was stopped effectively through the use of *Trico.* The areas that were stripped using a leaf blower needed additional treatment with chemicals at the lower ends of the bines. Stripping by hand took far more time in man hours per hectare than any other method of defoliating.

Half the sections coated with glue did not need chemicals to combat spider mites, as opposed to the untreated control area of the stand. However, all the sections where glue had been applied showed signs of damage – the coated parts turned brown or showed signs of constriction, causing the tissue to rot and the bines to wither. Chapter 5 will deal with this damage in more detail. On the other areas where chemicals were used to suppress spider mite infestation, regular inspections took place running up to harvest and one area was even left untreated because the control threshold had not been exceeded.

At this juncture, it is not possible to draw any conclusions as to whether intensive surveillance and detailed recommendations have led to potential reductions in the use of plant protection products.

Optimization of drip irrigation in hop growing (ID 4273)

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung (*Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding*)
Funding:	Dt. Bundesstiftung Umwelt (*Federal Foundation for the Environment*) und Erzeugergemeinschaft HVG e.G. (*HVG Hop Producer Group*)
Project Lead:	Dr. M. Beck
Project Staff:	T. Graf
Collaboration:	Dr. M. Beck. Weihenstephan-Triesdorf University Prof. Urs Schmidhalter, Technical University Munich, Weihenstephan
Duration:	01.12.2011 – 31.12.2015

Hop yields vary greatly from year to year owing to variations in weather conditions, thus putting at risk the security of supply that the brewing industry needs. For this reason, irrigation systems have, in the past, become established on about 15% of the hop growing acreage, although this development is constrained by the amount of water that is available.

In this context, questions also arise as to how far irrigation in hop growing makes economic and ecological sense.

The aim of the project is to develop a system of irrigation management for hop which will help to stabilize crop yields in spite of low water resources, while taking the economic aspects into account.

The key practice-relevant issues to be resolved:

- positioning of the drip hose
- most suitable time to irrigate, and quantities to use
- means of controlling irrigation

Details and results of the trials will be outlined as part of a dissertation entitled *Tröpfchenbewässerung im Hopfenbau – Feldversuche, Physiologie und Rhizosphäre (Drip Irrigation in Hop Growing – Field Trials, Physiology and Rhizosphere)* to be published in the summer of 2016.

Release and establishment of predator mites for sustainable spider mite control in hop farming

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung. AG Pflanzenschutz Hopfen IPZ 5b (*Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Plant Protection IPZ 5b*)
Funding:	Bundesanstalt für Landwirtschaft und Ernährung (BLE) (*Federal Agency for Agriculture and Food)(BLE*), Bundesprogramm Ökologischer Landbau und andere Formen nachhaltiger Landwirtschaft (BÖLN project 2812NA014)
Project lead:	Dr. F. Weihrauch
Project staff:	M. Jereb, A. Baumgartner, D. Eisenbraun, M. Felsl, L. Wörner
Scheduled to run:	01.05.2013 – 30.04.2016

Objective

In the battle against the two-spotted spider mite, *Tetranychus urticae,* there are currently no effective plant protection products available for use in organic cultivation systems, the only promising alternative being the deployment of predator mites as biological control agents. In hop growing, however, it is not possible to keep infestation by the two-spotted spider mite in check over any length of time by using predator mites established in the crop (as is often the case in viticulture and fruit growing in Germany), because the parts of the hop plants above the soil, where the predators might find cover during the winter, are completely removed during harvesting. The aim of this project is to create suitable overwintering sites as habitat augmentation by providing ground cover in the tractor lanes, in an effort to maintain predator mite populations at a stable size over several growing seasons. To this end, tests with tall fescue grass, *Festuca arundinacea,* and other plants as undersown ground cover in the lanes are underway. In addition, the deployment of purpose-bred predator mites is to be optimized with respect to both numbers to be released and judicious timing, alongside development of a standard method of distribution as an effective and economically viable alternative to acaricide use.

Method and Results

See section 6.2 of the detailed report for 2015.

Minimizing the use of copper-containing plant protection agents in organic and integrated hop farming

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Pflanzenschutz Hopfen (IPZ 5b) (*Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Plant Protection*)
Funding:	Erzeugergemeinschaft Hopfen HVG e.G. (*HVG Hop Producer Group*)
Project lead:	Dr. F. Weihrauch
Project staff:	Dr. F. Weihrauch, A. Baumgartner, M. Felsl, A. Haid, D. Ismann
Collaboration:	Naturland-Hof Pichlmaier, Haushausen; Agrolytix GmbH, Erlangen; Hopsteiner (Hallertauer Hopfenveredelungsgesellschaft m.b.H.), Mainburg
Scheduled to run:	01.03.2014 – 28.02.2017

Objective

According to an assessment by the Umweltbundesamt (*German Federal Environment Agency*), inter alia, of the toxological impact on both environment and users, plant protection agents containing copper should no longer be in general use. However, as things stand at the moment, organic operations growing all kinds of produce can hardly do without copper as an active agent. For this reason, a four-year test programme running from 2010 to 2013 was set up by the BLE (*Federal Institute for Food and Agriculture*) through BÖLN (*Federal Organic Farming Programme*) to investigate how far copper levels in hop could be reduced per season without yields and crop quality being adversely affected. The application rate of 4.0 kg Cu/ha/ per year at present permitted needed to be reduced by at least one quarter to 3.0 Cu/ha/ per year.

As a result of the successful completion of the programme, the current follow-up project aims to take a critical look at the 3.0 kg Cu/ha/year achieved thus far and to ascertain whether the use of copper can be reduced even further.

Results

As a consequence of the hot and dry weather conditions in 2015, there was no incidence of infestation by downy mildew (*Pseudoperonospora humuli)* at all, so that tests yielded no results relevant to the actual objective of the project. However, in contrast to proceedings in 2013 – a very similar year – the planned test programme involving six treatments was performed in full, making it possible to carry out a valuable impact assessment of the agents being tested, rather than an evaluation of the efficacy of the test programme. In this context, phytotoxic effects which were very difficult to explain were recorded in some plots. Conversely, the incidence of phototoxicity through the use of *CuCaps* in all variants where the application rate was at least 2 kg Cu/ha/ per year was not difficult to explain.

The fatty acid capsules containing encapsuled copper sulphate, which have been used hitherto in this formulation, had a melting point of 50°C, but it seems that, during the period of extreme heat in 2015, this temperature was exceeded several times over longer periods at the surface of the leaves. The fatty acid capsules then melted completely quite soon after application, and the copper sulphate inside almost immediately dropped onto the leaves, where it caused burning. As a consequence of this experience in 2015, the melting point of the *CuCaps* will be raised to 70°C in future to prevent any repeat of these unwelcome effects.

Developing methods of keeping the hop flea beetle (*Psylliodes attenuatus*) in check in organic hop farming

Sponsored by: Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung (*Bavarian State Center for Agriculture, Institute for Crop Science and Plant Breeding*), AG Pflanzenschutz Hopfen
(IPZ 5b), (*WG Hop Plant Protection*)

Funding: Bayerisches Staatsministerium für Ernährung, Landwirtschaft und Forsten (BioRegio 2020 – Landesprogramm Ökologischer Landbau)
(*Bavarian State Ministry for Food, Agriculture and Forestry (BioRegio 2020 – State Programme Organic Farming)*)

Project lead: Dr. F. Weihrauch

Project staff: Dr. F. Weihrauch, D. Eisenbraun, M. Jereb, L. Wörner

Collaboration: Plant Research International B.V., Wageningen UR (University & Research Centre, NL); Julius-Kühn-Institut, Institut für Biologischen Pflanzenschutz, Darmstadt; Agrolytix GmbH, Erlangen; Hopsteiner (Hallertauer Hopfenveredelungsgesellschaft m.b.H.), Mainburg

Scheduled to run: 03/2015 – 02/2018

Objective

The hop flea beetle (*Psylliodes attenuatus)* is steadily becoming a major concern for organic hop growers. The damage it causes can be divided into two phases. In early spring, the shoots of the young plants are the first source of food for the overwintering hop flea beetles, and, where infestation is severe, the leaves are reduced almost to skeletons and plant growth is noticeably slowed. From July onwards, even worse damage is done by the new adult generation of beetles, which nibble at the hop flowers and the developing cones, reaching up as far as 5 to 6 metres on the trellises, causing significant yield losses where there is a greater degree of infestation.

For the time being, there is no effective practice method of keeping the hop flea beetle at bay in organic hop growing, and growers have no option but to bear the losses. Since pest pressure has increased considerably in the last ten years, an effective flea beetle control method for hop that is suitable for use in organic agricultural systems would therefore play a key role in integrated plant protection management.

Methods and Results

In the first year of the trial, the various methods under consideration were tested for effectiveness. First results have shown that catching the beetles in yellow trays proved to be the most successful approach, although a better fluid to be used as a lure is still being sought. First trials showed that using the beta acids contained in hop as a repellent were at best only temporarily successful. A mechanical method relying on large glue-lined traps functioned well, but was very labour-intensive. A trial directed at diverting the beetles away from the developing hop shoots and getting them to feed on stinging nettles planted in pots can only be described as a failure.The most important sub-project in collaboration with PRI Wageningen is the testing to identify the hitherto unrecognized sexual pheromone of the hop flea beetle so that it can be used as a highly effective lure targeted at attracting the pests. In the spring of 2015, more than 5 000 hop flea beetles were caught and taken to the Netherlands, where numerous tests are being conducted in the laboratories at Wageningen to analyse the odoriferous substances exuded by male and female beetles and infested hop plants. The tests will continue in 2016 and will serve as a basis for further trials.

Cross-breeding with Tettnanger landrace

Sponsored by: Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtungsforschung Hopfen und AG Hopfenqualität /Hopfenanalytik
(*Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Breeding Research and WG Hop Quality/Hop Analytics)*

Funding: Ministerium für Ländlichen Raum und Verbraucherschutz (*Ministry for Rural Affairs and Consumer Protection*), Baden-Württemberg
Hopfenpflanzerverband (*Hop Growers'Association*) Tettnang**;**
Gesellschaft für Hopfenforschung e.V. (*Society for Hop Research*)
(2011-2014)

Project leads: 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 IPZ 5d)

Collaboration: Straß Hop Experimental Station of the LTZ (*Augustenberg Center for Agricultural Technology*), Baden-Württemberg, F. Wöllhaf

Scheduled to run: 01.05.2011 – 31.12.2016

Objective

The aim of this breeding programme, begun in 2011, is to develop a cultivar with the aroma typical of *Tettnanger landrace,* or at least with a similar fine, noble aroma. At the same time, it is the intention to improve on the original Tettnanger in the new lines, as far as yield potential and resistance to fungus are concerned. However, this is something that cannot be achieved solely through selective breeding within the natural variability of *Tettnanger landrace,* therefore, attempts must be made to obtain the desired result through cross-breeding for traits of interest with preselected male hops. The male breeding lines come from crosses with traditional fine aroma lines resulting from breeding work at Hüll. The father plants were additionally selected for their broad spectrum disease resistance and for good agronomic performance, on the basis of relatedness.

Results

Seedling assessment

From 21 specifically created crosses performed since 2010 from *Tettnanger landrace* and male hop breeding lines from Hüll aroma breeding programmes, it has been possible to plant out for seedling assessment at the breeding yard in Hüll more than 840 female seedlings, which had been preselected for resistance and vigorous growth. Just as in 2013, the difficult and extreme weather conditions in 2015 had a highly negative impact on plant development. Cones from only 17 seedlings were harvested and a chemical analysis of the constituent compounds of their cones carried out (EBC 7.7).

Advanced trial (Stammesprüfung)

The two promising breeding lines 2012/29/13 and 2013/45/37 went through to the next selection stage – the field trial with advanced selections – in 2015. Twelve plants from each line are being grown over four years in two Hallertau locations and at the experimental station at Straß in Tettnang. Breeding line 2013/45/37, in particular, with its fine, noble spicy/hoppy aroma, comparable to that of *Tettnanger*, its good agronomic traits, and its resistance to disease, has made a very positive impression after the first season.

Tab. 1.1: Yields from the 2015 field trial with advanced selections of two breeding lines compared toTettnanger landrace

Trait	Tettnanger	Seedling 2012/29/13	Seedling 2013/45/37
Aroma Assessment	noble, hoppy-spicy	noble, hoppy-spicy	noble, hoppy-spicy
Oil Compound	Farnesene	Farnesene	Farnesene
α-Acids (%)	1.7 - 3.5	7.2 - 8.4	4.6 – 4.7
β-Acids (%)	3.2 - 4.3	4.1 - 8.5	6.4 - 8.5
Cohumulone (%)	23 - 24	20 - 23	17 - 23
Xanthohumol (%)	0.26 - 0.32	0.47 - 0.52	0.32 – 0.42
Agronomic Features	club-shaped, often premature blooming, large cones, low yield potential	club-shaped, angel wings, cones prone to scattering, good yield potential	cylindrical bine, good cone set from top till bottom, compact cones, good yield potential

Five further seedlings bred in 2012 and 2014 have been shortlisted after the 2015 season to be included at this selection stage. Before propagation of these breeding lines can begin, they will be tested to make sure they are free of viruses and *Verticillium* wilt disease.

Outlook

From the breeder's point of view, the four-year advanced field trial with advanced selections of the first lines from the *Tettnanger* breeding programme in 2015 was the start of a first decisive phase. For the first time, it will be possible to assess the potential of a breeding line in different soils and weather conditions. Thus, conclusions with respect to vigour, yield, resistance, compounds, and aroma will be much more reliable.

Following the field trial with advanced selections with several replications, a breeding line must then pass muster in plot trials on actual commercially run hop farms (row planting and large-scale growing trial). It will not be possible to implement this test phase until 2019/2020 at the earliest, but it should deliver a wealth of information about resistance and agronomic performance traits at different sites. In addition, the commercial practice field trials, especially the large-scale per-hectare growing trial, will provide enough test material for processing studies and various standardized and individual brewing trials.

Reference

Seigner, E. and Lutz, A.: Kreuzungsprogramm mit der Landsorte Tettnanger. Hopfen-Rundschau International 2015/2016, 66-67.

Powdery mildew isolates and their use in breeding for PM resistance in hop

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*)
Funding:	Gesellschaft für Hopfenforschung e.V.(*Society for Hop Research*) (2013 - 2014; 2017 - 2018); Erzeugergemeinschaft Hopfen HVG e.G. (*HVG Hop Producer Group*) (2015 – 2016)
Project leads:	Dr. E. Seigner, A. Lutz
Project staff:	A. Lutz, J. Kneidl S. Hasyn (EpiLogic)
Collaboration:	Dr. F. Felsenstein, EpiLogic GmbH, Agrarbiologische Forschung und Beratung, Freising
Scheduled to run:	01.01.2013 – 31.12.2018

Objective

Powdery mildew isolates with previously characterized virulence properties have been used since 2000 in testing for PM resistance in the greenhouse and laboratory. The continually optimized lab- and greenhouse-based testing systems, alongside the tests using PM isolates, form the mainstay of effective breeding for PM resistance. For this purpose, EpiLogic, Agrarbiologische Forschung und Beratung, Freising, supplies 11 PM isolates with all the currently known virulence genes for the diverse breeding work centred on PM resistance. Seedlings from all the breeding programmes undergo this PM testing in the greenhouse at Hüll and at the EpiLog laboratory (leaf assay). This explains why the PM tests conducted in close collaboration between LfL and EpiLogic as part of this project are so important.

Description of the work

Eleven previously characterized single-spore isolates of *Sphaerotheca macularis*, the fungus causing powdery mildew in hop, are used every year in conjunction with the resistance testing systems to investigate and find answers to the following:

- **PM isolates – maintenance and characterization (of virulence)**

Every year in February, before testing begins, the virulence properties of all the PM isolates are verified. To do this, a selection of eleven hop varieties carrying all resistance genes known to date is required so that distinctions can be made between the different virulence properties. This is to make sure that, years now after initial cultivation, the available isolates have not lost any of their virulence genes in the meantime, due to mutation. Moreover, at the same time, PM populations new to the hop growing region and the greenhouse are examined for their virulence properties.

- **Testing for resistance to powdery mildew in the greenhouse**

Under standardized infection conditions, all the seedlings (approx. 100 000) from the crosses of the previous year are artificially infected in the greenhouse, using three PM isolates which contain all the virulence types common in the Hallertau region. In this way, a large number of seedlings can be monitored for the extent to which they display the resistances urgently required in hop growing in the region. Only seedlings categorized as PM resistant are sent on to the vegetation hall for further selection.

- **Testing for resistance to powdery mildew in the laboratory, using the detached leaf assay**

Breeding lines, cultivars and wild hops which have been shown to be resistant in previous years in the greenhouse are further tested using the leaf test in the lab at EpiLogic. The plants are inoculated with an English PM isolate (*R2 Resistenz-Brecher)* and an isolate which has relevance for the Hallertau region (*RWH18-Brecher*). Only breeding lines and cultivars with a broad spectrum resistance to powdery mildew proven in both tests (greenhouse and leaf test) are used for further selection purposes.

- **Assessment of the virulence situation in the hop growing region and evaluation of the resistance sources via the leaf test**

Every year the virulence genes of the current PM populations in the German hop growing regions are determined. This involves testing the reaction of 11 cultivars and wild hops carrying all resistance genes known globally to date (termed the set of differential hop varieties) to all PM isolates available at present. As a result, it is possible to establish whether existing resistances in current cultivars and breeding lines are still fully effective (as, for example, in *Hallertau Blanc* and 2010/72/20), or whether resistance is limited to region only (as is the case with *Herkules*).

Tab. 1.2: Overview of PM resistance testing with characterized PM isolates in 2015

2015	**Greenhouse tests**		**Leaf test in lab EpiLogic**	
	Plants	**Assessments**	**Plants**	**Assessments**
Seedlings from 82 crosses	Approx. 100 000 by mass screening		-	-
Breeding lines	153	401	153	779
Cultivars	17	25	18	125
Wild hop	26	72	9	75
Virulences, PM isolates	-	-	11	536
Total (individual tests)	**196**	**498**	**191**	**1.515**

Mass screening in plant trays; individual tests = selection as individual plants in pots

Meristem cultures to eliminate viruses – faster availability of virus-free planting stock

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung (*Bavarian State Research Center for Agriculture*, *Institute für Crop Science and Plant Breeding*), AG Züchtungs-forschung Hopfen (*WG Hop Breeding Research*)
Funding:	Wissenschaftliche Station für Brauerei in München e.V. *(Scientific Station for Brewing in Munich)*
Project leads:	Dr. E. Seigner, A. Lutz
Project staff:	B. Haugg
Collaboration:	Dr. L. Seigner and team IPS 2c
Scheduled to run:	01.07.2014 – 31.12.2016

Objective

Virus-free planting stock has for years played a major role in the quality campaign for hop. Results for virus and viroid monitoring from Germany's hop growing region and the Hüll breeding yard (Seigner et al. 2014) show how important meristem culture is in providing healthy planting stock for German hop planters and the Hüll breeding programme itself.

The aim is to accelerate availability of virus-free hops using an improved *in vitro* system of culture.

Method

In order to produce virus-free hop plants, the uppermost growth zone (= meristem) at the very tip of the shoot is first heat-treated, then cut out and prepared. The meristems obtained in this way then regenerate complete plants on special culture media.

To ascertain whether the hop plants developed from the meristems are free of viruses, the WG IPS 2c team examines the leaves for signs of the various viruses typical in hop, employing a DAS-ELISA (Double Antibody Sandwich Enzyme Linked Immunosorbent Assay) technique or a RT-PCR test (Reverse Transcriptase Polymerase Chain Reaction). As a general rule, the cheaper ELISA detection method is used when testing for hop mosaic carlavirus (HpMV) and apple mosaic ilarvirus (ApMV). The molecular technique is deployed only in testing for American hop latent carlavirus (AhpLV), hop latent virus (HpLV), hop stunt viroid (HpSVd), and hop latent viroid (HpLVD), or in cases where only very little *in vitro* starting material is available.

Results

The first step – development of the cut and prepared meristem into a small shoot - takes only a relatively short time, but the subsequent steps – continuing shoot growth and stages of cloning using a solid medium – mean that elimination of a virus is a time-consuming process. Up to ten months can elapse, from the beginning of the virus elimination process involving preparation of the meristem, to the various stages of tissue culture, to virus testing of the new plants grown from the meristem. For this reason, we are looking to speed up the whole process appreciably and are currently investigating and optimizing different parameters relating to culture management.

References

Gatica-Arias, A. (2012): Metabolic engineering of flavonoid biosynthesis in hop (*Humulus lupulus* L.) for enhancing the production of pharmaceutically active secondary metabolites. University of Hohenheim, Dissertation.

Penzkofer, M. (2010): Untersuchungen zur Massenvermehrung von *Phlox*-Sorten in einem *temporary immersion system* (TIS). Fachhochschule Weihenstephan, Fakultät Gartenbau und Lebensmitteltechnologie, Diplomarbeit.

Schwekendiek, A., Hanson, S.T., Crain, M. (2009): A temporary immersion system for the effective shoot regeneration of hop. Acta Hort 848, 149-156.

Seigner, L., Lutz, A. and Seigner, E. (2014): Monitoring of Important Virus and Viroid Infections in German Hop (*Humulus lupulus* L.) Yards. BrewingScience - Monatsschrift für Brauwissenschaft, 67 (May/June 2014), 81-87.

Research work into *Verticillium* management in hop

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*)
Funding:	Erzeugergemeinschaft Hopfen HVG e.G. (*HGV Hop Producer Group*)
Project lead:	Dr. S. Seefelder (until 30.10.2015); Dr. E. Seigner (as of 01.11.2015)
Project staff:	P.Hager, D. Eisenbraun (until 31.03.2015) A. Lutz
Collaboration:	Dr. S. Radišek, Slovenian Institute of Hop Research and Brewing, Slovenia Dr. B. Javornik, University of Ljubljana, Slovenia AG Hopfenbau und Produktionstechnik (*WG Hop Cultivation/ Production Techniques*), IPZ 5a
Scheduled to run:	since 2008 – 30.05.2020

Objective

Hop wilt disease, caused by the soil fungi *Verticillium albo-atrum* (according to the new taxonomy: *Verticillium nonalfalfae* Inderbitzin et al.) and, less often, by *Verticillium dahlia,* is a major issue at the moment for hop growers and the ongoing hop research at the LfL. Combating *Verticillium* with plant protection products is not an option, alternative ways must, therefore, be found to deal with this very serious threat to hop growing in Germany.

- **Verifying *Verticillium*-free hops using phytopathological and molecular techniques**

Alongside the implementation of horticultural and phytosanitary measures (see *Green Pamphlet*), the use of *Verticillium*-free plant material plays a decisive role in preventing the further spread of the *Verticillium* hop wilt fungus. In order to make sure of a reliable supply of *Verticillium*-free planting stock for LfL in-house testing and for the GfH propagation contractor, phytopathological techniques and, since 2012, a newly developed molecular detection system (Maurer et al., 2013) are being deployed to test hops direct from the bine (*in planta test*) in order to detect the fungus that causes wilt disease.

- **Outdoor selection of hops with resistance/tolerance to *Verticillium***

It is also vitally important to speed up the breeding of hops with resistance/tolerance, not only to milder strains of *Verticillium*, but to the highly aggressive strains in particular, as well. At the hop research centre at Hüll, there is no screening system for *Verticillium*-tolerant hops in the greenhouse or lab that is currently either already in place or being developed, as there is for hops resistant/tolerant to powdery mildew and downy mildew. In 2015, breeding lines and cultivars grown in the open field on a former commercially run site, where the presence of the aggressive *Verticillium* strains had been verified, were tested for tolerance to wilt. English cultivar *Wye Target* is used as a reference for wilt tolerance.

Methods of detecting *Verticillium* in hop samples

- Sections of hop bine are placed on a fungus selection medium; the fungus growth is then examined under the microscope to identify possible infection with *Verticillium albo-atrum and V. dahliae.*
- Using DNA isolations from pure cultures of fungi and hop bines.
- Molecular differentiation between *Verticillium albo-atrum and V. dahliae* via real-time PCR assay.

Results

– **Molecular *Verticillium* detection**

Using the highly sensitive *Verticillium* detection tool developed by Maurer et al. (2013), over 100 lines from the Hüll breeding programme were examined in 2015 in order to spot *Verticillium*. Hops showing absolutely no *Verticillium* contamination were given clearance as healthy planting stock. The real-time PCR assay is able to detect even negligible levels of contamination.

– **Field selection for *Verticillium* tolerance**

Twenty-nine breeding lines and 6 cultivars (7 plants per test block with three replicates) were trialled against the *Wye Target* wilt-resistant cultivar in the field trial. In spite of the extreme weather conditions in 2015, it was possible to differentiate clearly between wilt-tolerant and highly sensitive hop breeding lines and the cultivars on the *Verticillium*-infected screening plot. The cold and wet weather, which continued until the end of June, meant that the wilt fungus was able to become fairly well-established in the bines of susceptible hops. Like the wilt-resistant *Wye Target*, some lines also showed either no or very few symptoms of wilt. These first findings with respect to wilt tolerance in certain breeding lines will definitely need to be validated in the coming season, before any conclusive assessment can be made, especially since all the plants were only replanted in the *Verticillium*-infected plot in 2015. In parallel with this field trial, a practicable artificial *Verticillium* infection system for selecting tolerant breeding lines is to be devised in the next few years. A specifically targeted breeding programme based on the findings will then follow. In this context, every hop grower needs to be aware that raised tolerance in hop to the *Verticillium* fungus will only encourage the fungus to develop even more aggressive plans of attack in order to ensure its survival.

The strategy, on its own, of growing a wilt-tolerant type of hop without beforehand having significantly reduced the risk of infection with *Verticillium wilt* in the soil (e.g. by clearing and decontaminating the soil under grass over a number of years), and without putting supporting phytosanitary and horticultural measures in place, will only result in a breakdown in the resistance of that particular hop, because novel, with novel, and even more aggressive, strains of *Verticillium* emerging as a consequence (Talboys, 1987).

Outlook

Management of *Verticillium* wilt disease in the German hop growing regions is a long-term undertaking. Both the research and guidance contributed by the LfL and the implementation of preventive horticultural measures by hop growers are of crucial importance in the struggle against *Verticillium* wilt in hop cultivation.

References

Inderbitzin, P. and Subbarao, K.V. (2014): *Verticillium* Systematics and Evolution: How Confusion Impedes *Verticillium* Wilt Management and How to Resolve It. Phytopathology 104 (6), 564-574. http://dx.doi.org/10.1094/PHYTO-11-13-0315-IA

Radišek, S., Jakše, J., Javornik, B. (2006): Genetic variability and virulence among ***Verticillium albo-atrum*** isolates from hop. European Journal of Plant Pathology 116: 301-314.

Maurer, K.A., Radišek, S., Berg, G., Seefelder, S. (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), 105–114.

Maurer, K., New strategies to control *Verticillium* wilt in hops. Dissertation, Technischen Universität Graz, 1-82, 2014.

Maurer, K.A., Berg, G., Seefelder, S.(2014): Untersuchungen zur *Verticillium*-Welke im Hopfenanbaugebiet Hallertau. Gesunde Pflanze, 66, 53-61.

Seefelder, S., Seigner, E., Niedermeier, E., Radišek, S. & Javornik. B. (2009): Genotyping of *Verticillium* pathotypes in the Hallertau: Basic findings to assess the risk of *Verticillium* infections. In: Seigner E. (Ed.) 2009: IHGC International Hop Growers' Convention of the Scientific Commission, Leon, Spain, 74-76.

Talboys, P.W. (1987): *Verticillium* wilt in English hops: retrospect and prospect. Can. Journal of Plant Pathology 9, 68-77.

Monitoring for dangerous viroid infections in hop in Germany

Sponsored by: Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenschutz, AG Virologie und Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtungsforschung Hopfen

(*Bavarian State Research Center for Agriculture, Institute for Plant Protection, WG for Pathogen Diagnostics, and Institute for Crop Science and Plant Breeding, WG Hop Breeding Research)*

Funding: Wissenschaftliche Station für Brauerei in München e.V.
(*Scientific Station for Brewing in Munich)*

Project leads: Dr. L. Seigner, Institut für Pflanzenschutz (IPS 2c);
Dr. E. Seigner, A. Lutz (both IPZ 5c)

Project staff: P. Georgieva, Huber, L. Keckel, M. Kistler, D. Köhler,
F. Nachtmann (all from IPS 2c); A. Lutz, J. Kneidl (both IPZ 5c)

Collaboration: Dr. K. Eastwell, Washington State University, Prosser, USA;
Dr. S. Radišek, Slovenian Institute of Hop Research and Brewing, Slovenia
IPZ 5a (*WG Hop Cultivation/ Production Techniques*)

IPZ 5b (*WG Plant Protection in Hop Growing*)
Local hop consultants
Hopfenring e.V.
Commercial hop farms
Eickelmann propagation facility, Geisenfeld

Duration: März - Dezember 2015

Objective

Since 2008, in an endeavour to keep German hop production free of viroid infections, the LfL has been monitoring for hop stunt viroid (HSVd). From 2014 on, monitoring has also included screening for citrus bark cracking viroid (CVd IV = CBCVd), which was first detected in hop in Slovenia: Radišek et al., 2013; Jakse et al., 2014.

To this end, samples are taken from the LfL hop yards and commercial hop crops in all the German hop growing regions and subsequently tested. A summary of this work was published in 2014 (Seigner et al., 2014). Both viroid infections can result in huge losses in yields and alpha acids levels, especially in conditions which put great strain on the plants. It is, therefore, imperative that focal infections are detected and eradicated without delay, since these pathogens cannot be controlled with plant protection agents.

Method

Leaf samples from hop plants from the LfL breeding yards, a GFH propagation facility, and commercial operations in the Hallertau, Tettnang, and Elbe-Saale regions were screened for the two pathogens listed in *Tab.1.3* in the pathogen diagnostics laboratory of IPS 2c, using a molecular technique (RT-PCR = Reverse Transcriptase Polymerase Chain Reaction). Testing was also done on foreign cultivars and on plants from abroad kept under quarantine.

Tab. 1.3: Viroid infections capable of causing serious damage in hop

Viroid German name	Viroid English name	Abbreviation	Detection method
Hopfenstauche-Viroid	Hop stunt viroid	HpSVd	RT-PCR*
Zitrusviroid IV	Citrus viroid IV	CVd IV = CBCVd	RT-PCR#

* Using primers from Eastwell und Nelson (2007) and from Eastwell (personal communication 2009);
# Primer published by Ito et al. (2002).

Parallel to the RT-PCR assay, an internal hop-specific mRNA-based control was also run (Seigner et al., 2008) in order to make sure that the RT-PCR assay was working correctly.

Results

A total of 192 samples were screened for HpSVd and CVd IV (CBCVd). None of the samples tested positive and it can be concluded that neither of the two viroid infections has found its way into German hop cultivation, as yet. In addition, 20 hop plants of foreign origin were tested for both viroid infections prior to the start of the plant variety registration test, with the result that no cases of infection were found. There is, therefore, a good chance that this threat can be overcome. It should be possible to keep both these dangerous viroid infections at bay in the future, provided that extensive testing is carried out in good time and steps are taken to eradicate the first sources of infection swiftly and effectively.

References

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

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

Jakse, J., Radišek, S., Pokorn, T., Matousek, J. and Javornik, B. (2014): Deep-sequencing revealed Citrus bark cracking viroid (CBCVd) as a highly aggressive pathogen on hop. Plant Pathology DOI: 10.1111/ppa.12325

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

Seigner, L., Seigner, E., Lutz, A. (2015): Monitoring of dangerous virus and viroids in German hop gardens. Brauwelt International, VI, Vol. 33, 376-379.

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

Seigner, L., Lutz, A. and Seigner, E. (2014): Monitoring of Important Virus and Viroid Infections in German Hop (Humulus lupulus L.) Yards. BrewingScience - Monatsschrift für Brauwissenschaft, 67 (May/June 2014), 81-87.

Seigner, E., Seigner, L., Lutz, A. (2015): Monitoring von gefährlichen Viren und Viroiden in deutschen Hopfengärten. Brauwelt Wissen, Nr. 26, 757-760.

Acknowledgement

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

Precision breeding in hop

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung *(Bavarian State Center for Agriculture, Institute for Crop Science and Plant Breeding)* Universität Hohenheim Pflanzenbiologie und Molekularbiologie Max-Planck-Institut für Entwicklungsbiologie
Funding:	Bayerisches Staatsministerium für Ernährung, Landwirtschaft und Forsten (*Bavarian State Ministry for Food, Agriculture and Forestry)* Ministerium für Ländlichen Raum und Verbraucherschutz (*Ministry for Rural Affairs and Consumer Protection*), Baden-Württemberg Hopfenpflanzerverband (*Hop Growers' Association*) Tettnang; Erzeugergemeinschaft Hopfen HVG e.G. (*HVG Hop Producer Group*) Universität Hohenheim
Project leads:	Dr. M. H. Hagemann, Universität Hohenheim (project overall) Dr. E. Seigner (LfL)
Project staff:	AG Züchtungsforschung Hopfen (*WG Breeding Research*) (IPZ 5 c), A. Lutz, J. Kneidl, E. Seigner and breeding team (all IPZ 5c) AG Hopfenqualität/ Hopfenanalytik (*WG Hop Quality/ Analytics*) (IPZ 5d) Dr. K. Kammhuber, C. Petzina, B. Wyschkon, M. Hainzlmaier und S. Weihrauch (all IPZ 5d) AG Genom-orientierte Züchtung (*WG Genome-oriented Breeding)* (IPZ 1d) Prof. Dr. V. Mohler AG Züchtungsforschung Hafer und Gerste (*WG Breeding Research Oats and Barley*) (IPZ 2c), Dr. Th. Albrecht
Collaboration:	Universität Hohenheim: Dr. M. H. Hagemann; Prof. Dr. J. Wünsche, Prof. Dr. Piepho; Dr. Möhring; Pflanzenbiotechnologie und Molekularbiologie: Prof. Dr. G. Weber Max-Planck-Institut für Entwicklungsbiologie: Prof. Dr. D. Weigel Hopfenplanzerverband (*Hop Growers' Association*), Tettnang
Scheduled to run:	01.07.2015 – 31.03.2017

Objective

In making available precision breeding, this project promises to provide the German hop breeding community with an innovative tool which has proven reliable in field crops. It will facilitate faster and more efficient breeding of robust, high-grade plants, in response to the need for the hop growing and brewing industries to react to new climatic, agricultural, and consumer demands. In order to deliver this, it will be necessary, in the first phase of the project (2015-2016), to develop a genetic map for hop, which will then, in the second project phase (2017 – 2019), be developed further, with the aid of phenotypic data and association mapping, to become an application-oriented precision breeding procedure.

Precision breeding will enable speedy assessment of the breeding potential of future breeding populations and, for the first time, will help to predict the breeding potential of male plants.

The influence of harvest timing on the sulphur compounds in flavor hops *Cascade, Hallertau Blanc, Huell Melon, Mandarina Bavaria* and *Polaris* (Diploma dissertation)

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung (*Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding*), AG Hopfenqualität- und -analytik (*WG Hop Quality and Analytics*)
Project lead:	Dr. K. Kammhuber
Project staff:	Maximilian Hundhammer
Collaboration:	Prof. M. Rychlik, Dr. Gerold Reil, Wissenschaftszentrum Weihenstephan für Ernährung, Landnutzung und Umwelt (*TUM School of Life Sciences, Weihenstephan*)
Duration:	01.10.2015 – 01.02.2016

Objective

Sulphur compounds, with their very low odour threshold values, play a large part in Special Flavor hops. The purpose of the work done here was to find out whether harvest date decisions had any influence on the levels of a number of selected sulphur compounds.

Method and results

The following aroma-active compounds were tested: dimethyl disulphide, S-Methyl thio isovalerate, 4-Mercapto-4-methyl-2-pentanone (4-MMP) S-Methyl thio hexanoate. These commercially available substances are the main sulphur compounds found in hop. Analysis and quantitative evaluation were performed using the new headspace gas chromatography/ mass spectrometry equipment in the laboratory at Hüll.

It was not possible to detect 4-MMP in the mass spectrometer because of insufficient sensitivity. When the other substances were evaluated, it was found that the sulphur compounds intensified significantly with later harvesting. Hops harvested at a later date often have aromas reminiscent of onion or garlic, and this was also confirmed by the analytical work done in this context.

1.2 Key Research Priorities

1.2.1 Research focus: breeding

Development of hop breeding material and cultivars with broad spectrum resistance and good agronomic traits within the aroma, high alpha, and Special Flavor varieties.

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

Project staff: A. Lutz, J. Kneidl, S. Seefelder, E. Seigner, IPZ 5c team

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

Beratungsgremium der GfH (*Hop Expert Group*)

Forschungsbrauerei Weihenstephan (*Research Brewery* Weihenstephan), Technische Universität München-Weihenstephan Lehrstuhl für Getränke- und Brautechnologie (*Chair of Brewing and Beverage Technology*) Prof. Becker, Dr. F. Schüll (until April 2015) und Dr. J. Tippmann

Bitburger-Braugruppe Versuchsbrauerei (*Experimental Brewery of Bitburger Brewery Group*), Dr. S. Hanke

National and international brewing partners

Partners from the hop trading and hop processing industries

Verband Deutscher Hopfenpflanzer (*German Hop Growers' Association)*

Hop growers

Objective

Breeding efforts at Hüll are directed at developing modern, top performing cultivars of the noble aroma and high alpha sector, and more recently, hops which have special fruity aromas (Special Flavor hops), but which will also meet the market requirements of the brewing industry and satisfy the needs of both craft brewers and German hop growers alike.

Material and Methods

In pursuit of this goal, 72 crosses were performed in 2015. The selection procedure, illustrated in the chart in Fig. 4.3, applies in general to all breeding programmes.

Results

Interesting breeding lines in the noble aroma and high alpha ranges are in the pipeline. As part of the project to improve Tettnanger landrace through cross-breeding, intensive breeding within the noble aroma range is underway. The work on developing robust, high yield, high alpha cultivars will be intensified as part of a 2016 project.

The drive to provide the booming global craft beer scene with Special Flavor hops, as fast as possible, led to the advent of the first Special Flavor cultivars from Hüll: *Mandarina Bavaria*, *Huell Melon* and *Hallertau Blanc*. These were selected and launched onto the market in 2012, in the record time of only 4 – 6 years. Two further highly promising Special Flavor cultivars to emerge from Anton Lutz's crosses are due to be launched in 2016.

Hüll Special Flavor hops

In spite of the speed with which these special aroma hops have been developed, significant progress has also been made with respect to resistance. In the case of powdery mildew in particular, the intensive and comprehensive resistance breeding programme, continuing over several years, has obviously been successful. All the Special Flavor hops from Hüll show *good*, *very good*, or *total* resistance to all currently identified powdery mildew strains. *Good* to *very good* tolerance to downy mildew in the new cultivars completes the picture. It is worth mentioning that we also discovered raised tolerance to hop wilt fungus during field screening in *Verticillium*-infested plots during the 2015 growing season. On the whole, it can be concluded that there has been obvious success in breeding for fungal resistance. Thus, the Special Flavor hops from Hüll are far better suited to coping with the pathogens present in the German hop growing regions than are the foreign varieties.

	Yield kg/ha	Quality			Resistance towards				
		Hoppy Aroma plus	Oil Content (ml/100g)	α-Acids (%)	Vertic. Wilt (mild)	Downy Mildew	Powdery Mildew	Spider Mite	Aphids
Mandarina Bavaria	2,100	mandarin, grapefruit	1.5 – 2.1	7- 10	+	+	+ +	+/-	+/-
Huell Melon	1,900	honeydew melon, apricot, strawberry	1.4 – 2.1	7 - 8	+	+ +	+ +	+/-	+/-
Hallertau Blanc	2,300	mango, gooseberry, white wine	1.5 – 1.8	9 - 11	+	+ +	+ + +	+/-	+/-
Callista	2,000	apricot, passion fruit	1.4 – 1.8	2 - 5	+ +	+ +	+ +	+/-	+/-
Ariana	2,300	black currant, blackberry	2.1 – 2.4	10 - 13	+ + +	+ +	+ + +	+	+/-

Fig. 1.1: Overview of the Hüll Special Flavor cultivars

Improvement of screening systems for assessing tolerance of hops to downy mildew (*Pseudoperonospora humuli*)

Lead: Dr. E. Seigner, A. Lutz

Staff: B. Forster

Objective

Downy mildew, which is caused by the fungus *Pseudoperonospora humuli*, has led to enormous problems in the last few years in hop crops already damaged by hailstorms. As a result, breeding for enhanced tolerance to downy mildew has once again become a major priority. Since 2012, work has been done first to improve seedling screening in the greenhouse (Jawad-Fleischer, 2013; Seigner and Forster, 2014). Efforts are now directed at judging the reaction of hop to downy mildew with greater precision, using a leaf test system.

Method

Based on studies using screening systems for downy mildew in the USA, the UK and the Czech Republic, and specifically by Dr. Kremheller at Hüll in the 1970s and 1980s, work has begun on a testing system using hop leaves which have been detached from the plants. Leaves from hops with very different tolerances to downy mildew were inoculated with a sporangia suspension and their reaction subjected to careful scrutiny 5 – 14 days after inoculation. The various trial parameters were reviewed and optimized.

Results and outlook

First findings from the work using the leaf test system (detached leaf assay) in 2013 were collated in a Bachelor dissertation (Jawad-Fleischer, 2014). After further improvements in reproducibility, while at the same time retaining vitality of the zoospores (Jones et al., 2001), it was possible reliably to trigger chloroses, necroses and even some sporulation on the leaves of the hops examined, depending on how susceptible they were to downy mildew. In 2016, individual leaf assay parameters will be further modified. One focus will be on optimizing the temperature regime (Rotem et al., 1978; Savory et al., 2011). Ultimately, the purpose is to clarify whether tolerance of hop in the field to secondary infection with downy mildew can be gauged by examining the tolerance/sensitivity of its leaves.

Fig. 1.2: : Leaves inoculated with downy mildew clearly displaying chloroses and necroses 13 days after inoculation

References

Beranek, F. and Rigr, A. (1997): Hop breeding for resistance to downy mildew (*Pseudoperonospora humuli*) by artificial infections. Proceeding of the Scientific Commission, I.H.G.C., Zatec, Czech Republic: 55-60.

Coley-Smith**,** J. R. (1965): Testing hop varieties for resistance to downy mildew. Plant Pathology**,** 14: 161–164.

Darby, P. (2005): The assessment of resistance to diseases in the UK breeding programme. Proceedings of the Scientific Commission, I.H.G.C., Canterbury, UK, 7-11.

Hellwig, K., Kremheller H.T., Agerer R. (1991): Untersuchungen zur Resistenz von *Pseudoperonospora humuli* (Miy. & Tak.) Wilson gegenüber Metalaxyl. Gesunde Pfl. 43: 400- 404.

Jawad-Fleischer, M. (2014): Optimierung eines Blatttestsystems (detached leaf assay) zur Testung der Toleranz gegenüber Falschem Mehltau (*Pseudoperonospora humuli*) bei Hopfen. Bachelorarbeit, Hochschule Weihenstephan-Triesdorf, Fakultät Land- und Ernährungswirtschaft.

Jones, E.S., Breese, W.A. and Shaw, D.S. (2001): Inoculation of pearl millet with the downy mildew pathogen**,** ***Sclerospora graminicola***: chilling inoculum to delay zoospore release and avoid spray damage to zoospores. Plant Pathology 50: 310-316.

Kremheller, Th. (1979): Untersuchungen zur Epidemiologie und Prognose des falschen Mehltaues an Hopfen (*Pseudoperonospora humuli* (Miy. et Tak.) Wilson). Dissertation, Tech. Univ. München: 1-110.

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.

Parker, T. B., Henning, J. A., Gent, D., and Mahaffee, W. F. (2007): The Extraction, Tetrazolium Staining and Germination of the Oospore of *Pseudoperonospora humuli* Miyabe and Tak. (Wil.) in: Parker, T.B. Investigation of Hop Downy Mildew through Association Mapping and Observations of the Oospore. PhD Thesis, Oregon State University, USA.

Rotem, J., Cohen, Y. & Bashi, E. (1978): Host and environmental influences on sporulation in vivo. Annual Review of Phytopathology, 16, 83-101.

Savory, E.A., Granke, L.L., Quesada-Ocampo, L.M., Varbanova, M., Hausbeck, M.K., and Day, B. (2011) The cucurbit downy mildew pathogen *Pseudoperonospora cubensis*. Mol Plant Pathol 12: 217–226.

Seigner, E. und Forster, B. (2014): Verbesserung des Sämlingstestsystems zur Beurteilung der Toleranz von Hopfen gegenüber Falschem Mehltau (*Pseudoperonospora humuli*) im Gewächshaus Jahresbericht 2013 – Sonderkultur Hopfen, LfL-Information: 48-49.

1.2.2 Research focus: hop farming, technical aspects of production

The impact of different drying parameters on the external and internal quality of the hop under conditions usual in commercial practice

Staff: J. Münsterer, Dr. K. Kammhuber
Collaboration: Dr. Barbara Sturm, Nacherntetechnologien und Verarbeitung (*post-harvest technologies and processing*), Fachgebiet Agrartechnik (*agricultural technology*), Universität Kassel

Objective

Using the measuring techniques which have been common practice up to the present, it is possible to give only an approximation of water content at any time during the hop drying process. Similarly, any deterioration in quality during drying, due to incorrect setting of the drying parameters, cannot be detected until after the end of the drying process, this detection relying on assessment or laboratory analysis. In the next few years, drying tests will be conducted in collaboration with the department for post-harvest technology and processing at the University of Kassel to investigate whether and how image recognition technology can be employed to advance optimization of the drying process.

Method

The different constituent compounds in hop absorb light within a very specific wavelength range. With the help of a colour camera, it is possible to photograph the 400 – 700 nm spectrum visible to the human eye; using a hyperspectral camera, the near infrared spectrum of 400 – 1010 nm can be photographed.

The two camera systems were installed in a test kiln. Special software captured the data of the wavelength spectrum during drying, at different load depths, drying temperatures and air velocities. Hop samples were taken at regular intervals throughout the entire drying process.

Every time a sample was taken, the water content of the hop was determined by oven drying. The hop samples to be analysed were vacuum packed and frozen. Before analysis took place, the samples were freeze-dried and adjusted to a uniform water content.

Results

Analysis of the hop samples is used to show whether and how specific components are altered under certain drying conditions. Simultaneously, spectral change in the hop is examined. Initial results have shown that water content can be estimated on the basis of only a small number of wavelengths. The colour camera recorded the colour changes occurring during the different drying variants while the hops were being dried.

Reaction of different cultivars to a reduction in trellis height (to 6 mtrs)

Staff: S. Fuß

Scheduled to run: 2013-2016

In the wake of devastating storms, which caused hop trellis systems to collapse prior to harvest, this research aims to establish whether the trellis systems can be reduced to a height of 6 metres without yields being affected. Initial calculations have shown that the static load of the Hallertau trellis system would then be reduced by approx. 15 – 20%, and stability in gale-force winds would be considerably improved.

Trellis costs would also be reduced through the utilization of shorter and weaker central poles, without adversely affecting the static equilibrium. Another benefit would be that plant protection could be improved, since the target area at the top of the plants would be more easily accessible for spraying.

In two projects already completed in a number of commercial hop yards (different varieties grown as commercial crops), the trellis systems in test plots were reduced in height from 7 m to 6 m, with the aim of establishing how the different hops responded to the reduction, in terms of plant development, infection/pest infestation, yield, and quality. For the trial, *Perle* and *Hallertauer Tradition* were used to test the aroma varieties, and *Hallertauer Magnum*, *Hallertauer Taurus*, and *Herkules* to test the bittering varieties. A general recommendation for commercial practice that trellis heights should be routinely reduced is not possible on the basis of these tests at this point.

However, it must be pointed out that with a trellis height of 7 m the tendency was towards higher yields from all varieties, the differences being especially marked at hop growing sites with good quality deep soils.

In addition to the above, in 2012, a new test plot with 6 m and 7 m trellises was set up at in the new breeding yard at the Stadelhof site, where *Perle*, *Herkules* and *Polaris* were planted in several replicates – an experimental design which allows the reactions of the different varieties to the different trellis heights to be monitored and compared. In 2013, hail damage prevented harvesting at the test site. Test harvests in 2014 and the drought year 2015 produced first interesting results, but at least one further year of testing will be necessary before the results can be published.

Varying sowing and incorporation dates for cover crops in hop growing

Staff: J. Portner

Duration: 2012 – 2015

Cover cropping between hop rows prevents soil erosion caused by water and reduces nitrate transfer and leaching after harvest. Until now, ground cover was always sown mainly in early summer after tilling, with the result that erosive precipitation, received at the time of sowing, before the cover crop could develop sufficiently, triggered serious soil erosion in some places.

In order to optimize the cover cropping model, 7 different variants of cover crops (no seed sown, summer sowing, autumn sowing) were sown at different times with different incorporation dates (from turning the soil in April through to mulching in late June without turning) on a site affected by erosion. Yield assessments, analysis of biological and physical soil parameters and qualitative monitoring of soil erosion will contribute information towards optimizing the system. For result details, please consult chapter 5 of this annual report.

The influence of different drying temperatures on the internal quality of *Mandarina Bavaria*

Staff: J. Münsterer, Dr. K. Kammhuber

Scheduled to run: 2014 - 2016

Hops of cultivar *Mandarina Bavaria* were dried at temperatures of 60°C, 65°C, 70°C, and 80°C in compact dryers, where the different drying variants were based on different drying temperatures and different storage times of the green hops before drying. In some variants, the hops were also intentionally overdried as a result of overlong drying times. Apart from standard chemical analysis, total oil content and individual oil components of the dried hops were also analysed. A definite deterioration in quality was found in hops which had heated up through already being stored for too long prior to drying and which were overdried at temperatures of 70°C and 80°C.

Testing different harvest dates in flavor hops *Mandarina Bavaria, Hallertau Blanc* and *Polaris*

Staff: J. Münsterer, Dr. K. Kammhuber, A. Lutz

Scheduled to run: 2014 – 2016

The aim is also to be able to make recommendations in the future as to the optimal harvest dates for the new cultivars, *Mandarina Blanc, Hallertau Blanc,* and *Polaris*. Harvest date trials were performed at 3 different locations. Twice a week, 20 bines in four replicates were harvested from commercial field crops on 5 different harvest dates.

The idea is to determine the best time for these cultivars from the standpoint of particular aspects such as yield, alpha acids content, aroma, and external and internal quality criteria. In the crops harvested in 2015, because of hail damage in *Mandarina Bavaria*, it was only possible to look at quality parameters at the different harvest dates. A yield assessment was not viable because of the disparate nature of the research plots.

Testing a lignite-enriched substrate when planting young hop plants

Staff: J. Portner, J. Münsterer

Scheduled to run: 2015 – 2016

Lignite derived from open-cast mines is often used in horticulture and landscape gardening because of its usefulness in improving substrate through moisture and nutrient fixation, particularly in the replanting of hedges and trees. With the aim of encouraging hop rhizomes to grow in particularly difficult soils (sandy and clayey loams), these were planted in the spring of 2015, as part of a randomized trial in 4 replicates in 2 locations, using lignite-enriched substrate in the seed placement slot, as compared to substrate without lignite and topsoil as a control. It is hoped that the trial will deliver facts about the positive soil-improving properties of lignite in hop cultivation, based on plant development in the year of planting and the first year of yield.

1.2.3 Research focus: hop quality and chemical-analytical work

Performance of all chemical-analytical studies in support of the Working Groups in the Hops Department, in particular, WG Hop Breeding

Project lead:	Dr. K. Kammhuber
Project staff:	E. Neuhof-Buckl, S. Weihrauch, B. Wyschkon, C. Petzina, M. Hainzlmaier, Dr. K. Kammhuber
Collaboration:	AG Hopfenbau/Produktionstechnik (*WG Hop Farming/Production Techniques*), AG Pflanzenschutz Hopfen (*WG Hop Plant Protection*), AG Züchtungsforschung Hopfen (*WG Hop Breeding Research*)
Scheduled to run:	Ongoing

Hop is cultivated and farmed, above all, for its compounds and, in hop research, content analytics is key. WG IPZ 5d carries out all the chemical-analytical work necessary to resolve issues relating to trials run by the other groups. WG Hop Breeding, in particular, bases its selection of breeding lines on the data processed by the lab.

Development of an NIRS calibration model for α acids and moisture content

Project lead:	Dr. K. Kammhuber
Project staff:	E. Neuhof-Buckl, B. Wyschkon, C. Petzina, M. Hainzlmaier, Dr. Klaus Kammhuber
Scheduled to run:	September 2000 – open end

Starting in 2000, Hüll and the laboratories of the hop processing companies have been developing an NIRS calibration model for α acids content, based on HPLC data, as a fast and cheap method to replace the increasing number of wet chemical tests. The objective is to achieve repeatability and reproducibility that can be translated into standard practice. WG Hop Analytics (AHA) considered this model to be practicable and workable as an analytical method useful in the context of hop supply contracts, provided that it is at least as accurate as conductometric titration according to the ECB 7.4 standard.

However, it was decided to discontinue collaboration in developing a joint calibration model in 2008, since no further improvement was possible. Work still continues on developing NIRS calibration in the laboratory at Hüll, as well as on efforts to develop a method of determining water content. NIRS is useful as a screening method in hop breeding and saves a lot of time and money otherwise spent on chemicals. It was also discovered that accuracy of analysis improves with the ongoing new developments every year.

Development of analysis methods for hop polyphenols

Project lead: Dr. K. Kammhuber
Collaboration: Arbeitsgruppe für Hopfenanalytik (*WG Hop Analytics*) AHA
Project staff: E. Neuhof-Buckl, Dr. K. Kammhuber
Scheduled to run: 2007 – open end

In the search for alternative applications for hop, polyphenols are taking on an ever more interesting role, above all because of their positive health properties. Of course, they also play a part in sensory impressions. It is therefore important to have access to suitable analysis models, although there are no official standardized methods available at present. All the laboratories involved in polphenol analytics are currently using their own methods.

Since 2007, the AHA has been working internally on improving and standardizing analysis models for both total polyphenol content and total flavonoid content. In the meantime, the model for determining total polyphenol content has been accepted as EBC method 7.14.

Analytical work for Working Group IPZ 3d Medicinal and Aromatic Herbs

Project lead: Dr. K. Kammhuber
Collaboration: AG Heil-und Gewürzpflanzen (*WG Medicinal and Aromatic Herbs)*
Project staff: E. Neuhof-Buckl, Dr. K. Kammhuber
Scheduled to run: 2009 – open end

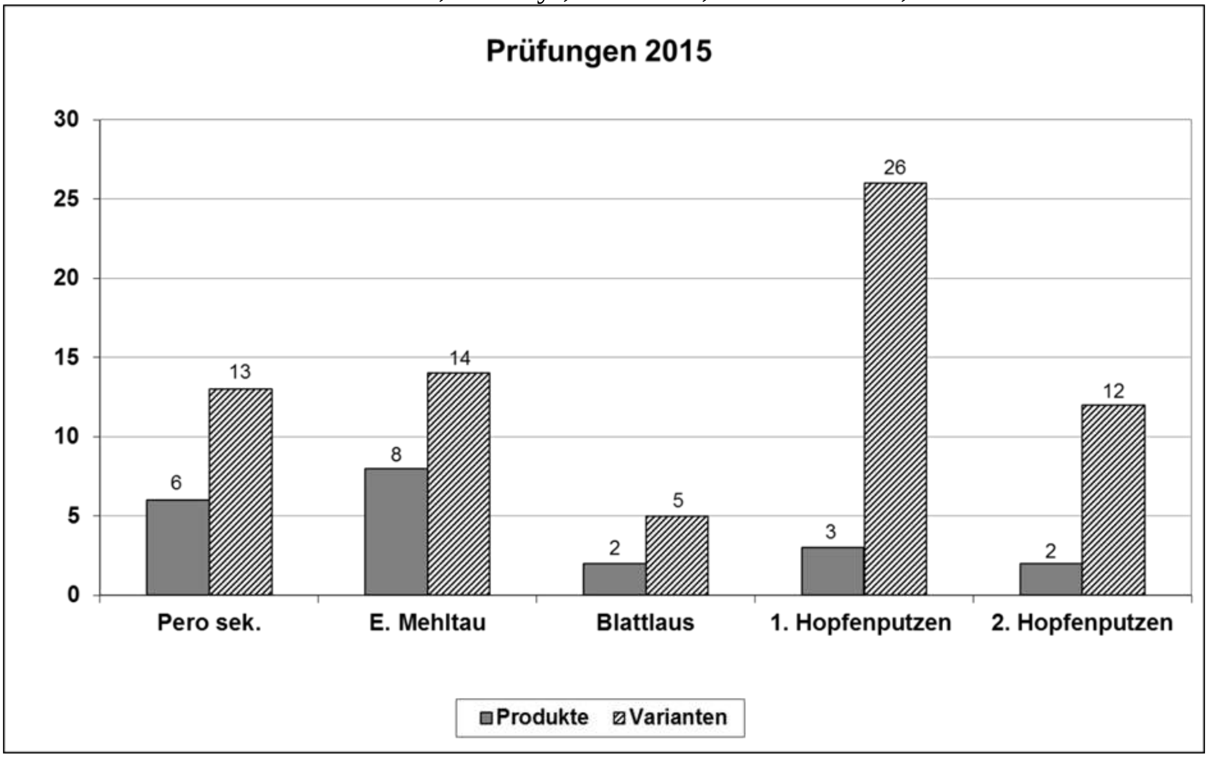
To ensure more efficient ulilization of the laboratory equipment at Hüll, analyses have been conducted on behalf of WG Medicinal and Aromatic Herbs, starting in 2009. Active substance analyses are being been carried out, using HPLC methods, on the following plants:

- Leonorus japonicus (motherwort): flavonoids, stachydrine, leonurine
- Saposhnikovia divaricata (Fang-feng): Prim-O-Glucosylcimifugin, 5-O-Methyl visamminoside
- Salvia miltiorrhiza (red sage): salvaniolic acid, tanshinone
- Paeonia lactiflora (white Chinese paeony): paeoniflorin

1.2.4 Research focus: plant protection in hop

2015 trials of plant protection products for licensing/approval and for advisory service documentation

Lead: W. Sichelstiel
Staff: L. Wörner, G. Meyr, J. Weiher, D. Eisenbraun, M. Felsl



Efficacy and crop tolerance trials to test herbicide application at primary stripping – focus on *Vorox F*

Starting point, problem definition, and objective

Primary stripping encourages growth of the trained main shoots and reduces infection/ infestation pressure from powdery and downy mildew and spider mites. Stripping entails removing all the lower leaves on the hop bine up to a height of 2 m, and pruning out lateral and newly sprouting basal shoots.

As of the 2014 season, the hitherto widely used plant protection product *Lotus* can no longer be used, since cinidon-ethyl has been withdrawn from the EU list of registered active agents. Hop growers are now looking for an alternative to bridge the gap and considering herbicides that have a similar effect, without creating tolerance issues in the crop.

Following a first exploratory test in 2012 in the breeding yard at Rohrbach, a number of trials were conducted in the period 2013 – 2015 at several sites, using potentially suitable active agents. In view of the results from the efficacy trials run in 2013, the manufacturer of *Vorox F* decided to submit an application for extension of authorization to cover use in hop stripping.

The trials conducted with this product in 2014 and 2015 concentrated on optimizing efficacy and crop tolerance. The manufacturer also ran simultaneous trials and, following approval of the product in 2015 for use in the 2016 season, were able to compile application recommendations at primary and secondary stripping, on the basis of the results.

A) 2013 Trials

Five trials involving cultivars *Herkules, Perle* and *Polaris* were set up in the Stadelhof hop breeding yard and on a participating farm in Siegertszell, in the variants listed below. Distribution took place by banded application using 1/3 of the specified per-hectare spray rate, with 400 l spray mixture applied to the band; i.e. the per-hectare calculation of spray mixture was 1 200 litres**.**

VG 1: Untreated			
VG 2: Lotus (Cinidon-ethyl)	0,25 l/ha	+ 30 % AHL	+ 250 ml/ha Breakthru
VG 3: Goal (Oxyfluorfen)	300 ml/ha	+ 30 % AHL	+ 250 ml/ha Breakthru
VG 4: B235 (Bromoxynil)	1,5 l/ha	+ 50 % AHL	+ 0,1% Wetcit
VG 5: Vorox F (Flumioxazin)	1,2 kg/ha		+ 0,1% Adhäsit
VG 6: Vorox F (Flumioxazin)	1,2 kg/ha	+ 30 % AHL	+ 0,1% Adhäsit
VG 7: Vorox F (Flumioxazin)	1,2 kg/ha	+ 50 % AHL	+ 0,1% Adhäsit
VG 8: Fox (Bifenox)	1,5 kg/ha	+ 30 % AHL	+ 250 ml/ha Breakthru
VG 9: Acetic acid	10%		+ 250 ml/ha Breakthru
VG 10: Acetic acid	10%	+ 30 % AHL	+ 250 ml/ha Breakthru

The exploratory test in 2012 revealed that the agents tested were insufficiently effective when used on their own. In order to strengthen the herbicidal effect, spray mixtures were made up with 30% and 50% AHL. In variants 2, 3, 8, 9, and 10, *Spreiter Breakthru,* which has proved reliable in improving stripping, was also used. In variants 4, 5, 6, and 7, agents to improve adhesion of the spray mixture were deployed at the request of the manufacturer. Treatment took place on June 12, following primary tillage. The plants had reached a height of 2 m to half the height of the trellis.

Results

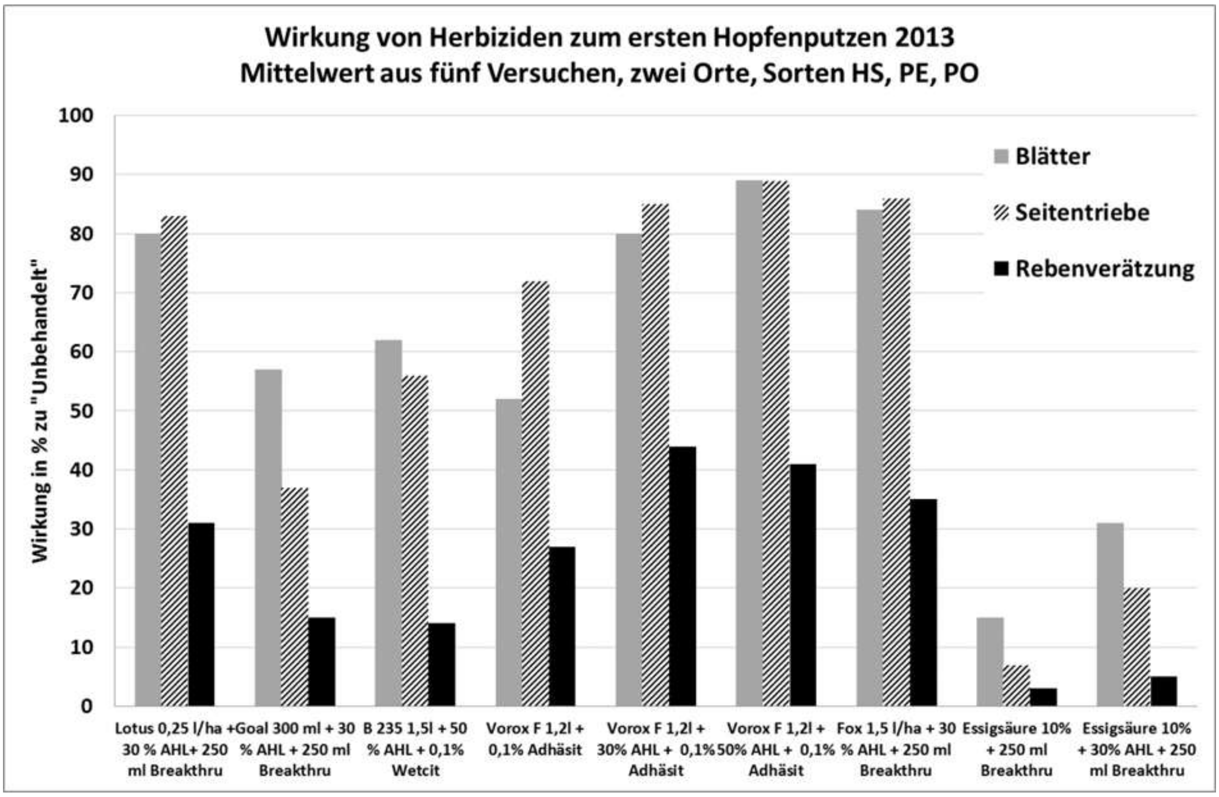


Fig. 1.3: Assessment results of trials at primary stripping in 2013

One finding from the first year of trials showed that *Vorox F* and *Fox* can produce an effect comparable to the old *Lotus* standard, although the efficacy of the products needs to be augmented with AHL and an adjuvant. Incidence of chemical burns on the bines increased slightly, especially in the case of *Vorox F* when compared to *Lotus*, but the burn marks were confined to the surface and did not prevent the hop developing normally. The efficacy of products *Goal* and *B 235* did not compare favourably to *Lotus*, although *B 235* was tolerated very well. The acetic acid variants also tested were not effective enough.

B) 2014 Trials

On the basis of the outcomes of the previous year's trials, the LfL and the manufacturer of *Vorox F* set up more extensive trials in 2014, in an attempt to find answers to the questions listed below. At the same time, an application for approval of the product had already been submitted.

To what degree can the spray rate be reduced at primary or secondary stripping without compromising the effectiveness of the treatment?

What is the optimal AHL admixture and which adjuvants are best used at what times?

How good are efficacy and tolerance if application takes place early, before primary tillage?

With the aim of clarifying these issues, trials were conducted at primary stripping, both before and after primary tillage; then at secondary stripping after secondary tillage.

Trials at primary stripping before primary tillage

At the testing farm in Siegertszell, two trials in the variants listed below were set up involving cultivars *Herkules* and *Perle*. Distribution took place by banded application using 1/3 of the specified per-hectare spray rate. 400 l of spray mixture was applied to the band, i.e. the per-hectare calculation of spray mixture was 1 200 litres. At the time of treatment (May 16, 2014), the crop was unevenly developed and had reached a plant height of only 1.5 to 2.5 metres.

VG 1: Untreated				
VG 2:	Vorox F (Flumioxazin)	180 g/ha	+ 30 % AHL	+ 0,05% Silwet Gold
VG 3:	Vorox F (Flumioxazin)	180 g/ha	+ 50 % AHL	+ 0,05% Silwet Gold
VG 4:	Vorox F (Flumioxazin)	270 g/ha	+ 30 % AHL	+ 0,05% Silwet Gold
VG 5:	Vorox F (Flumioxazin)	270 g/ha	+ 50 % AHL	+ 0,05% Silwet Gold
VG 6:	Vorox F (Flumioxazin)	360 g/ha	+ 30 % AHL	+ 0,05% Silwet Gold
VG 7:	Vorox F (Flumioxazin)	360 g/ha	+ 50 % AHL	+ 0,05% Silwet Gold
VG 8:	Vorox F (Flumioxazin)	630 g/ha	+ 50 % AHL	+ 0,05% Silwet Gold

Results

- Even the lowest spray rate, in combination with the lower AHL concentration, worked very well. The treated bine section was completely cleaned of leaves.
- Basal and lateral shoots exhibited a very sensitive reaction to even the lowest spray rates.
- When spray rates and AHL concentration were raised, the incidence of chemical burns on the bines rose accordingly. In severe cases, thickness growth of the bine was impeded and arrested development was observed, sometimes even leading to withering and dying off of the plant.

Trials at primary stripping after primary tillage

At the hop breeding yard at Stadelhofen and at the testing farm in Siegertszell, five trials were set up in cultivars *Herkules*, *Perle* and *Polaris*, in the variants described below. Distribution was by banded application, using 1/3 of the specified per-hectare spray rate. 400 litres of spray mixture was applied to the band, i.e. the per-hectare calculation of spray mixture was 1 200 l/ha. At the time of treatment (May 20, 2014), the crop was unevenly developed and had reached a plant height of 2 to 2.5 metres.

VG 1:	Untreated			
VG 2:	Vorox F (Flumioxazin)	90 g/ha	+ 30 % AHL	+ 0,05% Silwet Gold
VG 3:	Vorox F (Flumioxazin)	90 g/ha	+ 50 % AHL	+ 0,05% Silwet Gold
VG 4:	Vorox F (Flumioxazin)	180 g/ha	+ 30 % AHL	+ 0,05% Silwet Gold
VG 5:	Vorox F (Flumioxazin)	180 g/ha	+ 50 % AHL	+ 0,05% Silwet Gold
VG 6:	Vorox F (Flumioxazin)	270 g/ha	+ 30 % AHL	+ 0,05% Silwet Gold
VG 7:	Vorox F (Flumioxazin)	270 g/ha	+ 50 % AHL	+ 0,05% Silwet Gold
VG 8:	Vorox F (Flumioxazin)	630 g/ha	+ 50 % AHL	+ 0,05% Silwet Gold
VG 9:	Fox (Bifenox)	1,5 kg/ha	+ 30 % AHL	+ 0,05% Breakthru
VG 10:	B235 (Bromoxynil)	1,5 l/ha	+ 50 % AHL	+ 0,10% Wetcit
VG 11:	Nonan acid	6%	+ 30 % AHL	

Results

- Effectiveness of all *Vorox F* variants and *VG 9* on leaves and lateral shoots was total.
- Test blocks 10 and 11 showed good efficacy on leaves, and slightly declining, but still adequate, effectiveness on lateral shoots, for both types tested.
- The degree of burning on the bines was unacceptably high in test blocks 3 to 9. Only the lowest tested spray rate of 90 g/ha of *Vorox F*, with 30% AHL and 0.05% *Silwet Gold*, was still tolerated.
- Variants 10 and 11 exhibited only slight incidence of chemical burning; also the levels of effectiveness were acceptable.

Discussion of trials at primary stripping

Even at the lowest tested spray rate, flumioxazin in combination with 30% AHL and additive *Silwet Gold* is highly effective. AHL is necessary to control the effect, but the concentration in the spray mixture should not exceed 30%. In all variants with *Vorox F*, treatments both before and after tilling resulted in chemical burns on the bines. The weaker the bines at the time of treatment, the more pronounced the damage. Only a spray rate of 90 g/ha of *Vorox F* was better tolerated by the plants. It still remains to be seen whether a further reduction in spray rate and a different additive will be able to improve tolerance without excessively diminishing effectiveness. These issues will be investigated in the 2015 trials.

Deployment of *Vorox F* too early produces a high risk of damage to the bine. It should not be used before primary tillage or in crops which have not yet reached half the trellis height. The same applies to vulnerable, unevenly developed crops.

Trials at secondary stripping after secondary tillage

At the testing farm in Siegertszell, two trials were set up on July 4, 2014 in cultivars *Herkules* and *Perle*, in the variants described below. The crop had reached trellis height. Distribution took place by banded application, using 1/3 of the specified per-hectare spray rate. 400 l of spray mixture was applied to the band; thus the per-hectare calculation of spray mixture was 1 200 litres.

VG	1: Unbehandelt			
VG	2: Reglone (Deiquat)	5 l/ha		+ 0,05% Silwet Gold
VG	3: Vorox F (Flumioxazin)	180 g/ha		+ 0,05% Silwet Gold
VG	4: Vorox F (Flumioxazin)	180 g/ha	+ 10 % AHL	+ 0,05% Silwet Gold
VG	5: Vorox F (Flumioxazin)	180 g/ha	+ 20 % AHL	+ 0,05% Silwet Gold
VG	6: Vorox F (Flumioxazin)	180 g/ha	+ 10 % AHL	+ 0,10% Adhäsit
VG	7: Vorox F (Flumioxazin)	270 g/ha		+ 0,05% Silwet Gold
VG	8: Vorox F (Flumioxazin)	270 g/ha	+ 10 % AHL	+ 0,05% Silwet Gold
VG	9: Vorox F (Flumioxazin)	270 g/ha	+ 20 % AHL	+ 0,05% Silwet Gold
VG	10: Vorox F (Flumioxazin)	270 g/ha	+ 10 % AHL	+ 0,10% Adhäsit

Results

- The effect of the *Vorox F* variants in combination with AHL compared well against the reference agent, *Reglone*, and similar results were obtained on leaves and the lateral shoots.
- Increasing the admixture of AHL was accompanied by an increase in efficacy, which was less dependent on spray rate and the additive used.
- The incidence of burns on the bines was no greater than with *Reglone*. When a higher spray rate was applied to *Herkules*, a slightly increased tendency to display a superficial brown discoloration was observed, but this had no effect on the further development of the plant.
- The hills in the plots treated with *Vorox F* remained, post-harvest until the end of the growing season, largely free of weeds.

C) 2015 Trials

Testing in 2015 was aimed at compiling and evaluating an application recommendation for *Vorox F* at primary and secondary stripping, on the basis of the trials conducted in previous years by the LfL and the manufacturer. The product was approved for use in the 2015 season, but, due to the experiences of the previous year, was only recommended for use at secondary stripping.

Trials at primary stripping after primary tillage

At the testing farm at Siegertszell two trials in cultivars *Herkules* and *Perle* were set up, in the variants described below. Distribution was by banded application using 1/3 of the specified spray rate. 400 l of spray mixture was applied to the band, i.e. the per-hectare calculation of spray mixture was 1 200 litres. At the time of treatment (May 28, 2015), the crop had reached a height of 2.5 to 3.5 m.

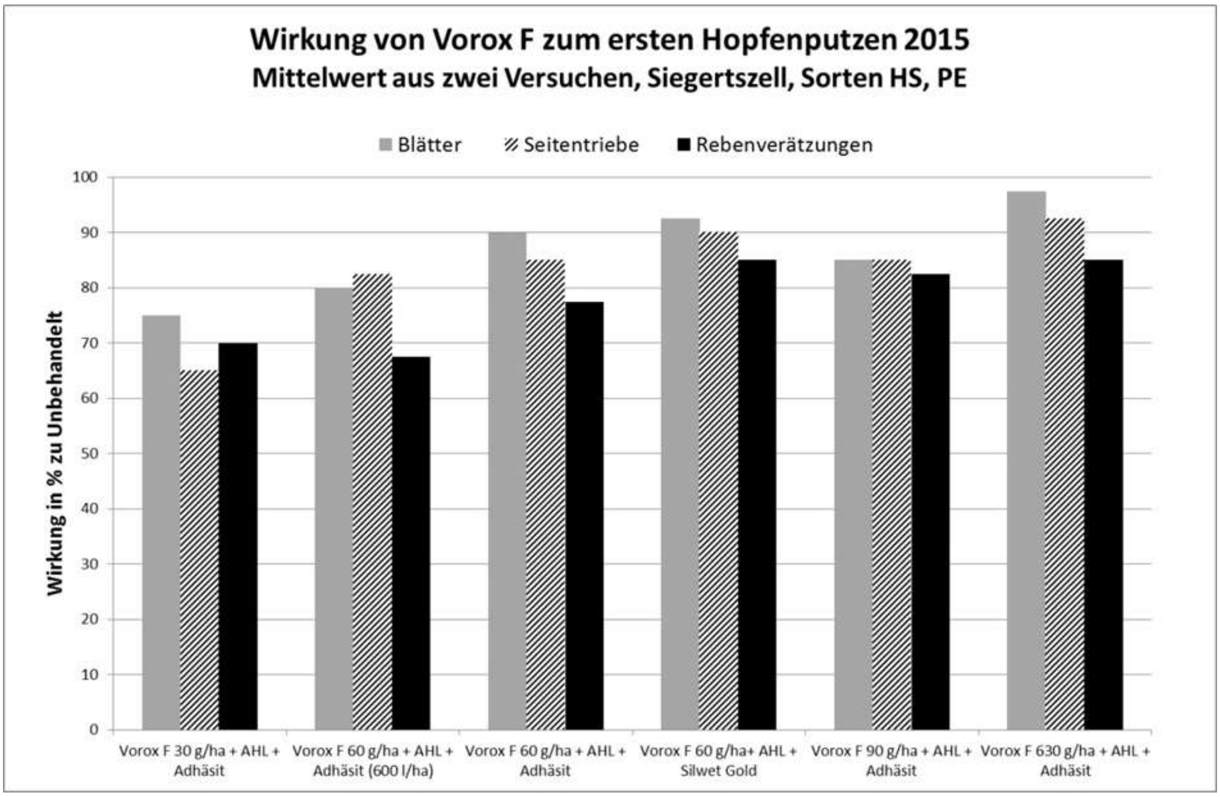


Fig. 1.4: Assessment results of trials at primary stripping in 2013

VG 1: Untreated			
VG 2: Vorox F (Flumioxazin)	30 g/ha	+ 30 % AHL	+ 0,10% Adhäsit
VG 3: Vorox F (Flumioxazin)	60 g/ha	+ 30 % AHL	+ 0,10% Adhäsit (600 l Brühe)
VG 4: Vorox F (Flumioxazin)	60 g/ha	+ 30 % AHL	+ 0,10% Adhäsit
VG 5: Vorox F (Flumioxazin)	60 g/ha	+ 30 % AHL	+ 0,03% Silwet Gold
VG 6: Vorox F (Flumioxazin)	90 g/ha	+ 30 % AHL	+ 0,10% Adhäsit
VG 7: Vorox F (Flumioxazin)	630 g/ha	+ 30 % AHL	+ 0,10% Adhäsit

Results

- As little as 60 g/ha of *Vorox F*, i.e. 20 g/ha of *Vorox F* on the hill being treated, have a satisfactory impact on hop leaves, basal shoots and lateral shoots at the time of primary stripping. The spray mixture will need to include 30% AHL if the desired effect is to be achieved.
- The use of 0.1% *Adhäsit* tends to be tolerated better than an admixture of 0.3% *Silwet Gold.*
- The degree of burning on the bines rises with an increased spray rate.

D) Application recommendation for *Vorox F* (active agent: flumioxazin) at primary and secondary stripping

Alongside the LfL, the manufacturer conducted comprehensive trials, in the period 2013 to 2015, to test for efficacy and crop tolerance at primary and secondary hop stripping. Based on the outcomes of these tests, the company has produced the following application recommendations:

Application recommendations for *Vorox F* at primary hop stripping

Preconditions for use:

- to be applied only after primary tillage
- crop must have reached a height of at least 3 m
- hop must be at least in the 3rd year of establishment
- crop is vigorous, evenly developed, and has no problems with hop wilt disease
- no hand-held equipment is used

Recommended spray rate for row treatment across 1/3 hectare from 3 m up to trellis height: 20 g/ha of *Vorox F* in 400 – 500 l spray mixture; 30% of this is AHL (120 -150 l) + 0.1% *Adhäsit*

Recommended spray rate for row treatment across 1/3 hectare from trellis height:
30 g/ha of *Vorox F* in 400 – 500 l spray mixture; 30% of this is AHL (120 – 150 l) + 0.1% *Adhäsit*

Application recommendation for *Vorox F* at secondary hop stripping

Preconditions for use:

- to be applied only after last tillage
- crop development is between BBCH 51 and BBCH 55
- hop must be at least in the 2nd year of establishment
- crop is vigorous, evenly developed, and has no problems with hop wilt disease
- primary stripping has already taken place, so that it is not necessary to shield the hill
- weeds on the hill have not yet accumulated, or are still at the cotyledon stage
- in order to ensure effectiveness on accumulating weeds, it is helpful to have a hill that had subsided somewhat, and a fine, crumbly soil structure

Recommended spray rate for row treatment across 1/3 hectare:

120 – 150 g/ha of *Vorox F* in 400 – 500 l spray mixture; 30% of this is AHL (120 -150 l) + 0.05 % *Silwet Gold*

2 Weather Conditions, Growth and Development in 2015 – impact on the technical aspects of production in the Hallertau

LD Wolfgang Sichelstiel, Dipl.-Ing. agr.

The agricultural year 2015 will be remembered as the second year of drought in the space of three years. And yet, the conditions for growth were favourable to hop until mid-year, and it was possible to complete the spring maintenance jobs at the usual times. In May and June, moderate temperatures and sufficient rainfall were conducive to plant growth. July saw the beginning of a period of mid-summer weather which, with only brief interruptions, continued throughout the whole of August. Apart from the lack of rain, more than 30 days at tropical maximum temperatures of over 30°C caused serious harm to hop crops. Flower and cone production was greatly reduced and the slowed development became acute during the flowering and cone-forming period. With the delayed harvest, the low-key expectations with respect to yield and alpha acids content were confirmed.

Specific weather anomalies and the consequences

- Warm winter with no ground frost

The winter of 2014/2015 was again very mild and moderately wet. In December, the average temperature at Hüll was about 3.0°C above the long-term monthly mean. The departure from the mean was even greater in January at 3.3.°C. Only February was cooler by 1.3°C against the long-term mean. At the same time, the level of precipitation in the three winter months, at 149.6 mm, corresponded to only 90% of the usual average. There was no period of dry ground frost, so that the soil was not broken up as a result. Conversely, the ground very soon dried out and the surface could be driven over from mid-March on, so that uncovering and cutting work could be done with no damaging impact on the soil.

- March and April stayed warm and dry

The warm and dry weather continued in March and April. With average temperatures of 5.1°C and 8.4°C respectively, both months were about 2.0°C and 1.1°C warmer than the long-term mean. Precipitation at 31.3 l/m² and 39.5 l/m² reached only 59.6% and 61.6%, respectively, of the long-term mean at Hüll. Compared to the previous year, which was even more advanced at this stage, the hop plants lagged about 10 days behind in their development. It was possible to complete the spring maintenance work under good conditions. Crowning commenced in mid-April and the plants were trained from the end of April. Control measures directed at the hop flea beetle and wireworm were necessary in some sub-plots, but incidence of primary infestation by downy mildew was rare.

- Precipitation in May ensured improved supply of water

In the month of May, the average temperature of 13.4°C and precipitation of 113.71 l/m², as measured at the Hüll weather station, conformed to the mean of the last ten years. However, against the long-term mean, May was 1.3°C too warm and brought 26% more precipitation. Training went on until May 12. Soil cultivation activities were carried out partially in conditions that were too wet. Primary tillage began in mid-May and was completed by the end of the month, allowing defoliation to begin. The existing hop stands showed average development and had grown to lengths of 3 to 4.5 metres by the end of the month. On May 29, a hailstorm passed through the northern part of the Hallertau, from Geisenfeld to Pfeffenhausen. There was a primary attack of downy mildew, predominantly in areas with heavy soils and in plants contaminated in previous years. Zoosporangia counts remained stable below the treatment threshold until the hailstorm. Isolated cases of powdery mildew were found, while damage from Rosy Rustic moth larvae or wireworms was only sporadic.

- Average growth conditions in June

The average rainfall of 112.9 l/m² at Hüll in June was 107% of the normal long-term mean. After a first heat wave around June 10, temperatures, too, remained chiefly within the moderately warm range, the average of 17.1°C being 1.8°C above the long-term mean. The hops developed normally, reaching trellis height at most locations by the end of the month. However, there was insufficient formation of lateral branches, especially at sites with heavy clay soils and on acreage with soil structure problems.The early maturing types of hop produced the first burrs and began to flower at the end of the month. In heavy soils, protracted secondary tillage went on until the end of July. The secondary attack of downy mildew found conditions favourable for infection from June onwards and, on June 1 and June 30, a spray alert went out to growers. Increasing powdery mildew pressure also called for a number of control measures. Aphid migration was negligible and the degree of infestation often did not warrant corrective action. Spider mite infestation varied from yard to yard, but, in many cases, steps had to be taken to combat it at the end of June.

- Transition to hot and arid weather conditions in July

July alone produced 14 very hot days, i.e. with maximum temperatures in excess of 30°C. The average of 21.1°C was 4.2°C higher than the long-term mean and 2.5°C above the mean of the last ten years. Added to that, the 27.6 mm of precipitation only amounted to just 30% of the normal level. However, on July 7/8, hailstones during a thunderstorm again caused localized damage. As a consequence of the change in the weather and sudden stress induced by the heat, many crops reduced lateral branch and bud production. The beginning of cone formation was also delayed because of the extreme weather conditions, although the counts of airborne spores of downy mildew steadily decreased after the first week in July. Even in susceptible varieties, treatment thresholds were no longer reached and it was not necessary to issue another spray alert, although treatments for powdery mildew continued. Low-level aphid migration came to an end. Due to the warm and dry conditions, renewed spider mite pressure built up in some places, requiring further treatment.

- High summer in August

The hot and arid conditions continued in August. The average temperature of 20.4°C was 4.4°C higher than the long-term mean; rainfall at 40.6 mm amounted to only 45% of the long-term mean. On 19 days in August, maximum temperatures in excess of 30°C were recorded, bringing the number of very hot days to a total of 34 since June. Tropical nights (minimum temperatures in excess of 20°C) and the absence of dew meant that water resources were depleted further. The decline in lateral branch and flower production grew worse, hampering development, with seriously affected stands struggling to form cones, and shedding their flowers or cones. Without irrigation, cone cluster density often dwindled and stands turned yellow. At the same time, downy mildew infection pressure lessened further and no more spray alerts were necessary. In a few isolated cases, treatment for powdery mildew was necessary. In several yards, spider mite infestation caused major problems and it was only with difficulty that it could be kept in check. The hop harvest began at the beginning of September and continued until the 40th calendar week. The poor yields had been anticipated. Throughout the Hallertau region, despite an increase in acreage, the crop yield amounted to only 70% of that of the previous year. Yield of alpha acids was also below the 2014 average, at 60% of the previous year's yield. Aroma profiles varied widely. Only the external quality of most hops was satisfactory.

Hüll weather data (monthly means and monthly totals) for 2015, compared with 10-year and 50-year means

Month		temperature at a height of 2 m mean (°C)	min.∅ (°C)	max.∅ (°C)	relative humidity (%)	Precipi-tation (mm)	days with precipit. >0.2 mm	sunshine (hrs)
January	2015	1.3	-1.5	4.1	90.7	87.8	18.0	35.1
∅	10-yr.	-0.4	-3.7	3.1	88.3	56.5	13.5	62.0
	50-yr.	-2.4	-5.1	1.0	85.7	51.7	13.7	44.5
February	2015	-1.8	-5.4	2.0	90.7	14.9	7.0	65.7
∅	10-yr.	-0.4	-4.6	4.4	85.8	44.0	12.7	83.6
	50-yr.	-1.2	-5.1	2.9	82.8	48.4	12.8	68.7
March	2015	5.1	0.1	10.6	75.9	31.3	12.0	139.4
∅	10-yr.	3.9	-1.3	9.9	80.3	57.1	12.7	149.2
	50-yr.	2.7	-2.3	8.2	78.8	43.5	11.3	134.4
April	2015	8.4	1.6	15.4	71.3	39.5	11.0	232.2
∅	10-yr.	9.6	3.3	16.3	73.8	60.8	10.9	199.9
	50-yr.	7.4	1.8	13.3	75.9	55.9	12.4	165.0
May	2015	13.4	8.3	18.6	78.6	113.7	17.0	161.1
∅	10-yr.	13.5	7.4	19.7	74.5	111.7	15.9	212.5
	50-yr.	11.9	5.7	17.8	75.1	86.1	14.0	207.4
June	2015	17.1	11.3	23.3	76.9	112.9	12.0	208.2
∅	10-yr.	18.6	1.2	23.9	81.0	124.1	14.5	210.8
	50-yr.	15.3	8.9	21.2	75.6	106.1	14.2	220.0
July	2015	21.1	12.8	28.8	67.7	27.6	9.0	280.7
∅	10-yr.	18.6	12.2	25.5	75.7	115.5	14.3	245.6
	50-yr.	16.9	10.6	23.1	76.3	108.4	13.9	240.3
August	2015	20.4	12.2	29.5	72.3	43.4	7.0	278.5
∅	10-yr.	17.0	11.2	23.9	81.0	124.1	14.5	210.8
	50-yr.	16.0	10.2	22.5	79.4	94.9	13.3	218.4
September	2015	13.3	7.2	21.3	79.1	40.6	11.0	139.8
∅	10-yr.	13.6	8.2	20.1	85.0	62.3	11.0	164.4
	50-yr.	12.8	7.4	19.4	81.5	65.9	11.4	174.5
October	2015	8.0	3.6	12.9	89.5	55.2	10.0	86.0
∅	10-yr.	8.9	4.3	14.7	88.5	50.0	9.7	119.5
	50-yr.	7.5	2.8	13.0	84.8	60.0	10.4	112.9
November	2015	6.4	1.6	11.7	86.1	75.1	13.0	89.1
∅	10-yr.	4.0	0.7	7.9	92.2	53.9	11.0	62.1
	50-yr.	3.2	-0.2	6.4	87.5	58.8	12.6	42.8
December	2015	3.5	-0.2	8.4	94.0	21.5	8.0	55.6
∅	10-yr.	0.5	-2.5	3.7	91.4	65.2	15.8	50.4
	50-yr.	-0.9	-4.4	1.6	88.1	49.1	13.3	34.3
∅ 2015		9.7	4.3	15.6	81.0	663.5	135.0	1771.4
10 – year mean		8.8	3.8	14.4	82.7	909.3	156.1	1785.0
50 – year mean		7.4	2.5	12.5	81.0	828.8	153.3	1663.2

The 50-year mean is based on the data from 1927 through 1976,
the 10-year mean is based on the data from 2005 to 2014.

3 Statistical Data on Hop Production

LD Johann Portner, 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
1975	7 654	2.64	2010	1 435	12.81
1980	5 716	3.14	2011	1 377	13.24
1985	5 044	3.89	2012	1 295	13.23
1990	4 183	5.35	2013	1 231	13.69
1995	3 122	7.01	2014	1 192	14.52
2000	2 197	8.47	2015	1 171	15.24
2005	1 611	10.66			

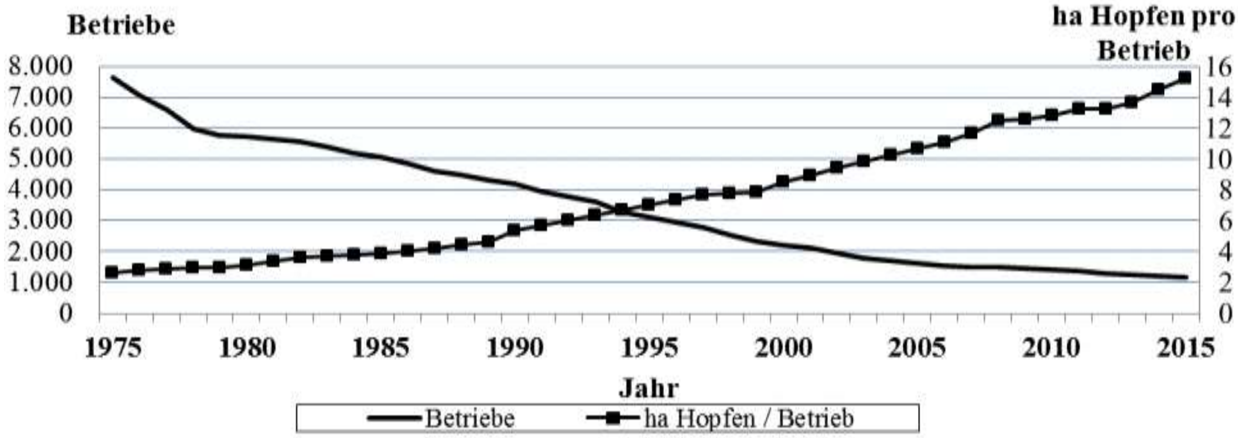


Fig. 3.1: Number of hop farms and their hop acreages in Germany

Tab. 3.2: Acreage, number 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	
	2014	2015	increase + decrease - 2015 / 2014		2014	2015	increase + decrease - 2015/ 2014		2014	2015
			ha	%			Farms	%		
Hallertau	14 467	14 910	444	3.1	966	947	- 19	- 2.0	14.98	15.74
Spalt	348	355	7	2.0	55	54	- 1	- 1.8	6.33	6.57
Tettnang	1 209	1 237	28	2.3	140	139	- 1	- 0.7	8.64	8.90
Baden, Bitbg Rhineland-Palatinate	20	20	± 0	± 0	2	2	± 0	± 0	10.00	10.00
Elbe-Saale	1 265	1 325	60	4.7	29	29	± 0	± 0	43.62	45.69
Germany	**17 308**	**17 847**	**539**	**3.1**	**1 192**	**1 171**	**- 21**	**- 1.8**	**14.52**	**15.24**

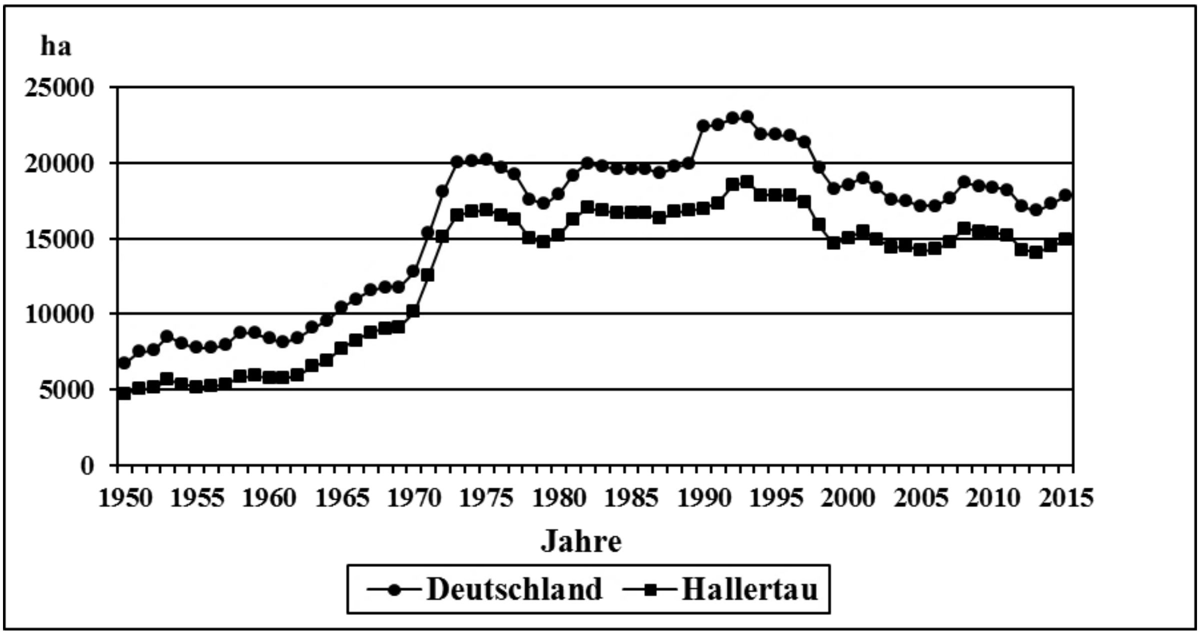


Fig. 3.2: Hop growing acreages in Germany and the Hallertau region

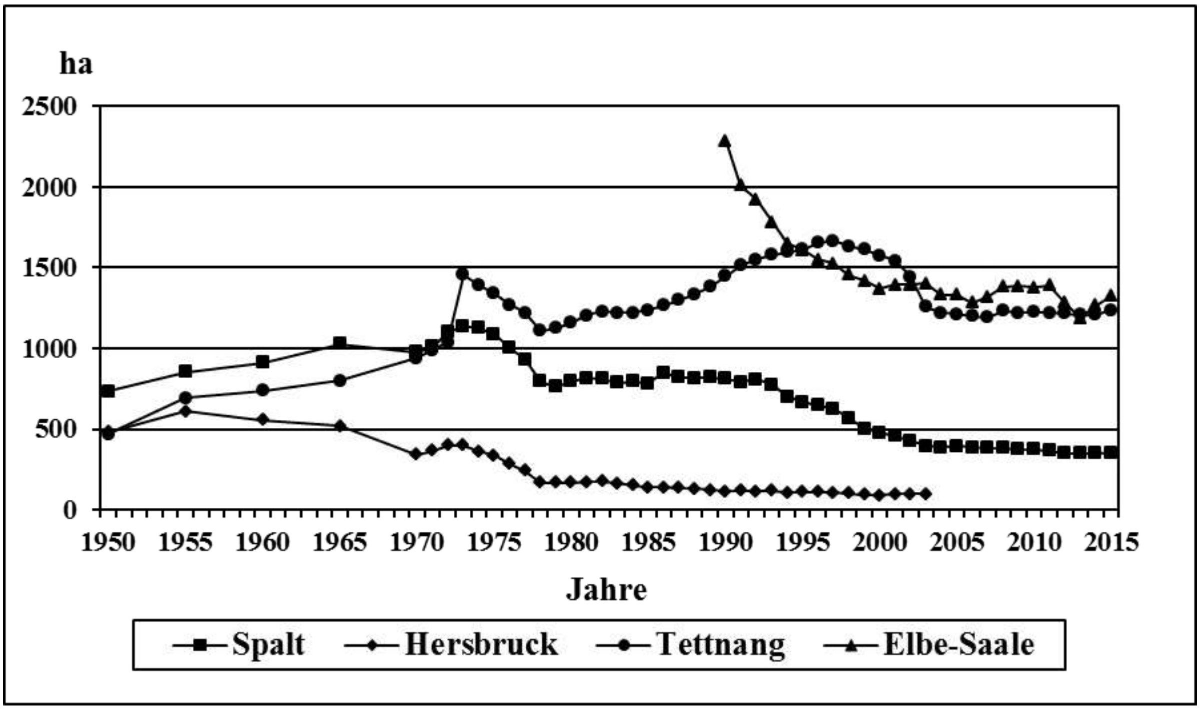


Fig. 3.3: Hop growing acreages in the Spalt, Hersbruck, Tettnang and Elbe-Saale regions

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

Hop varieties

The acreage devoted to growing hop in Germany again increased substantially by 539 hectares in 2015 and now stands at 17 847 hectares.

Amongst the aroma varieties, only those areas which were used for growing the old landrace hops, *Hallertauer Mittelfrüher* and *Tettnanger*, saw reductions in acreage. The biggest gains in acreage in this group were for *Hallertauer Tradition* (89 ha), *Opal* (67 ha), and *Saazer* (55 ha).

The bittering and high alpha varieties, *Hallertauer Magnum* (-289 ha) and *Hallertauer Taurus* (-129 ha), are increasingly being replaced by *Herkules*, which saw a 540 hectare increase in 2015. It is thus evident that *Herkules* is now the most extensively grown variety, accounting for 23.5% – almost a quarter – of the German hop growing acreage.

The trend towards growing more of the types known as flavor hops continues, and the acreage devoted to them doubled in size in 2015 to 467 hectares, now claiming a 2.6% share of the total acreage and expected to expand further in the coming years.

For a detailed overview of variety distribution by region see *Tab. 3.3 to Tab. 3.5*

Aroma varieties

Tab. 3.3: Hop varieties by hectare in the German hop growing regions in 2015

Hop growing region	**Total hop acreage**	**HA**	**SP**	**TE**	**HE**	**PE**	**SE**	**HT**	**SR**	**OL**	**SD**	**SA**	**other**	**Aroma varieties**	
														ha	**%**
Hallertau	14,910	557			950	2.868	443	2,790	387	127	33	6	2	8,162	54.7
Spalt	355	33	113		4	26	79	33	15	1	1		1	307	86.6
Tettnang	1,237	155		744		66	7	58	21	1	13			1,065	86.1
Baden, Bitbg, Rheinpfalz	20	1				8	0	4						14	71.1
Elbe-Saale	1,325					219	5	28				68		320	24.1

Variety changes in Germany

Germany	**17,847**	**746**	**113**	**744**	**954**	**3,187**	**533**	**2,914**	**423**	**130**	**47**	**74**	**3**	**9,869**	**55.3**
Variety share (in **%**)		4.2	0.6	4.2	5.3	17.9	3.0	16.3	2.4	0.7	0.3	0.4	0.0		
2014 (in ha)	17,308	838	112	762	924	3,154	523	2,825	381	63	39	19	2	**9,644**	**55.7**
2015 (in ha)	17,847	746	113	744	954	3,187	533	2,914	423	130	47	74	3	**9,869**	**55.3**
Change (in ha)	539	-93	0	-18	30	32	10	89	42	67	8	55	1	**225**	**-0.4**

Tab. 3.4: Hop varieties by hectare in the German hop growing regions in 2015

Bittering and high alpha varieties

Hop growing region	**NB**	**BG**	**NU**	**TA**	**HM**	**TU**	**MR**	**HS**	**PA**	**other**	**Bittering varieties**	
											ha	**%**
Hallertau	150	17	137	1	1,671	440	22	3,836	44	32	6,351	42.6
Spalt					2		3	32		0	37	10.5
Tettnang						3		133	4	5	144	11.7
Baden, Bitbg., Rhineland-Palatinate				0	3			3	0		6	28.4
Elbe-Saale	88		25		677	21		150	12	1	973	73.4
Germany	**238**	**17**	**162**	**1**	**2,353**	**465**	**26**	**4,152**	**60**	**37**	**7,511**	**42.1**

Variety changes in Germany

Variety share (in **%)**	1.3	0.1	0.9	0.0	13.2	2.6	0.1	23.3	0.3	0.2		
2014 (in ha)	267	17	173	1	2,642	594	31	3,622	53	28	**7,428**	**42.9**
2015 (in ha)	238	17	162	1	2,353	465	26	4,152	60	37	**7,511**	**42.1**
Change(in ha)	-29	0	-11	0	-289	-129	-6	530	7	9	**83**	**-0.8**

Tab. 3.5: Hop varieties by hectare in the German hop growing regions in 2015

Flavor varieties

hop growing region	**CA**	**HC**	**HN**	**MB**	**MN**	**CO**	**flavor varieties**	
							ha	**%**
Hallertau	30	97	90	171	5	5	397	2.7
Spalt	4	2		3			10	2.9
Tettnang	6	6	5	10			27	2.2
Baden, Bitbg., Rhineland-Palatinate.	0	0	0	0			0	0.5
Elbe-Saale		4	6	22			32	2.4
Germany	**41**	**109**	**101**	**207**	**5**	**5**	**467**	**2.6**
Variety share (in **%)**	0.2	0.6	0.6	1.2	0.0	0.0		

Variety changes in Germany

2014 (in ha)	30	48	56	99	0	3	**236**	**1.4**
2015 (in ha)	41	109	101	207	5	5	**467**	**2.6**
Change(in ha)	10	61	46	108	5	1	**231**	**1.2**

3.2 2015 Yields

The 2015 hop harvest produced 28 336 520 kg (= 566 730 cwt), a volume which, due to the hot and dry summer, fell far short – by 10 163 250 kg (= 203 265 cwt) – of the harvest in the record year 2014 (38 499 770 kg or 769 995 cwt). This amounts to a yield loss of 26.4 %, in spite of the increase in acreage.

With a yield per hectare of 1 588 kg, a calculation based on the acreage in total, the quantity harvested was well below average. In fact, the 2015 harvest delivered one of the worst yield results of the last decades.

As a consequence, alpha acids levels were correspondingly low. When multiplied by the low yield, the quantity delivered by many varieties did not even amount to half the alpha acids levels of the 2014 crop. In fact, the quantity of alpha acids produced in Germany totalled just over 2 500 tonnes, a figure which fell 1 600 tonnes short of the previous year's result.

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

	2010	2011	2012	2013	2014	2015
Yield kg/ha and (cwt/ha)	1862 kg (37.2 cwt) (hail damage)	2091 kg (41.8 cwt) (hail damage)	2013 kg (40.3 cwt)	1635 kg (32.7 cwt) (hail damage)	2224 kg (44.5cwt)	1588 kg (31.8 cwt)
Acreage in ha	18 386	18 228	17 124	16 849	17 308	17 847
Total yield in kg and cwt	34 233 810 kg = 684 676 cwt	38 110 620 kg = 762 212 cwt	34 475 210 kg = 689 504 cwt	27 554 140 kg = 551 083 cwt	38 499 770 kg = 769 995 cwt	28 336 520 kg = 566 730 cwt

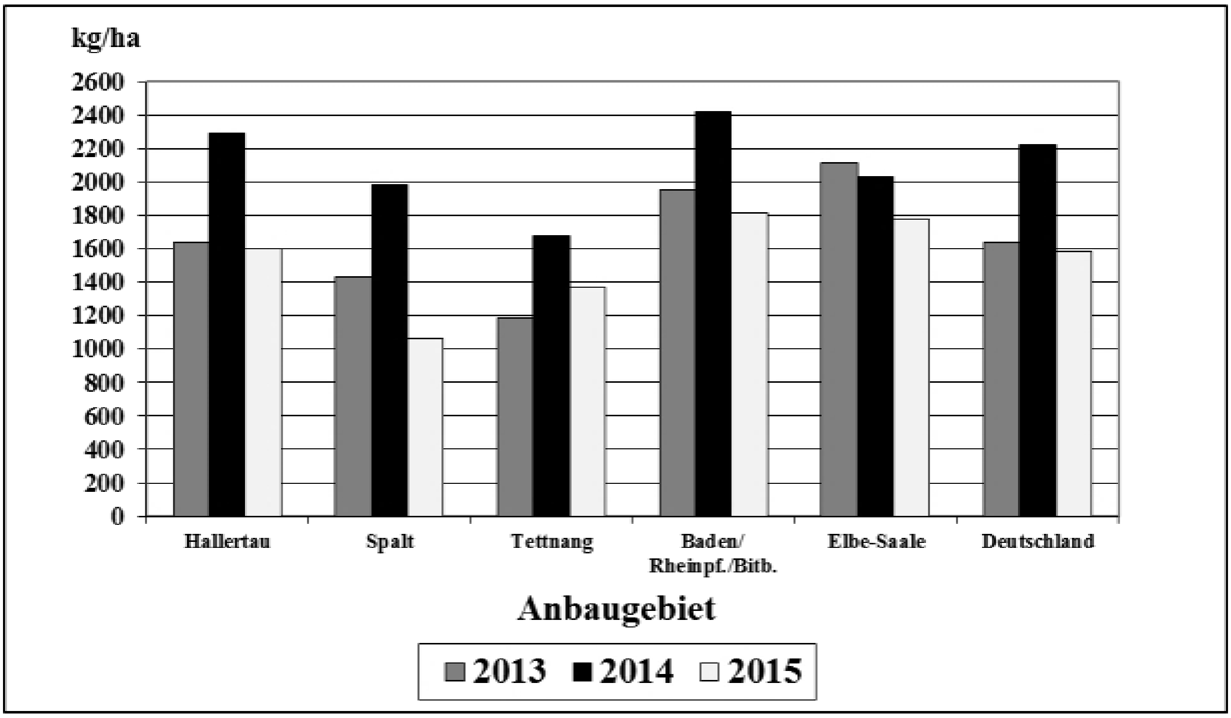


Fig. 3.4: Average yields by hop growing region in kg/ha

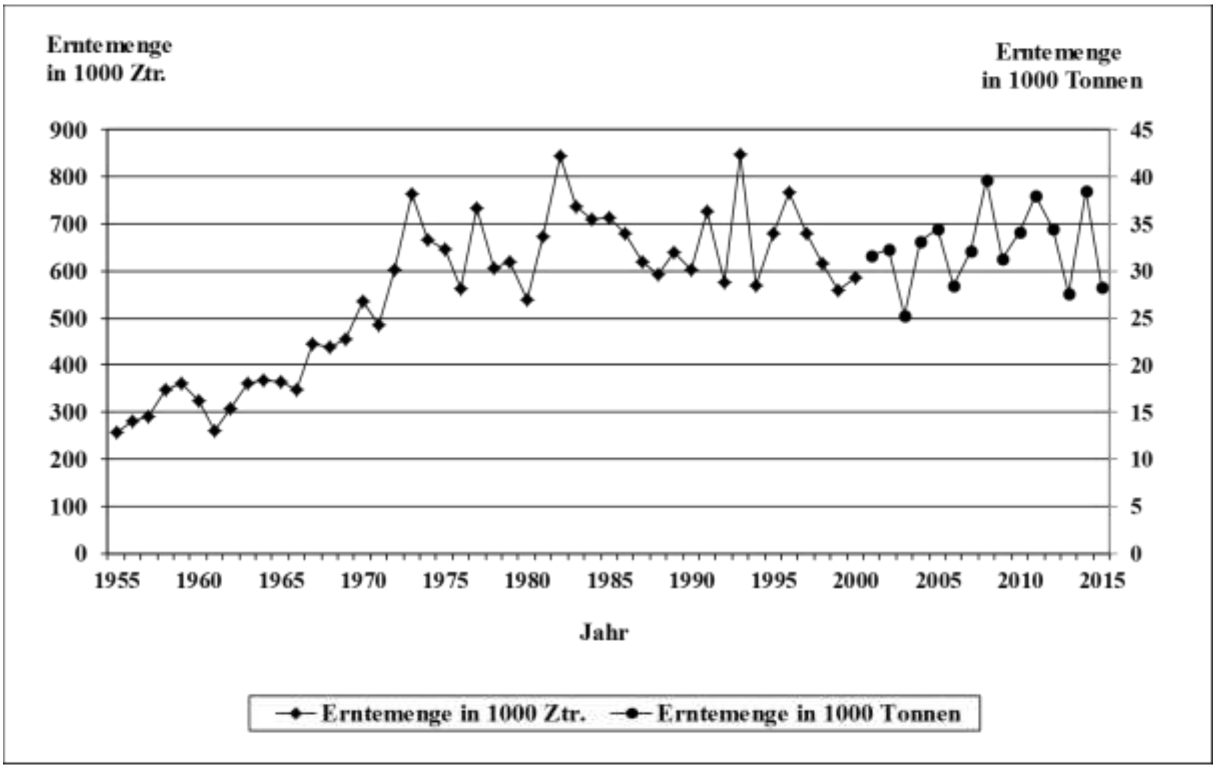


Fig. 3.5: Crop volumes in Germany

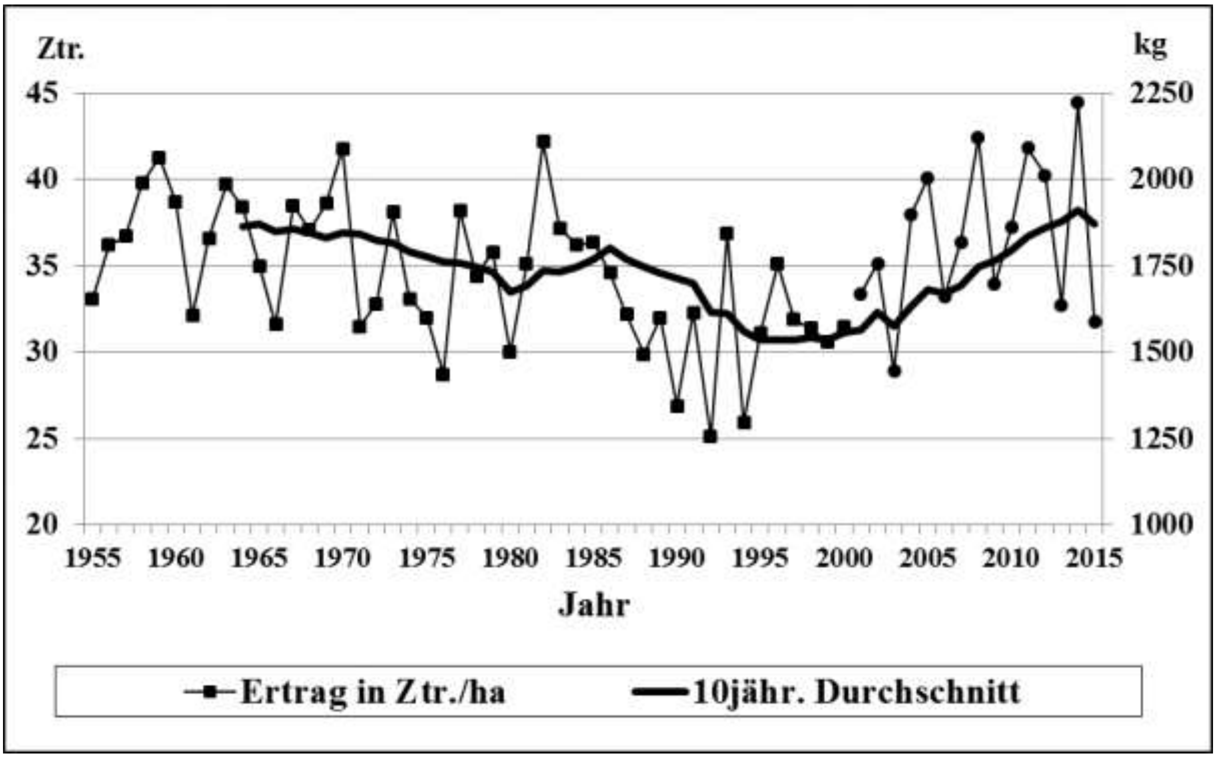


Fig. 3.6: Average yields (cwt and kg/ha) in Germany

Tab. 3.7: Yields per hectare by German hop growing region

Region	Yields in kg/ha total acreage								
	2007	2008	2009	2010	2011	2012	2013	2014	2015
Hallertau	1 844	2 190	1 706	1 893	2 151	2 090	1 638	2293	1601
Spalt	1 532	1 680	1 691	1 625	1 759	1 383	1 428	1980	1062
Tettnang	1 353	1 489	1 320	1 315	1 460	1 323	1 184	1673	1370
Bad. Rheinpf./ Bitburg	2 029	1 988	1 937	1 839	2 202	2 353	1 953	2421	1815
Elbe-Saale	2 043	2 046	1 920	1 931	2 071	1 983	2 116	2030	1777
∅ yield per ha **Germany**	**1 819 kg**	**2 122 kg**	**1 697 kg**	**1 862 kg**	**2 091 kg**	**2 013 kg**	**1 635 kg**	**2224 kg**	**1588 kg**
Total crop Germany (t and cwt)	32 139 t 642 777	39 676 t 793 529	31 344 t 626 873	34 234 t 684 676	38 111 t 762 212	34 475 t 698 504	27 554 t 551 083	38 500 t 769 995	28 337 t 566 730
Acreage Germany (ha)	17 671	18 695	18 473	18 386	18 228	17 124	16 849	17 308	17 847

Tab. 3.8: Alpha acids values for the various hop varieties

Region/variety	2006	2007	2008	2009	2010	2011	2012	2013	2014	**2015**	∅ 5 years	∅ 10 years
Hallertau Hallertauer	2.4	3.9	4.4	4.2	3.8	5.0	4.6	3.3	4.0	**2.7**	**3.9**	**3.8**
Hallertau Hersbrucker	2.2	2.6	2.9	3.4	3.5	4.5	3.0	1.9	2.1	**2.3**	**2.8**	**2.8**
Hallertau Hall. Saphir	3.2	4.6	5.1	4.5	4.5	5.3	4.4	2.6	3.9	**2.5**	**3.7**	**4.1**
Hallertau Perle	6.2	7.9	8.5	9.2	7.5	9.6	8.1	5.4	8.0	**4.5**	**7.2**	**7.5**
Hallertau Spalter Select	4.3	4.7	5.4	5.7	5.7	6.4	5.1	3.3	4.7	**3.2**	**4.5**	**4.9**
Hallertau Hall. Tradition	4.8	6.0	7.5	6.8	6.5	7.1	6.7	5.0	5.8	**4.7**	**6.0**	**6.1**
Hallertau North. Brewer	6.4	9.1	10.5	10.4	9.7	10.9	9.9	6.6	9.7	**5.4**	**8.7**	**8.9**
Hallertau Hall. Magnum	12.8	12.6	15.7	14.6	13.3	14.9	14.3	12.6	13.0	**12.6**	**13.5**	**13.6**
Hallertau Nugget	10.2	10.7	12.0	12.8	11.5	13.0	12.2	9.3	9.9	**9.2**	**10.7**	**11.1**
Hallertau Hall. Taurus	15.1	16.1	17.9	17.1	16.3	17.4	17.0	15.9	17.4	**12.9**	**16.1**	**16.3**
Hallertau Herkules		16.1	17.3	17.3	16.1	17.2	17.1	16.5	17.5	**15.1**	**16.7**	
Tettnang Tettnanger	2.2	4.0	4.2	4.2	4.0	5.1	4.3	2.6	4.1	**2.1**	**3.6**	**3.7**
Tettnang Hallertauer	2.6	4.3	4.7	4.5	4.2	5.1	4.7	3.3	4.6	**2.9**	**4.1**	**4.1**
Spalt Spalter	2.8	4.6	4.1	4.4	3.7	4.8	4.1	2.8	3.4	**2.2**	**3.5**	**3.7**
Elbe-S. Hall. Magnum	12.4	13.3	12.2	13.7	13.1	13.7	14.1	12.6	11.6	**10.4**	**12.5**	**12.7**

Source: WG for Hop Analysis (AHA)

4 Hop Breeding Research

RDin Dr. Elisabeth Seigner, Dipl.-Biol.

The breeding work carried out at the Hop Research Center at Hüll pursues three specific objectives:

- to develop noble aroma cultivars with the fine hoppy aroma profiles
- to create robust, top performing high alpha varieties
- to breed special aroma types (Special Flavor hops) with unique fruity/floral aroma profiles.

For the new breeds created at Hüll, not only are cone compounds and the consequent brewing quality crucial, at the same time, raised resistance to the most significant diseases and pests and the properties essential to enhanced agronomic performance are also of prime importance as selection criteria.

Conventional breeding techniques are supported by genome analysis and biotechnology methods, with, among the latter, meristem culture, in particular, playing a principal role in developing new varieties. This means that healthy virus-free plant material can be produced and made available for the Hüll growing trials and propagation. Molecular techniques are also used to analyse the genetic material of hop and to identify the pathogens affecting it.

4.1 Conventional breeding

4.1.1 Crosses in 2015

In pursuit of the three objectives set out above, a total of 72 crosses were carried out in 2015.

4.1.2 Two new Special Flavor hops from Hüll – unique aroma compositions for new taste sensations in beer

Objective

The Hüll breeding programme for Special Flavor hops was set up as a response to the global trend, kicked off by US craft brewers, towards more diversity in beer, which has created a greater demand for hops. Increased hopping rates combined with unique hop aromas make it possible to create beers with body and character, which are selling exceptionally well, in spite of the higher price.

With the aim of opening up this new market as quickly as possible to German hop growers, the first Hüll Special Flavor hops, *Mandarina Bavaria*, *Huell Melon*, and *Hallertauer Blau*, were selected in the record time of just 4 – 6 years, and the Gesellschaft für Hopfenforschung (*Society of Hop Research*) registered them for national listing as plant varieties in 2012. An acreage of over 400 hectares is now devoted to growing these hops in Germany – evidence that the Hüll Special Flavor hops have managed to penetrate the lucrative market for specialty types, although this sector had originally been dominated almost exclusively by US growers with their flavor varieties. The US craft brewer scene continues to drive growth in the brewing and hop growing industries in the US. The number of breweries is rising steadily and has now reached over 4 000 (end of 2015). The newly acquired enthusiasm for beer has changed US hop production dramatically. The acreage devoted to hop growing has increased in the last few years and now stands at over 17 800 hectares, with flavor varieties accounting for a proportion of nearly 60%, and outpacing the high alpha varieties, which have been steadily reduced to a share of currently under 30%. There has also been a marked expansion in the range of varieties. In the US alone, the number of different varieties now grown has risen from 54 to 70 during the last 5 years. In a similar development in Germany, change has come about now that brewers have rediscovered hop as a raw material of value essential to brewing. Three cultivars with unique fruity/floral aroma signatures and one cultivar from the high alpha range with special aroma nuances, all bred at the Hop Research Center at Hüll, were released for cultivation in 2012. Now, two more special aroma hops which derived from the crosses produced by breeder Anton Lutz are due for registration. These two cultivars make an important contribution towards the expansion of the variety portfolio available to German hop growers. The number of varieties grown in Germany rose between 2010 and 2015 from 23 to 35.

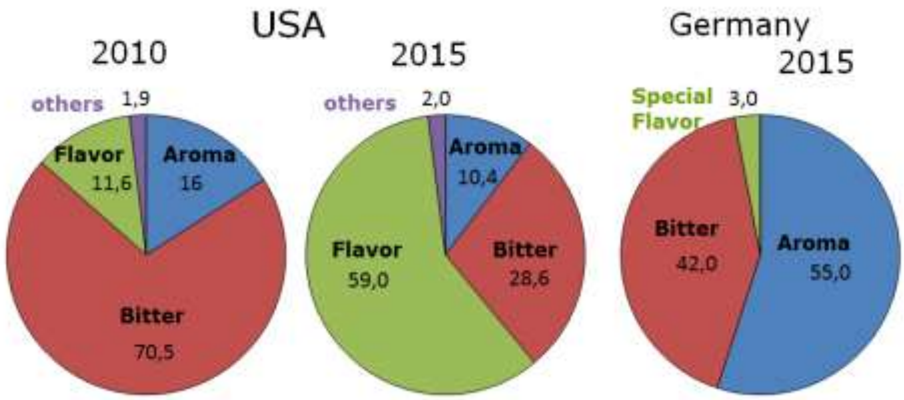


Fig. 4.1: Changes in acreage devoted to growing aroma, bittering and flavor hops in the USA, between 2010 and 2015, and the situation in Germany in 2015. Details given in % of the total acreage under hop; additional information on total hop growing acreage, main hop growing states (WA = Washington, OR = Oregon, ID = Idaho), and number of varieties grown (acc. to I.H.G.C. list of varieties).

Material and procedure

The first crosses on the way to achieving the goal of breeding Special Flavor hops were based on US cultivar *Cascade*, which introduced fruity elements into the Hüll breeding stock. As breeding work proceeded, preference was increasingly given to Hüll breeding stock which, thanks to crosses with *Cascade* and other US breeding material, featured fruity and exotic aroma profiles and which also contributed the potential for broader resistance to disease and the best agronomic performance traits in the subsequent progeny. This work was also directed at adapting the resultant hops better to suit the climatic conditions, soil properties and, in particular, disease factors, prevailing in Germany and to give them a clear advantage over US flavor hops in cultivation.

Healthy and top performing Hüll breeding lines and cultivars with interesting aroma combinations were used for the special crosses. Seedlings from these crosses were subjected – as always – to careful resistance screening in the greenhouse and laboratory. Only powdery mildew-resistant and downy mildew-tolerant hops were selected in the vegetation hall to go on to the next stage, where the most promising of these were trialled over 3 years as single plants in field testing at the Stadelhof breeding yard.

Since only healthy plant material with *Verticillium*-free and virus-free status is accepted for the subsequent growing trials at the Stadelhof breeding yard and for the various trials which take place under practice conditions, all the eligible seedlings and lines were tested accordingly. Testing for *Verticillium* was done using a highly sensitive molecular technique (Maurer et al., 2013). In addition, it was also possible to eliminate plants with dangerous virus and viroid infections by means of ELISA and RT-PCR tests (see Seigner et al., 2014).

There followed a stricter assessment of selected seedlings in the field trial with advanced selections, with 2 replicates of 6 plants each in two locations. Breeding lines with the required resistance reactions, agronomic performance traits and aroma profile were grown in rows (60 – 200 plants from each breeding line) on the commercially managed land of selected trial participants.

Harvest samples of preselected, highly promising breeding lines from the trials run by the LfL and the row plantings under practice conditions were finally submitted in January 2014 to the newly appointed hop expert group at the GfH (see Annual Report, Special Crop Hop 2014, p. 41), for aroma evaluation and overall assessment. With their unique aroma profiles, breeding lines 2010/08/33 (= cv. Callista) and 2010/72/20 (= cv. Ariana) made a favourable overall impression on the representatives of the various business groupings and eventually the management board of the GfH. The two breeding lines were then released by the GfH for the large-scale growing trial, which subsequently began in the spring/summer of 2014, on a per-hectare basis, on the land of the participating farmers.

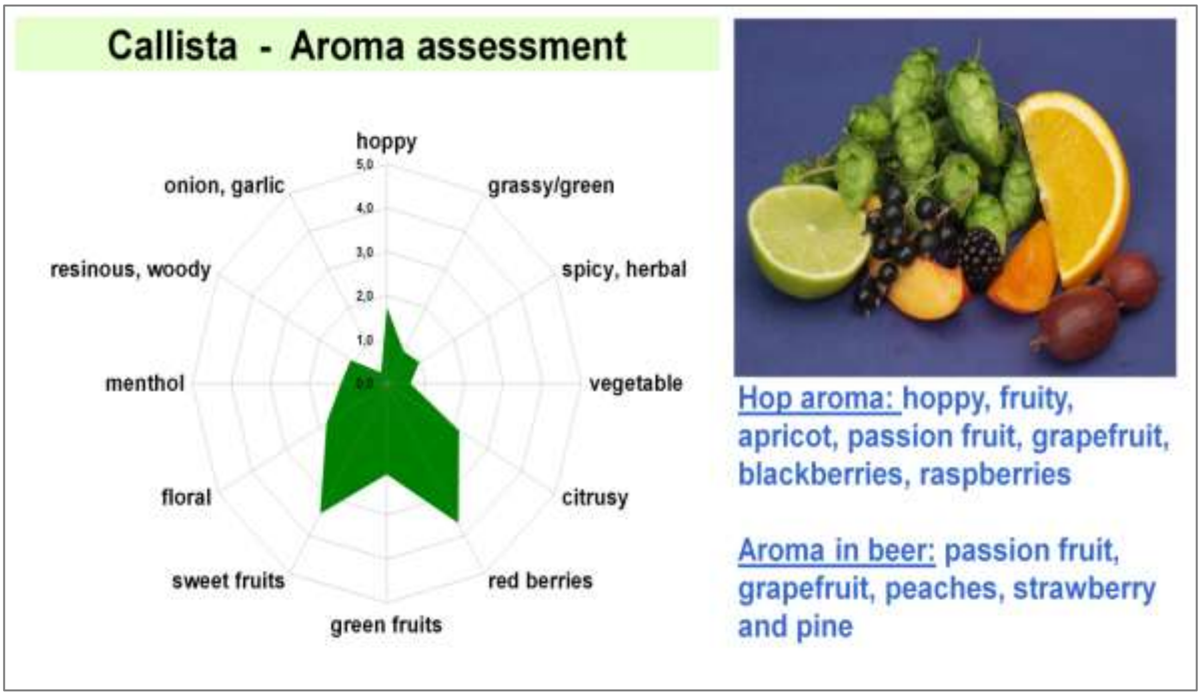
Results for the two new Special Flavor hops from the large-scale growing trial

The breeding lines 2010/08/33 and 2010/72/20 were trialled under commercial conditions on sites of 6.3 and 5.3 hectares respectively. The growers involved were required to report back on the trial, so that the LfL is now in possession of a wealth of information on the two lines. This information forms the current knowledge base with regard to growth vigour, homogeneity, twining ability, cone properties and aroma.

Tab. 4.1: Agronomic traits, reaction to fungi and pests, and aroma of breeding line 2010/08/33 (= cv. Callista), based on findings to date from tests conducted by the LfL and from trials (row and large-scale growing trials) conducted under typical practice conditions

Pedigree and Agronomic Features (current results)	
Pedigree	Hallertauer Tradition x Hüll male breeding line
Advantages	vigorous homogenous growth, good twining ability, nice large cones
Disadvantages	slightly club-shaped, sl.hermaphrodite, no sites with Vert.wilt
Maturity	medium - late (before Hersbrucker Spät)
Harvest	good pickability and very good drying
Yield Potential	high (comparable to Hallertauer Tradition and Perle)

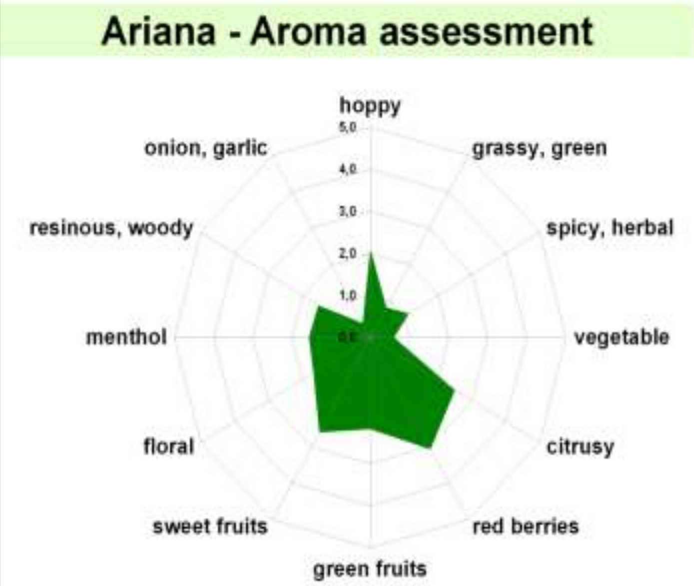
Resistance towards	
Verticillium wilt	so far good
Downy Mildew primary infection	high
Downy Mildew sec. infection	high
Powdery Mildew	resistant
Botrytis	poor - medium
Red Spider Mite	medium
Hop Aphid	medium



Tab. 4.2: Agronomic traits, reaction to fungi and pests, and aroma of breeding line 2010/72/20 (= cv. Ariana), based on findings to date from tests conducted by the LfL and from trials (row and large-scale growing trials) conducted under typical practice conditions

Pedigree and Agronomic Features (current results)	
Pedigree	Herkules x male wild hop
Advantages	vigorous homogenous growth, robust, cylindrical bine, good stature, good formation of side arms, very nice cones
Disadvantages	large leaves
Maturity	late (comparable to Herkules)
Harvest	good pickability and good drying
Yield Potential	high - very high

Resistance towards	
Verticillium wilt	so far very good
Downy Mildew primary infection	medium - good
Downy Mildew sec. infection	good – very good
Powdery Mildew	fully resistant
Botrytis	medium - good
Red Spider Mite	good – very good
Hop Aphid	medium



Hop aroma: black currant, peach, pear, citrus, tropical fruits, slightly resinous

Aroma in beer: grapefruit, cassis, geranium, gooseberry, citrus and vanilla

From the standpoint of agronomics, both lines showed positive trial results for vigorous growth, twining ability, picking and drying and, last but not least, a high to very high yield.

The reactions of both new lines to diseases and pests provided very good insight into their resistance to pathogens at different locations (Tab. 4.1 *and* Tab. 4.2), highlighting the success of years of comprehensive and intensive efforts in breeding for resistance to powdery mildew.

As with all Hüll Special Flavor hops, *very good* to *total* resistance to all currently identified powdery mildew strains has been realized in the two new cultivars. In addition, the new lines have so far displayed raised tolerance in field selection to hop wilt fungus in plots infected with *Verticillium*. *Good* to *very good* tolerance to downy mildew further substantiates the claim that the Special Flavor hops from Hüll are better suited than are foreign cultivars to coping with the pathogens prevalent in the German hop growing areas.

Representatives of the GfH hop expert group, headed by breeder Anton Lutz, were also involved in the aroma assessments. They discerned new and positive aroma combinations in both lines: underlying hoppy aroma with notes of passion fruit/ apricot, grapefruit and forest berries, and blackcurrant and lemon.

However, the real test is how these aromas will develop in different beers and, ultimately, how they are rated by the beer taster.

Results of expanded brewing trials

Thanks to the large-scale growing trial, hop from the two new breeding lines was available for the first time in sufficient quantities for brewing trials on a larger scale. As usual, individual brewing experiments were carried out by brewers from all over the world who had shown an interest in these lines. More advanced brewing experiments, carried out for the first time according to a standardized procedure devised by the GfH expert group, delivered more particulars with regard to their brewing quality. Even the beer tasting procedure also adhered to the evaluation criteria defined by the experts. This standardization ensured complete transparency in all the findings with respect to aroma characteristics and bittering quality in the beer of the tested breeding lines, thus benefiting not only hop traders and the LfL but also, most importantly, the brewing industry.

Depending on the type of beer (top-fermented or bottom-fermented), the timing and the hopping rate used (beginning of the boil, whirlpool, dry hopping alone, or additionally in a combination of whirlpool hopping rate and dry hopping), unique aroma profils were achieved with both breeding lines. A report submitted by Hanke et al. (2015a and b) outlines the experimental design for these brewing trials, describes the top-fermented and bottom-fermented beers, and sets out the implications for both breeding lines from the standpoint of brewing quality and suitability.

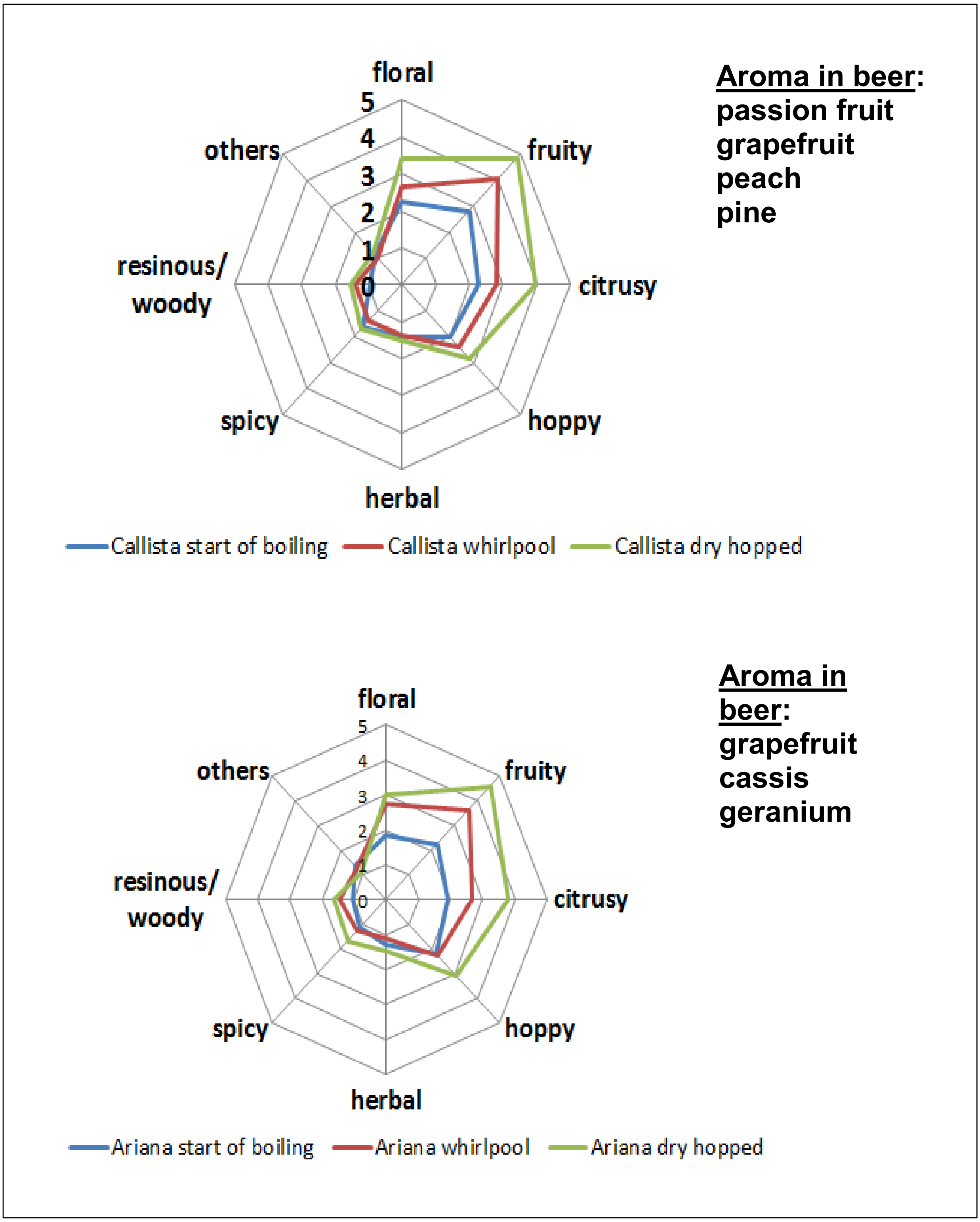


Fig. 4.2: Flavour impressions of the beers from the systematic brewing trials (averages independent of beer type) with breeding line 2010/08/33 (top= cv. Callista) and breeding line 2010/72/20 (below = cv. Ariana).

Whereas the descriptions of the hop aromas differentiate between sweet, green and red fruit, in characterizing the flavour of the beer, all the fruit-like flavour impressions are summed up in one term.

Summary

For the first time, the two breeding lines 2010/08/33 (Callista) and 2010/72/20 (Ariana) have benefited from all the changes that were made in the context of developing new hop cultivars (see Fig. 4.3 – details in red), which were jointly agreed at the end of 2013 by the LfL, the GfH, the Hop Trade Association and the Hop Growers' Association. The breeding lines were evaluated by the hop expert group, and the various groupings from the hop and brewing industries were closely involved in the large-scale field trial and the brewing tests; this meant that these groups were included to a much greater extent in the selection process of the two new lines.

As a result, a sound knowledge base was established for these two new breeding lines within a very short time. All the data relating to agronomics, resistance, content, and aroma profiles in the cones and the different types of beer have encouraged us to anticipate that the cultivation of 2010/08/33 and 2010/72/20 will be an economic success. The GfH management board have therefore decided that the time has now come to make these two lines, with their unique aroma profiles, available to the brewing industry.

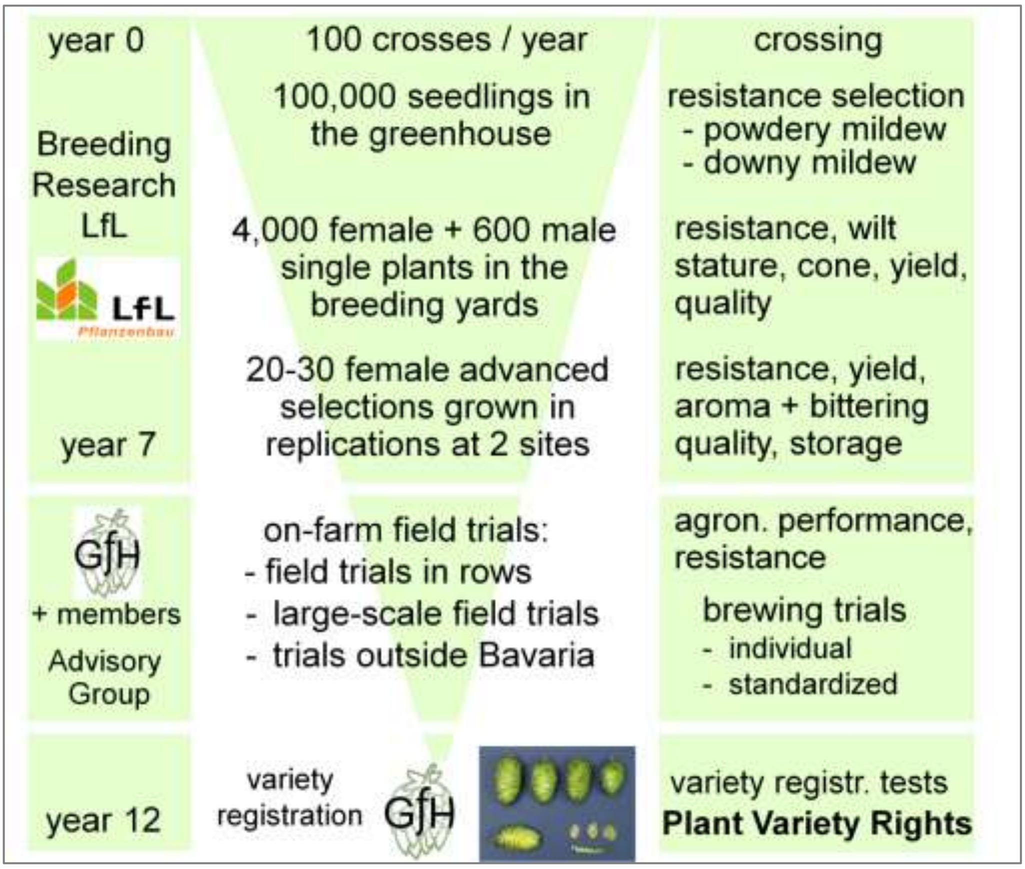


Fig. 4.3: Development of a new hop cultivar

Although heightened tolerance to hop wilt disease has been found in the two new cultivars, every hop grower should bear in mind that growing a wilt-tolerant cultivar in soil still contaminated with wilt fungus will actually exacerbate the problem. In its need to retain the hop as host plant and food resource, the wilt fungus would produce even more aggressive strains (Talboys, 1987). It would then only be a matter of time before the tolerant hops were attacked by *Verticillium*, withering and dying as a result. Hop plants must be uprooted from land severely affected by aggressive wilt infection, and the soil must be decontaminated over several years with the help of wilt-neutral plants, e.g. under grass cover (Talboys, 1987, *Green Pamphlet, Verticillium wilt*). Only then will it be possible to plant hop there again. These measures also apply to the two new wilt-tolerant hops.

References

Hanke, S., Schüll, F., Seigner, E., Lutz, A. (2015):.Zuchtstämmen auf den Zahn gefühlt – Teil 2: weiterführende Brauversuche. Brauwelt Wissen Nr. 42-43, 1230-1234.

Hanke, S., Seigner, E., Engelhard, B., Lutz, A. (2015): Systematic Brewing Trials for Evaluation and Selection of new German Hop Breeding Lines and Hop Varieties", Proceedings 35th Congress EBC European Brewery Convention, Porto, 25-28 May 2015

Lutz, A. und Seigner, E. (2015): Innovationen rund um die Hüller Hopfenzüchtung. Brauwelt Nr. 3: 57-59.

Maurer, K.A., Radišek, S., Berg, G., Seefelder, S. (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), 105–114.

Seigner, E. und Lutz, A. (2015): Jahresbericht 2014, Sonderkultur Hopfen. Bayerische Landesanstalt für Landwirtschaft - Institut für Pflanzenbau und Pflanzenzüchtung - und Gesellschaft für Hopfenforschung e.V. http://www.lfl.bayern.de/mam/cms07/ipz/dateien/jahresbericht_hopfen_2014.pdf

5 Hop Farming –Technical Aspects of Production

LD Johann Portner, Dipl.-Ing.

5.1 N_{min} Audit in 2015

The use of nitrogen fertilizers in compliance with DSN (N_{min}) is an established part of fertilization management on commercially run hop farms. In 2015, 504 hop farms – 50% of the total number in the Bavarian Hallertau and Spalt hop growing regions – took part in the DSN audit, in the course of which, 2 848 hop yards were tested for N_{min} levels, and a fertilization recommendation drawn up.

The graph below is a compilation showing the development of the number of samples taken for the purposes of the N_{min} audit. The average N_{min} concentration of 65 kg N/ha in the Bavarian hop yards in 2015 was significantly lower than the previous year's figure (80 kg N/ha). The reason is probably down to the high yields of the previous year with consequently greater nitrogen depletion, and the wet autumn and winter, during which there was more transfer and leaching of nitrogen from the soil. The average fertilization recommendation of 161 kg N/ha for the Bavarian hop yards, based on the N_{min} value, was higher than the previous year. As every year, there were again considerable fluctuations from farm to farm and, within the farms, from yard to yard, and from variety to variety. It therefore makes sense to continue running individual checks to determine the optimal application recommendation for each farm.

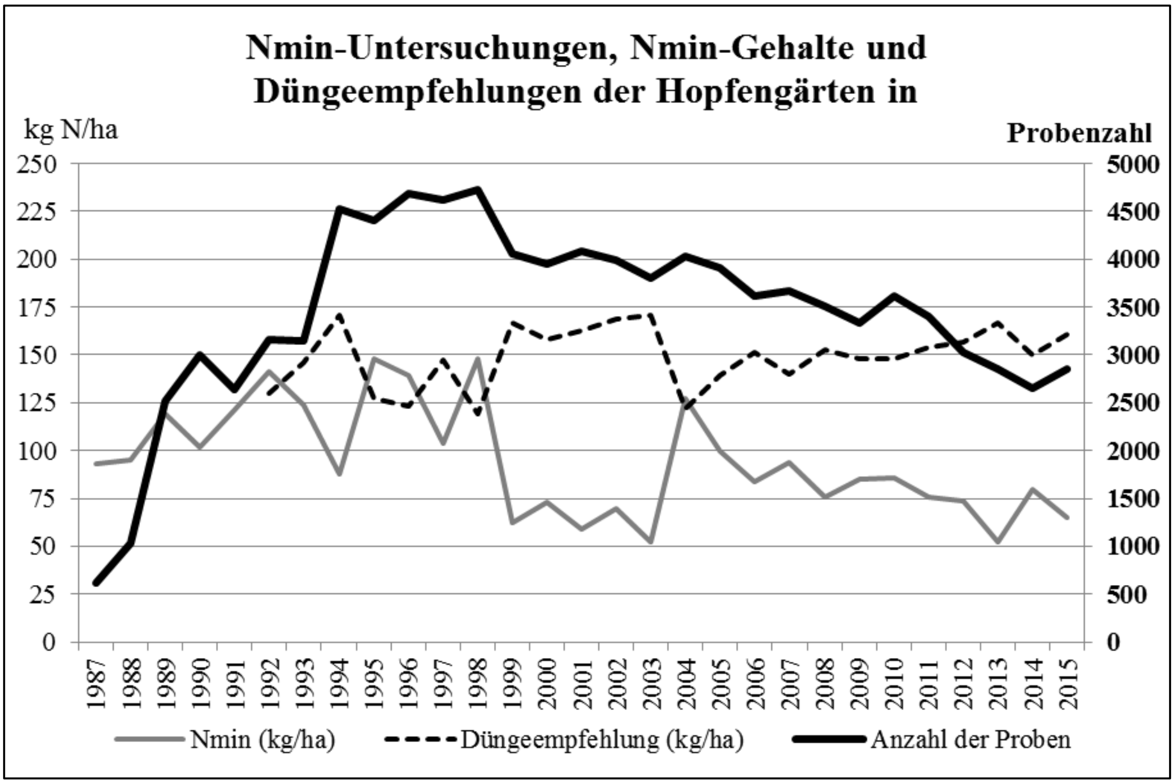


Fig. 5.1: Nmin audits, Nmin levels, recommended amounts of fertilizer in the Bavarian hop yards over the years.

The next chart shows the number of hop yards audited in the Bavarian hop growing regions, by rural administrative district, along with the average N_{min} value and the average recommendation for nitrogen fertilization calculated accordingly. The list shows that the highest N_{min} values by far were found in the certified quality seal district of Hersbruck, followed by Kinding and Spalt in the Hallertau region. The lowest N_{min} values were those recorded in the rural districts of Pfaffenhofen and Freising.

Tab. 5.1: Number, average N_{min} levels and fertilizer recommendations in Bavarian hop yards by rural district/region in 2015

Rural district/ region	**Number of samples**	**N_{min} kg N/ha**	**Fertilizer recommendation kg N/ha**
SB Hersbruck	56	107	117
Eichstätt (incl. Kinding)	226	84	155
SB Spalt (without Kinding)	93	76	140
Landshut	128	69	156
Kelheim	1101	66	160
Neuburg-Schrobenhausen	2	65	195
Freising	296	60	164
Pfaffenhofen	946	57	167
Bavaria	**2848**	**65**	**161**

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

Tab. 5.2: Number, average N_{min} levels, and fertilizer recommendations for varieties in Bavaria in 2015

Variety	**Number of samples**	**N_{min} kg N/ha**	**Fertilizer recommendation kg N/ha**
Herkules	603	58	178
Mandarina Bavaria	28	51	174
Polaris	11	67	166
Huell Melon	14	64	166
Hallertau Blanc	11	61	165
Hall. Magnum	307	61	162
Hall. Taurus	107	61	161
Opal	23	56	160
Nugget	24	71	158
Perle	555	66	157
Saphir	74	68	157
Northern Brewer	33	64	155
Hersbrucker Spät	197	69	155
Hall. Tradition	534	71	155
Spalter Select	112	71	153
Hallertauer Mfr.	142	65	145
Spalter	49	72	136
Sonstige	24	64	156
Bavaria	**2848**	**65**	**161**

5.2 Impact of the different cover cropping models on hop yield, soil humidity, soil structure and earthworm populations

Project lead: Johann Portner (IPZ 5a)
Collaboration: Robert Brandhuber (IAB 1a), Roswitha Walter (IAB 1 d)
Duration: 2012 – 2015

Starting point and problem definition

Cover cropping between the hop rows is beneficial in preventing soil erosion caused by water and in reducing the incidence of nitrate transfer and leaching after harvest. Traditionally, cover crops have normally been sown in early summer after primary or secondary tillage, with the result that precipitation events in the phase between sowing and adequate development of the cover crop has, in some places, often led to serious erosion problems.

Fig. 5.2: Soil erosion after cover crop sowing in summer (photo July 1, 2011)

Another drawback of summer sowing is that, during application of the necessary plant protection agents, ruts are made in the loosened earth where the cover has been freshly sown, with the result that the cover crop then fails to thrive and any precipitation runs off.

Fig. 5.3: Surface run-off in the vehicle ruts after cover crop sowing

Consequently, many farms have now switched to autumn ground cover or to additional autumn sowing of overwintering cover crops after harvest. The idea is to create a green zone in the vehicle ruts, with the intention of reducing water run-off and encouraging the production of more plant biomass in the spring. Depending on timing and intensity of spring incorporation, reasonably dense mulch cover can then develop.

Fig. 5.4: Autumn green zone as compared to summer green zone

Fig. 5.5: Mulch cover after late incorporation of autumn sowing in spring

Experimental design

Testing area/plot size: in each test block 2 rows or vehicle lanes

Factors: 1 = summer sowing
2 = autumn sowing (winter ground cover)
3 = no sowing

Test blocks:

1.1 summer sowing; incorporation into the soil in April; reseeding after secondary tillage
1.2 summer sowing; mulching, incorporation and reseeding in May after primary tillage
1.3 summer sowing; mulching at end of May/beginning of June; incorporation and reseeding after secondary tillage in June
2.1 autumn sowing of rye; incorporation in April
2.2 autumn sowing of rye; mulching, incorporation and reseeding in May after primary tillage
2.3 autumn sowing of rye; mulching at end of May/beginning of June; incorporation and reseeding after secondary tillage

2.4 autumn sowing of rye; mulching at end of May/beginning of June; no incorporation and reseeding

3.1 no seed sown

Harvest: 20 plants from the middle row of the plot with 3 non-randomized replicates in succession.

1.1.	1.2.	1.3.	2.1.	2.2.	2.3.	2.4.	3.1.
Sommereinsaat; Einarbeitung April; Neuansaat nach dem 2. Ackern (Roggen)	**Sommereinsaat**; Mulchen, Einarbeitung und Neuansaat im Mai nach dem 1. Ackern	**Sommereinsaat;** Mulchen Ende Mai/Anfang Juni; Einarbeitung und Neuansaat nach dem 2. Ackern im Juni	**Herbsteinsaat** Roggen; Einarbeitung April	**Herbsteinsaat** Roggen; Mulchen, Einarbeitung und Neuansaat im Mai nach dem 1. Ackern (Hafer od. Ölrettich)	**Herbsteinsaat** Roggen; Mulchen Ende Mai/Anfang Juni; Einarbeitung und Neuansaat nach dem 2. Ackern (Hafer od. Ölrettich)	**Herbsteinsaat** Roggen; Mulchen Ende Mai/Anfang Juni; **keine** Einarbeitung und Neuansaat	**ohne** Einsaat

Fig. 5.6: Experimental design and description of variants

5.2.1 Variations in scheduling cover crop sowing and incorporation

Objective and method

By varying the dates when sowing and incorporation of the cover crop takes place, compared to the control plot where no seed was sown, it is possible to establish the extent of surface water run-off and the subsequent erosion. By examining yield, it is then possible to work out to what degree the competition for water and nutrients impacts plant growth.

Summer sowing has always been guided by the optimum timing for primary and secondary tillage and the hitherto latest KuLaP sowing date of June 30. In the years of the trial, 2012-2015, summer sowing of rye or Triticale (variant 1.2), or fodder radish/ mustard/ rape or oats (variant 2.2) took place after primary tillage between May 21 and June 8; sowing of rye or Triticale (variants 1.1 and 1.3) or fodder radish/rape or oats (variant 2.3) was done after secondary tillage between June 17 and 29. Autumn sowing of rye or Triticale was undertaken after harvest from the end of September to the beginning of October on 2.1 – 2.4. In variant 3.1 no cover crop was sown. In this plot, the soil was worked four times in the period from April to June 4, as a measure to suppress weeds and level the ground (2 x tillage).

The usual practice of incorporating the cover crop into the soil in spring took place in April prior to defoliation and training, with the help of a mini cultivator and a rotary harrow (variants 1.1 and 2.1), or later, following mulching and just prior to reseeding (primary tillage, variants 1.2 and 2.2), or not until mid June (variants 1.3, 2.3 and 2.4). The smallest amount of work was done on variant 2.4. Here, mulching was done late on the seed sown in the autumn, the hop was tilled once and no further mechanical soil cultivation took place until reseeding in the autumn.

Results

<u>Soil erosion and water run-off</u>

In examining the run-off of water between the hop rows and the accompanying soil erosion, the aim was not to make quantitative oberservations, but rather to look at soil sediments collecting, above all, in the ruts at the foot of the slope, and to draw conclusions as to quality. Over a period of years, even the smallest amount of soil erosion in variant 2.4 was noted, where, after a single tillage, the tall rye or Triticale crop was mulched laterally onto the hill, and where, in addition, the soil was not mechanically cultivated during the growing season and the weeds and grain stubble largely prevented water run-off and erosion of the soil.

As anticipated, most water run-off and soil erosion was found in plot 3.1 (no seed sown).

Fig. 5.7: Variant 2.4 (left) with no erosion and 3.1 (right) showing soil erosion (July 12,2012)

It was also found that more plant biomass was produced in the plots where sowing was done in the autumn, and, after incorporation, more mulch material covered the ground than in the summer-sown variants 1.1 - 1.3.

The later the incorporation date, the more plant biomass was produced and the greater the amount of mulch cover.

Fig. 5.8: Mulch cover in variant 2.1 (left, 1%), variant 2.2 (centre, 7%) and variant 2.3 (right, over 50% after incorporation on the same day (June 7, 2015)

Yield and alpha acids content

On looking at yields and alpha acids content, it must be noted that the individual trial results in the 8 variants are based on non-randomized replications and are, therefore, not statistically valid and can only provide an overview. Another point to consider is that not all the plots were harvested in 2012, and no individual alpha tests were carried out in the replicates in 2013, making calculations for all plots across all years very difficult.

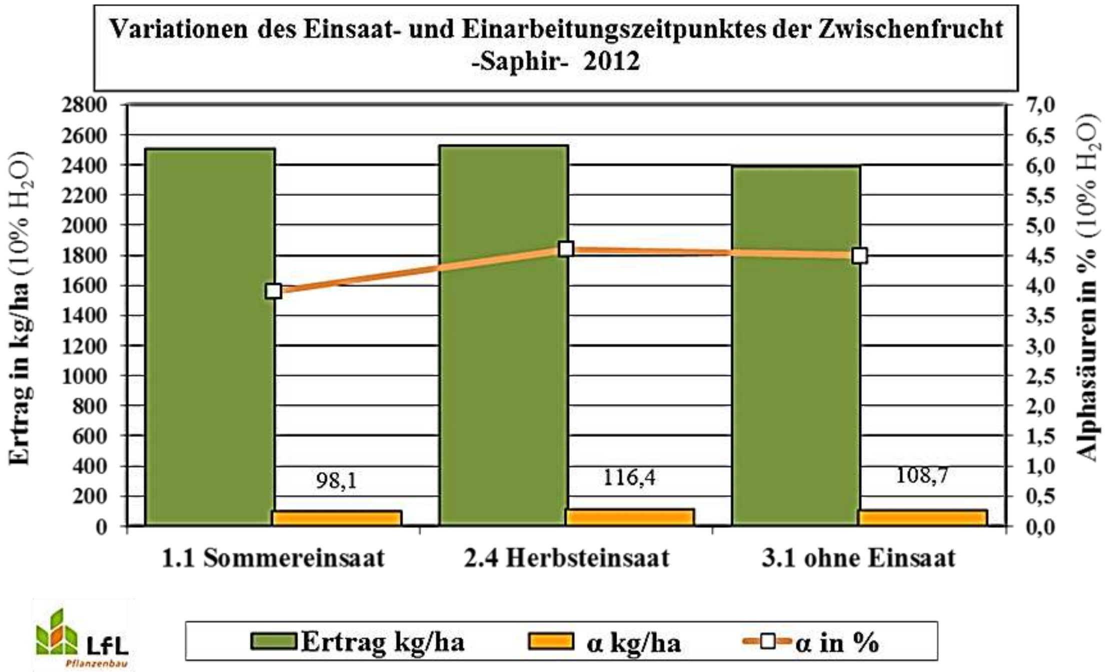


Fig. 5.9: Average yield, alpha acids content, and alpha acids yield per hectare in selectedvariants in 2012

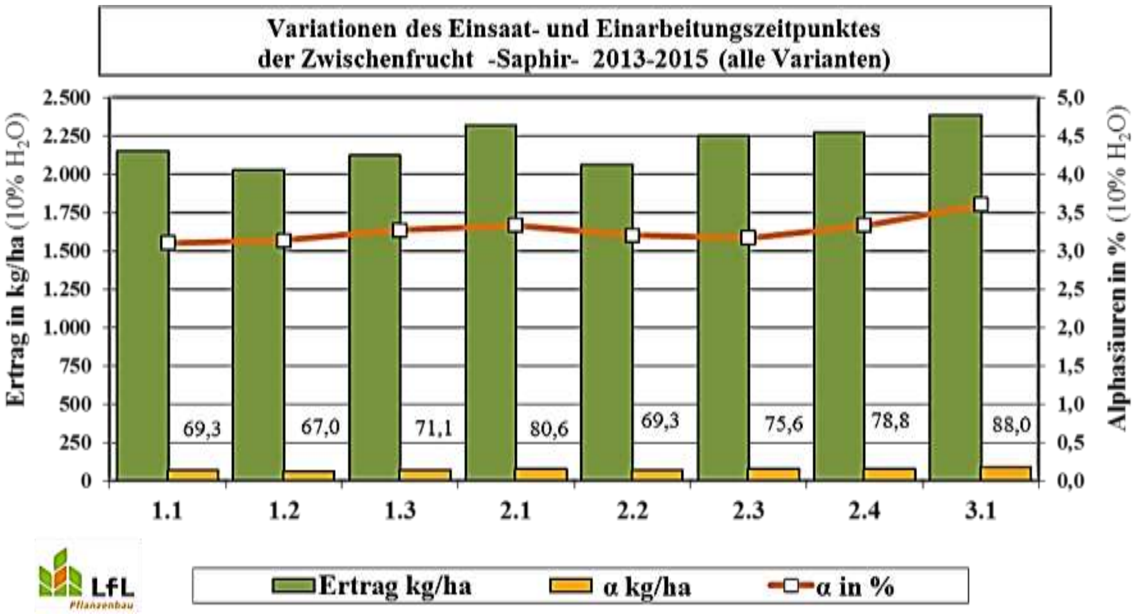


Fig. 5.10: Average yield, alpha acids content, and alpha acids yield per hectare across all variants in 2013 - 2015

Although there are no differences, in statistical terms, in yield and alpha acids content among the variants, there is a noticeable tendency towards low yields in variants 1.2 and 2.2.

Here the soil was only tilled once, and summer sowing was undertaken early. Here also, the biomass of the cover crop increased prior to the hop harvest, so that it probably competed with the hops for water and nutrients. In the variants lacking undersown cover crops in the summer (2.1 and 3.1), the yields were highest, especially during the drought periods in 2013 and 2015.

However, these variants did not fare so well in the years when summer precipitation was higher (2012, 2014), and water run-off and the subsequently depleted supply of water affected yield when compared to variants 2.3 and 2.4 (no run-off to speak of). Thus, variants 2.3 and 2.4 represent the best compromise when it comes to protecting against erosion and producing optimal yields. In the case of variant 2.3, it should be considered whether additional summer sowing is necessary, or whether the remaining mulch material, after shallow incorporation, is enough in combination with the developing natural weed cover, until autumn sowing is undertaken post-harvest.

5.2.2 Effect of cover cropping on earthworm population density

Institut für Ökologischen Landbau, Bodenkultur und Ressourcenschutz (IAB)
(*Institute for Organic Farming, Applied Life Sciences and Natural Resources*)

Sub-project lead:	Roswitha Walter (IAB 1d)
Project staff:	Finn Beyer (IAB 1d), Elke Fischer (IPZ 5a), Maria Lutz (IPZ 5a) Roswitha Walter (IAB 1d), Josefa Weinfurtner (IAB 1d)
Collaboration:	Johann Portner (IPZ 5a), Robert Brandhuber (IAB 1a)
Duration:	2014 – 2015

Objective

Earthworms make numerous important contributions to improving soil fertility. Their burrowing activities facilitate development of a stable soil structure and create a continuous pore space which improves air and water circulation and infiltration of precipitation into the soil, thus helping to reduce surface water run-off and soil erosion. By breaking down and incorporating organic matter into the soil, earthworms also have a positive effect on nutrient replenishment. The aim of the investigation was to gauge the effect that cover cropping in hop yards has on population density, biomass and species composition of earthworms.

Method

The quantitative and qualitative research into earthworm populations was carried out in variants 2.3 and 2.4, where rye was sown in the autumn as a cover crop, and no mulching was done until late spring, on June 5. While in variant 2.3 the cover crop was turned over prior to secondary tillage in mid-June and oats were newly sown, no further mechanical soil cultivation was carried out on 2.4 after mulching on June 5. By comparison, variant 3.1 had no cover cropping, tilling took place twice and soil cultivation activities were carried out four times between the rows in the period April to June 2014. Earthworm sampling was done on September 18, 2014, two years after commencement of the trial. Eight random samples per variant were taken, of which four were from the hills (Bifa) and four from the central strip between the ruts in the lanes (see Fig. 5.11). Before each sample was taken, the worms were expelled from the ground using a highly diluted 0.2% formaldehyde solution, divided into two applications (40 l/m² in total), spread over a sampling area measuring 0.5 m².

After each application, the worms were collected over a period of at least 15 minutes, following which a part of the sampling area (1/10 m²) was dug to a depth of approx. 30 cm and the soil crumbled by hand in search of any remaining worms.

Fig. 5.11: Taking earthworm samples in September 2014 at the cover crop trial in Aiglsbach; left: location of the sample sites (hill and central strip between the vehicle ruts); right: collecting the worms

Results

The green zone created by a cover crop in the hop yard clearly had a positive effect on the worms, evidenced by the greatly increased numbers (Fig. 5.12). Where cover crops were present, on average, twice as many individuals and an almost four times greater worm biomass were found than in areas where no cover crop was sown. Differences between the two cover cropping variants (mulching only, or incorporation and reseeding) had no discernible effect on the worm population. However, with respect to the hills (Bifang), the mulch variant (2.4) had a slightly more positive influence on worm numbers (Tab. 5.3). Big differences in population density and biomass were found between the central strip of the vehicle lane and the hills. The central strip of the lane, particularly in the two cover crop variants, was, on average, far more densely populated than the hills.

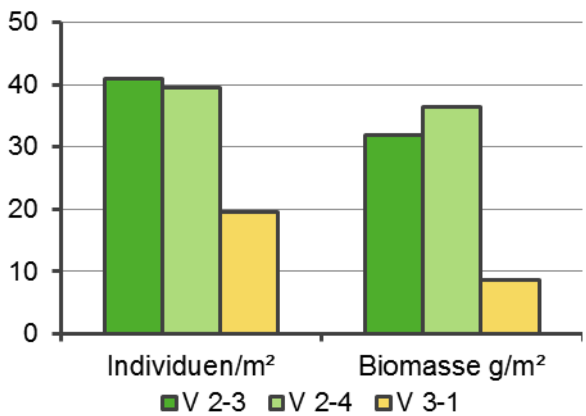


Fig. 5.12: Earthworm population in the hop yard in September 2014 with (2.3. and 2.4) and without (3.1) cover cropping at trial site in Aiglsbach, Hallertau region, (mean values, n= 8 per variant)

The deep-burrowing species *Lumbricus terrestris* (common earthworm) was predominant in all variants, especially with regard to worm biomass. Although all three species of earthworm were found, species diversity was poor compared to usage as arable land. This is especially the case with respect to shallow-burrowing mineral layer dwellers (endogeic forms of life), for which no evidence was found in the hills.

Tab. 5.3: Average density of individuals and worm biomass with (2.3 and 2.4) and without cover crops (3.1), in each case for the hills (Bifa, n=4) and in the central strip between the vehicle ruts of the lane (Weg, n=4) in September 2014 in Aiglsbach

	individuals/m²						**biomass g/m²**					
	V 2-3		**V 2-4**		**V 3-1**		**V 2-3**		**V 2-4**		**V 3-1**	
	Bifa	**Weg**	**Bifa**	**Weg**	**Bifa**	**Weg**	**Bifa**	**Weg**	**Bifa**	**Weg**	**Bifa**	**Weg**
Juveniles												
Lumbricus spec	5.5	10.5	3	22	8.5	18.5	1.9	13.3	1.9	12.4	9.4	4.2
other juveniles	0	10	0	12.5	0.5	2.5	0	0.3	0	0.5	0.01	0.07
Adults												
D. rubidus (epigeic)	0	0	3	0	0	0	0	0	0.2	0	0	0
P. tuberculatus (endogeic)	0	40	0	17.5	0	7.5	0	2.1	0	1.07	0	0.4
L. terrestris (anecic)	4	12	9	12	0.5	1	12.8	33.6	24.2	32.3	1.3	1.8
Total	**9.5**	**72.5**	**15**	**64**	**9.5**	**24.5**	**14.7**	**49.3**	**26.3**	**46.3**	**10.7**	**6.4**

Earthworm life forms: **epigeic**: litter-dwelling species; **endogeic**: mineral layer dwellers, horizontal- und mostly shallow-burrowing species; **anecic**: deep-burrowing species

Conclusion

Cover cropping in the hop yard increases worm populations, probably thanks to improved feeding resources and the more permanent ground cover. This encourages biological activity in the soil, and the worm burrows, by allowing air and water to circulate, play an important role as drainage systems in infiltration and protection against erosion. Cover cropping in the hop yard can certainly be recommended.

5.2.3 Soil water content and aggregate stability

Method

Penetration resistance was measured by means of a penetrologger prior to hop harvest on August 18, 2014. The pressure exerted was recorded centimetre by centimetre and the data then saved. A cone with a surface area of 1 cm² and a 60° tip was used for measuring. Five measurements per variant were taken at depths of 0 to 60 cm.

In order to determine **soil water content**, samples were taken from the 0 – 30 cm and 30 – 60 cm layers in 3 replicates each, using a core sampler. The soil water content was then determined in the lab. First the wet weight was established and then the sample was dried at 105°C until it reached a constant weight. The water content is calculated as follows:

$$\frac{wet\ weight - dry\ weight}{dry\ weight} \times 100 = water\ content\ in\ \%$$

A sampling scoop was used to take soil samples at a depth of 0 – 10 cm from variants 2.3, 2.4, and 3.1 in order to determine **aggregate stability**. The composite samples were then sieved to 1 – 2 mm and their aggregate stability tested according to DIN 19683-16.

Results

The measurements show that **penetration resistance** increases with increasing depth (*Fig. 5.13*). The pressure gradient in variants 2.3 and 2.4 does not deviate until a depth of 60 cm is reached, and there is a pressure increase from only 0.5 MPh to 1.5 MPh. In variant 3.1 there was a rise between 22 cm and 26 cm, indicating a cultivation horizon. From a depth of 33cm to 60 cm penetration resistance in variant 3.1 rose from 1.8 MPh to 3.5 MPh. It was found that soil humidity at 15.6% between the vehicle ruts in variant 3.1 at a depth of 30 – 60 cm was the lowest figure, followed by variant 2.3 (17%) and 2.4 (18.6%). There was a 1.5% difference in soil humidity between variants 3.1 and 2.3 and a clear difference in the penetration resistance curve. A similar difference in humidity of 1.6% was observed between variants 2.3 and 2.4, but the penetration resistance curve was almost the same. Therefore, the humidity differential cannot be the only reason for the greater penetration resistance in variant 3.1. Since earthworm activity was lower in variant 3.1 and the subsoil contained fewer roots in the absence of a cover crop, it can be surmised that this might have led to more tightly packed subsoil throughout the duration of the tests.

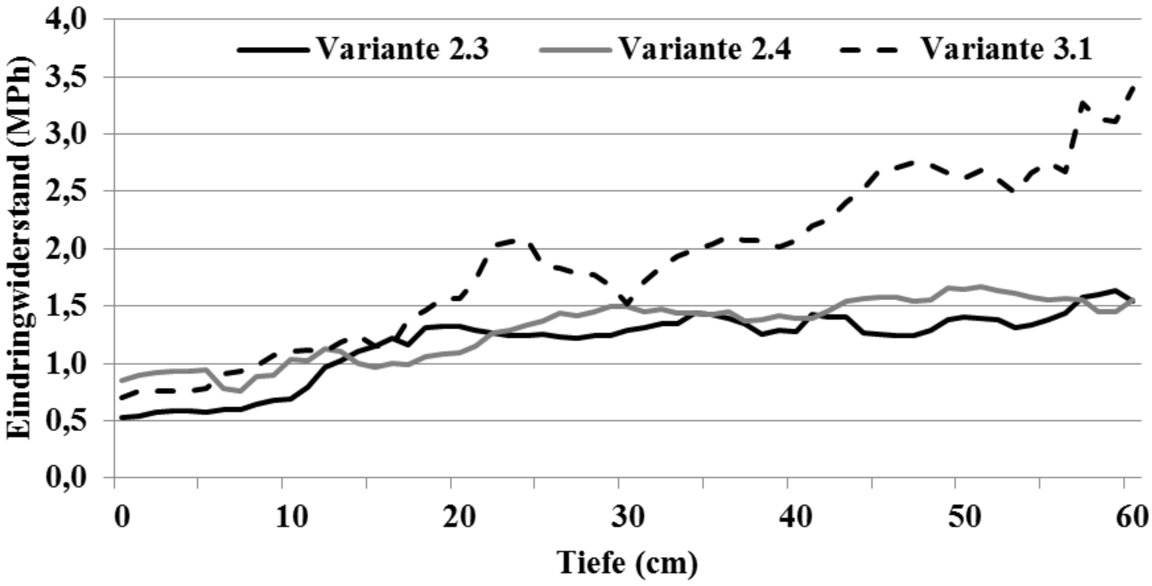


Fig. 5.13: Penetration resistance (MPh) on August 18, 2014 in variants 2.3, 2.14 and 3.1 at depths of 0 – 60 cm, measured between the vehicle ruts

At the start of the drought period in 2015, measurements of **soil water content** were taken at two-week intervals from July until harvest. This is affected mainly by the water needs of the plants (hop and cover crop), precipitation levels and infliltration capacity of the soil. The precipitation data were provided by the Stadelhof weather station. The following graphs show development of water content in the topsoil and subsoil of selected variants. It is striking that soil water content in the variant without cover crop is higher at the start of the measurement period, later declining in the run-up to harvest. This could be because the cover crop took up more water from the soil. The low water content in 3.1 running up to harvest might be due to increased surface run-off or higher consumption by the plants.

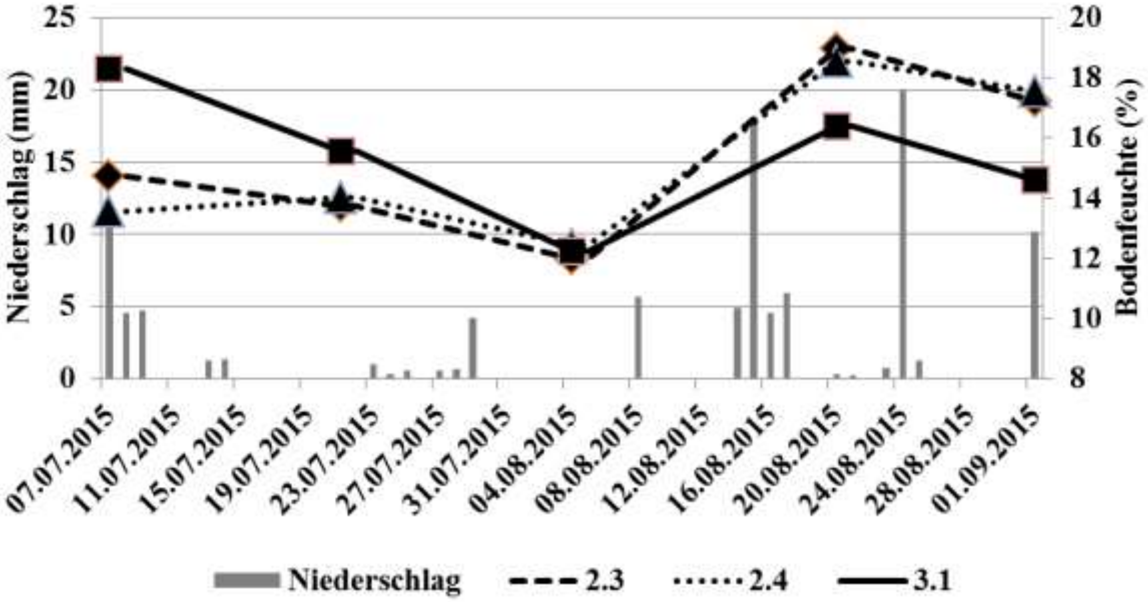


Fig. 5.14: Development of soil humidity in the individual variants at depths of 0-30 cm, with precipitation details from Stadelhof weather station; period July 7 to September 1, 2015

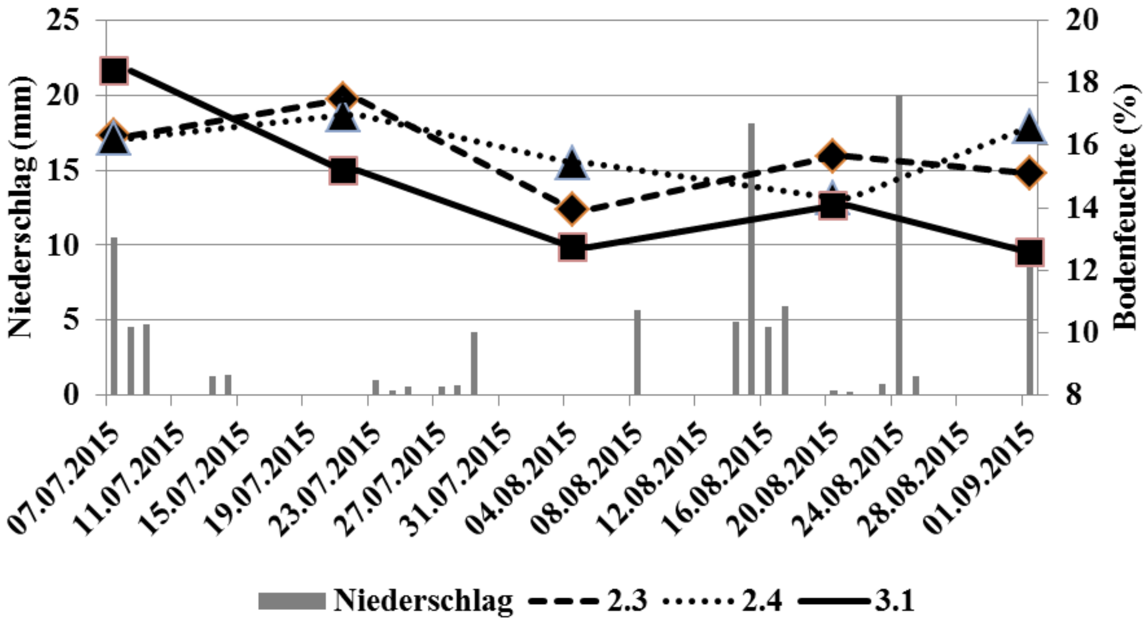


Fig. 5.15: Development of soil humidity in the individual variants at depths of 30 – 60 cm, with precipitation details from Stadelhof weather station; period July 7 to Sept.1, 2015

The different cover crop models affect the stability of the individual aggregates in different ways. For example, aggregate stability between the lane ruts decreases from 22% (variant 2.3) to 19% (variant 2.4) and 16% in variant 3.1. The same decline occurs on the hill: 15% in variant 2.3, 12% in variant 2.4, and 9% in variant 3.1. In the vehicle ruts, variants 2.3 and 2.4 are the same at 9.7% and 9.5%, while only variant 3.1 dips to 6%.

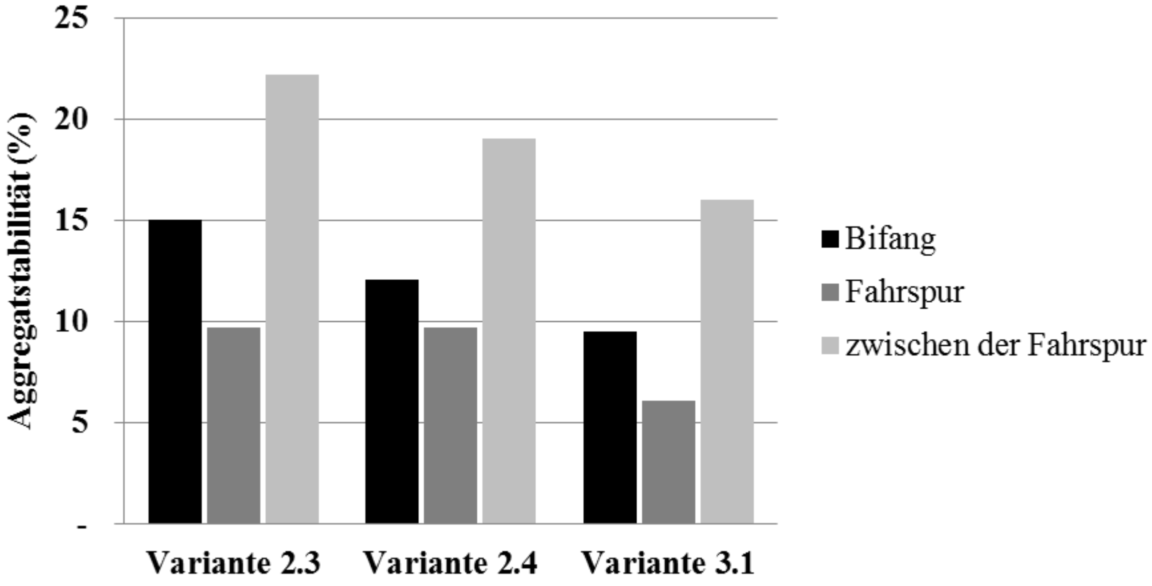


Fig. 5.16: Aggregate stability on August 18, 2014 in variants 2.3, 2.4 and 3.1 on the hill (black), in the vehicle ruts (dark grey) and on the strip between the ruts (light grey)

Since aggregate stability very much depends on biological activity in the soil, and this, in turn, is affected by the availability of organic plant biomass, the reduction in aggregate stability in variant 3.1 (no cover crop) could be measured and was clearly recognizable. However, less stable aggregates make the soil more vulnerable to erosion and led in variant 3.1 of the trial to major soil losses.

5.2.4 Discussion and implications for commercial practice

The greater the growth of cover crop biomass and the later incorporation is undertaken, the sooner water run-off and soil erosion can be reduced. Nevertheless, there is a danger that, even with incorporation at a later date and some soil cultivation work, water run-off and erosion will still take place in the vehicle ruts, which form in the newly loosened earth during the necessary plant protection operations. Anyone who wishes to avoid this and still wants to have regular vehicle access to the hops, should not undertake any further mechanical cultivation, or at least do only general work, on the ground in the summer after tillage and cover crop mulching. Apart from this, observations have shown that, alongside the amount of mulch cover, the timing, quantity and intensity of precipitation have the greatest impact on run-off and erosion. Later dates for incorporation (late May to mid-June) tend to work better because more mulch material builds up and stays on the surface. Early cover crop sowing after primary tillage runs the risk of having major precipitation events cause extensive damage, due to lack of sufficient mulch material. there is also a danger that the cover crop will compete with the hops for water and nutrients because of increased biomass in the summer. Variations 1.2 and 2.2 displayed a tendency towards slightly lower yields.

The investigations into earthworm populations showed that cover cropping in the hop yard can substantially improve earthworm numbers, thanks to the increased food resources and the more permanent ground cover it provides. It also encourages biological activity in the soil, and the worm burrows, in which air and water can circulate, act as a drainage system and play a positive role in aiding infiltration and preventing erosion. Cover cropping in the hop yard can definitely be recommended for supporting soil life.

Closely bound up with the supply of organic plant biomass and the biological activity in the soil is aggregate stability. Here, it was possible to measure the clearly recognizable decrease in variant 3.1 (no cover crop). Less stable aggregates make the soil more vulnerable to erosion and in the trial led to major soil losses, something which – for environmental reasons – cannot be countenanced in the long term when growing row crops like hop.

Cover cropping is, therefore, crucial in preventing surface water run-off and soil erosion, as well as in contributing to and maintaining soil fertility.

5.3 Model Project: Demonstration farms with integrated plant protection m*anagement* – sub-project: *Hop growing*; glue damage to hops during spider mite control measures

5.3.1 Objective

In 2015, applications of insect glue were used on three of five demonstration farms in an attempt to prevent infestation by the two-spotted spider mite.

In the past, as part of the integrated plant protection programme to control the two-spotted spider mite, the Bayerische Landesanstalt für Landwirtschaft (*Bavarian State Center for Agriculture*) developed and trialled a method of coating hop bines with insect glue.

There was never any sign of damage to the plants, either at the development stage, or later in practice in organic hop growing, and the measure was used successfully in 2014 on a demonstration farm on *Hallertauer Mittelfrüher*. No acaricide treatment was needed on the stand, since the treatment threshold was not exceeded.

5.3.2 Method

Under the direction and with the participation of the project team, coatings of insect glue were applied in 2015 at the Weingart farm on 1.4 hectares of its *Hallertauer Mittelfrüher*. An area of 0.311 ha of the same stand had been treated with the glue the previous year. During the 2015 season, two more farms followed suit, and glue was applied to sub-plots of their stands, under the supervision of the project team: on the Moser farm (0.17 ha of *Herkules*), on the Obster farm (0.249 ha of *Herkules*, and 0.288 ha of *Hallertauer Tradition*).

On all the farms the leaves were stripped in the relevant sub-plots by hand, at the beginning of June 2015, leaving the bines free of foliage and stems to a height of 1.5 m. The operations managers then applied a band of glue about 20 cm wide just below the first pair of leaves (see Fig. 5.17). This was done on all three farms in the first two weeks in June, 2015.


Fig. 5.17: (left): Bartholomäus Obster applying insect glue to Hallertauer Tradition on June 1, 2015;

Fig. 5.18: (right): a Hallertauer Tradition bine (Obster farm) June 24, 2015. As yet, there is no discernible damage.

5.3.3 Results

From early June to mid-August 2015, no changes in the glue-coated areas or the bines were noticed. The glue had the desired effect, and had many insects sticking to it (see Fig. 5.18).

However, from the second half of August onwards, within the space of a few days, damage was visible on all the stands that had been treated, and it subsequently got worse. The damage took the form of a brown discoloration and shrinking in the areas treated, followed by rotting of the tissue (see Fig. 5.19). As a result, insufficient water was transported to the upper parts of the plant and the bine withered. It is suspected that the extremely hot summer weather (30 days of excessive heat at over 30°C) caused the glue to have this negative impact on the plants for the first time.

And yet, in two of the plots which had undergone glue treatment no acaricide application was needed to control spider mites. In these, the treatment threshold was not exceeded, as opposed to the untreated areas of the stand (see Fig. 5.20). However, the damage done by the glue was considerable and the Temmen insect glue was still extremely sticky right up until harvest.

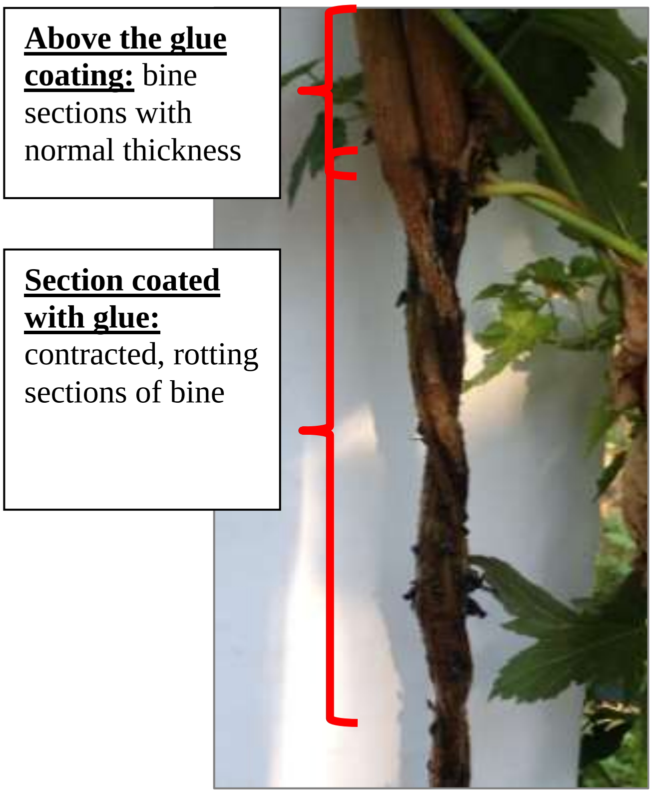


Fig. 5.19: (left): Glue damage on Hallertauer Tradition (Obster farm) on August 12, 2015;

Fig. 5.20: (right): untreated Herkules bines (Obster farm) on August 30, 2015.

In 2015, only sub-plots on 3 demonstration farms received the glue treatment, so that yield losses were limited. The following numbers of totally damaged bines were assessed pre-harvest on the farms.

Tab. 5.4: Number of bines with glue damage

Farm	Field section	Cultivar	Total number of vines treated with glue	Number of damaged bines	Percentage of damaged bines (%)
Weingart	Lerchenfeld	HA	6 562	264	4
Moser	Trünkelanger	HS	728	451	62
Obster	Berchert	HS	904	394	44
	Grünbrunn	HT	1 076	288	27

5.4 Testing infrared sensors for measuring and recording cone surface temperature during hop drying

Starting point

For a hygroscopic product like hop, the drying process is split into 3 stages. During the first stage of drying, water is removed, mainly through evaporation at the cone surface. If a good drying rate is to be achieved and external quality simultaneously maintained, a sufficiently high air velocity is necessary. During the second stage of drying, the temperature inside the cone rises and evaporation moves to the interior of the cone.

The drying speed can be substantially increased if the drying temperature is raised at this stage. As long as not enough water is removed from the cone by the drying air, the cone surface temperature is lower than the drying temperature, due to the cooling effect. In the course of the third stage of drying, physically bound water is removed. Evaporation takes place until moisture equilibrium is attained. If temperatures are too high at this stage, the hop can very quickly become overdried, and the quality suffers. For this reason, the drying temperature should be lowered again during this stage. With more recent control systems for hop kilns it is now possible to pre-set drying temperatures in °C and the appropriate air flow in m/sec or fan speed in %, for the different drying stages.

Objective

Until now, not much attention has been paid, in practice, to the surface temperature of the hop during drying. Small-scale drying trials and experiments to optimize belt drying techniques have shown that promising results can be obtained by using infrared sensors to measure surface temperature on the cone during drying. Therefore, this measuring technique was tested during the 2015 harvest in several hop kilns. The intention was to show the relation between drying temperature and cone temperature and, at the same time, to find out whether the optimal ratio of temperature to air velocity can be regulated via the surface temperature on the cones.

Method

In a commercially operated kiln with a drying surface area of 46 m², infrared sensors for measuring cone surface temperature were installed in the top tier, the intermediate tier and the movable tier. During drying, the hop cone heats up from its exterior inwards; the temperature is therefore always highest at the surface of the cone. The changing temperatures were monitored and recorded via the appropriate software.

The cone loading depth was 25 cm; the temperature during the first drying stage was 65°C, at stage two 69°C, and at stage three 63°C. The average air velocity was 0.45 m/sec during the first two drying stages; during stage three it was reduced to 0.3 m/s. These settings enabled a regular loading frequency. The drying process took 3.2 hours on average, from loading the top tier to emptying the movable tier.

Results

The measurements made by means of the infrared sensors clearly illustrated the evenness of the drying process on all three levels of the kiln.

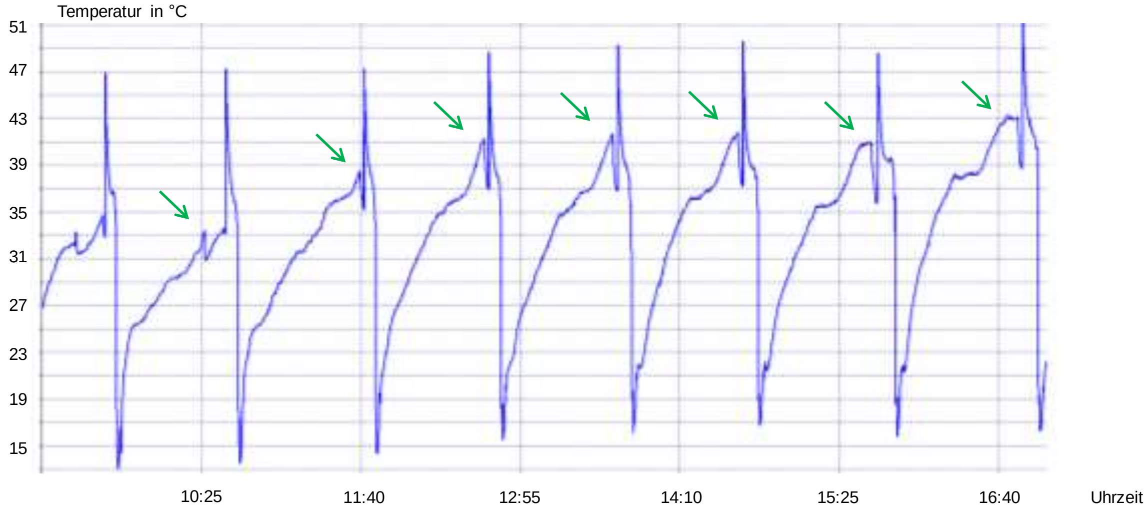


Fig. 5.21: Changing temperatures at the surface of the hop cones on the top drying tier

The temperature of the outgoing drying air on the top tier was 30°C, on average, at the time of the greatest water release from the hop and it rose to 38 – 41 °C, up to the point where the hops were poured out from the top tier onto the intermediate tier. The cone surface temperature was much lower than that of the drying air until shortly before pouring took place. As the water content of the hops decreased, the temperature differential was steadily reduced during the dwell time in the dryer. Just before pouring took place, the temperature of the outgoing drying air and that at the cone surface were more or less the same. Air velocity was reduced prior to pouring, so that the cone surfaces cooled down briefly due to the slower removal of water. This point in time is indicated in the graph by the arrows.

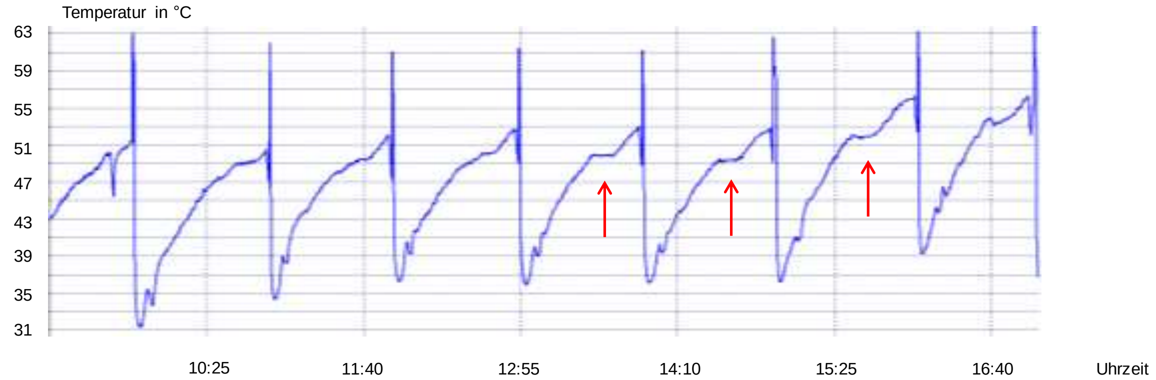


Fig. 5.22: Changing temperatures at the surface of the hop cones on the intermediate drying tier

On the intermediate drying tier, although the temperatures at the cone surface are higher, they are still well below the drying temperature setting. The red arrows in the chart indicate the stagnating temperature rise at this drying stage. During stage three, air velocity was reduced from 0.45 m/s to 0.3 m/s. The graphs point to the conclusion that air velocity was reduced either too far or too soon at this point. Because removal of the water released from the cones was not satisfactory, drying was slowed down, evidenced by the fact that the drying process took longer.

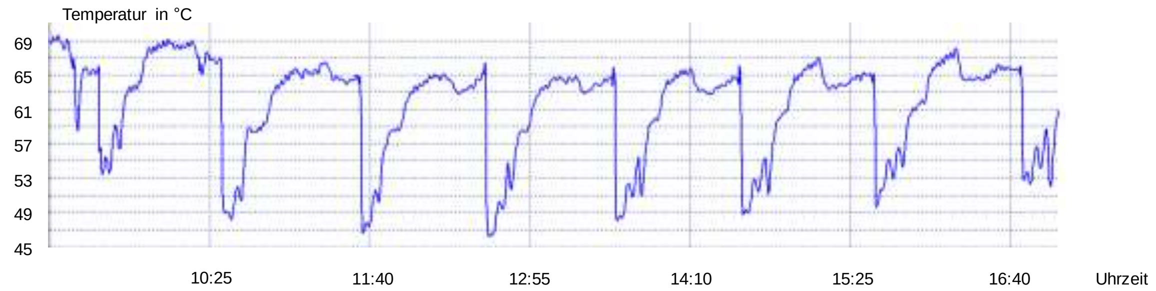


Fig. 5.23: Changing temperatures at the surface of the hop cones on the movable tier

The situation on the movable tier demonstrates clearly that, when drying hop, it is necessary to differentiate between drying temperature and cone temperature. With the first two loads, the temperature at the cone surface rose to 69°C, corresponding to the temperature of the drying air. This probably had to do with the fact that the hop from the previous day, left in the kiln overnight, was already almost dry.

As the cooling effect was only slight, the temperature at the cone surface increased. With the other loads, the cone temperature of 65°C was maintained without difficulty, despite the higher drying temperatures.

Conclusion and Outlook

Where hop is concerned, the drying temperature has a considerable impact on quality and drying timescale. The effect of the drying temperature on the hops can easily be ascertained by measuring what is termed the product surface temperature. The appropriate cone temperature can then be regulated according to the desired temperature or to that required for an optimal drying process. The required air velocity results from the change in temperature at the cone surface. It thus becomes possible to reproduce the conditions more easily in drying trials.

5.5 LfL projects as part of the production and quality campaign

As part of an agricultural production and quality drive in Bavaria, the Bayerische Landes-anstalt für Landwirtschaft (*Bavarian Center for Agriculture*) has once more arranged for representative data on yields and quality of selected agricultural crops to be collected, recorded and analysed in the period 2014 to 2018. The work was done on behalf of the IPZ Hops Department by their joint advisory service partners Hopfenring e.V (*hop growers' syndicate*). There follows a brief outline of the objectives of the individual projects concerning hop, with a short resumé of the results for 2015.

5.5.1 Annual survey, study and analysis of data on hop quality post-harvest

Dry matter and alpha acids monitoring

In the period August 18 to September 29, 2015 – spread across the Hallertau region – trained bines from each of 3 aroma varieties and 3 bittering varieties, taken each time from 10 different commercially run hop yards, were harvested at weekly intervals and then dried separately. This was done on 5 (aroma varieties) and 7 (bittering varieties) different dates. By determining the extent of water loss, and analysing the dry matter content and alpha acids content in an accredited laboratory, it was possible, the following day, to establish the dry matter content of the green hop and the alpha acids content at 10% water content. The information was subsequently sent on to the LfL Hop Advisory Service for evaluation.

The results were averaged, presented in the form of graphs, tables and charts and then uploaded to the internet, together with accompanying comments. Agriculturalists can then refer to the data when they need information as to the best harvest maturity of the most important hop varieties.

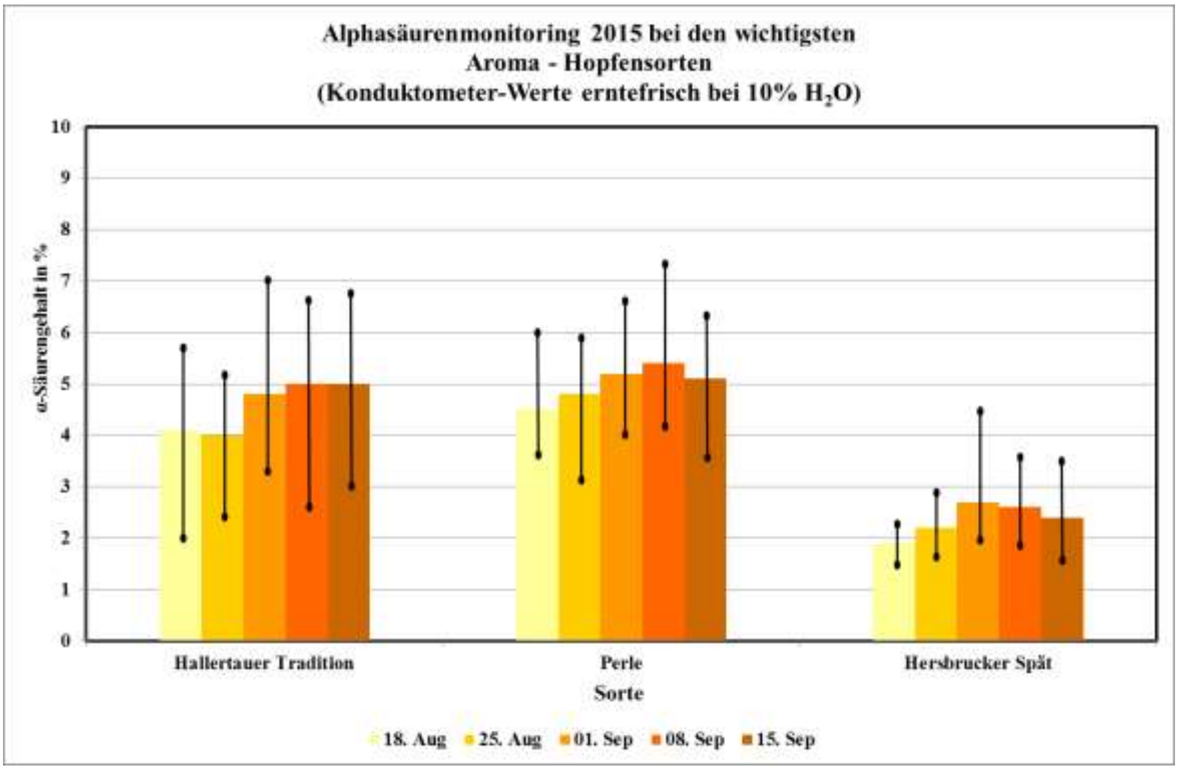


Fig. 5.24: Alpha acids monitoring in the major aroma varieties in 2015

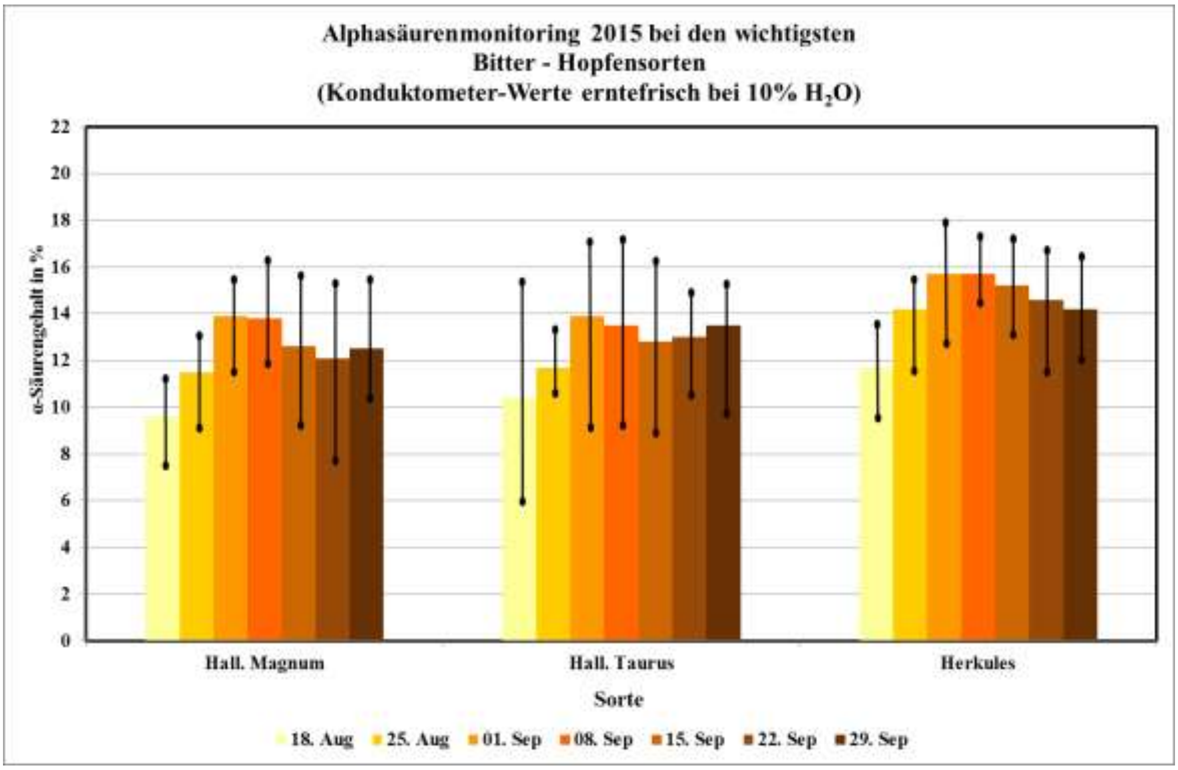


Fig. 5.25: Alpha acids monitoring in the high alpha varieties in 2015

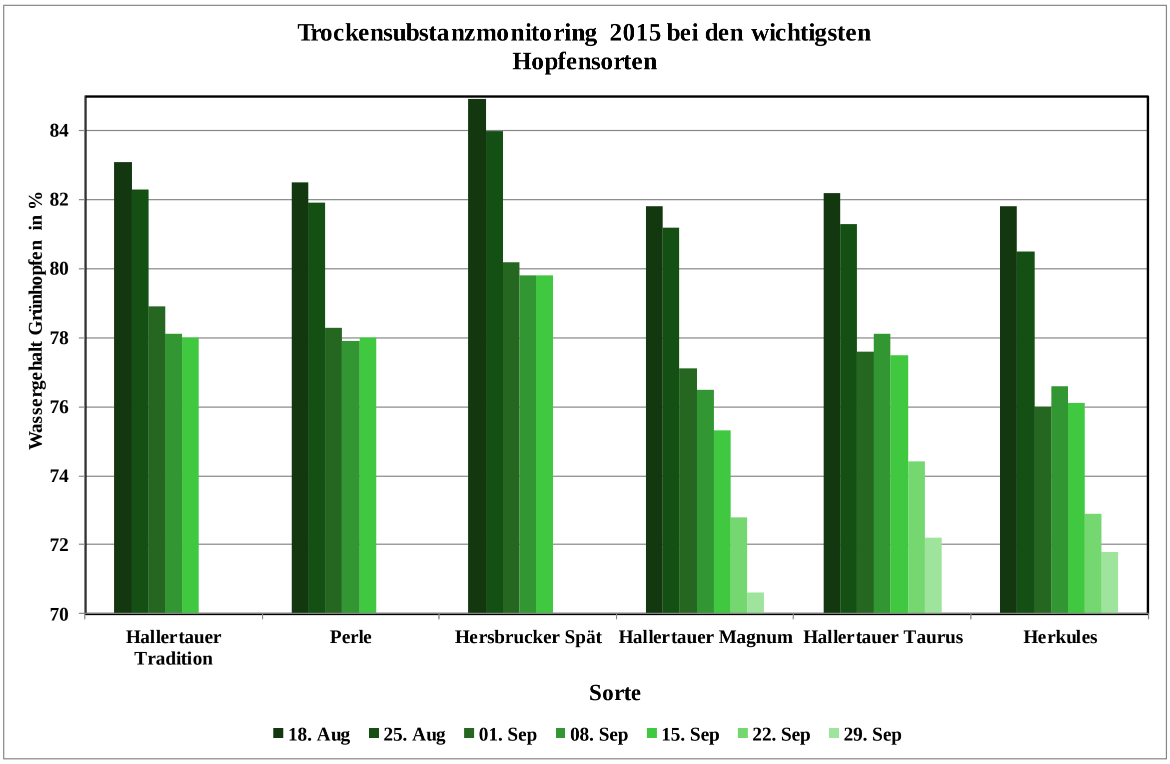


Fig. 5.26: Dry matter monitoring in the major hop varieties in 2015

Impact of location and technical aspects of production on hop quality

The data on quality gathered as part of the NQF (Neutrale Qualitätsfeststellung) quality assessment provides valuable information about hop quality for the different harvest years, as well as on diseases and pest infestation, technical production failings, or inappropriate treatment of harvested hops.

While the project continues, the NQF data from 150 batches each of HT, PE, HM, and HS is to be expanded to include the corresponding alpha acids content and selected data concerning location and production techniques. It is hoped that the evaluation of location-specific parameters and details of production techniques alongside the quality data will deliver valuable information for the advisory service.

However, only 155 of the anticipated 600 data sets were submitted in 2015, which meant that stratification and an evaluation were not possible.

5.5.2 Annual survey and investigation of pest infestation in representative hop yards in Bavaria

Surveys and accurate assessments of levels of infestation in commercially run hop yards are necessary to provide a basis for the advice dispensed and the strategies devised to keep aphids and spider mites in check.

To this end, in the period June 1 to August 3, 2015, assessments were carried out on 10 different dates, at weekly intervals, in 30 representative hop yards (various different varieties) in the Hallertau region (22), Spalt (5), and Hersbruck (3) to scout for infestation by the hop aphid and the two-spotted spider mite, and thus to determine the average level of infestation by the aphids (counts) and the spider mites (infestation index).

The findings obtained found their way into advisory recommendations and control strategies.

5.5.3 Multiple-laboratory ring analysis for quality assurance in determining alpha acids content for hop supply contracts

For years, hop supply contracts have included a rider linking payment to the alpha acids content of the consignments of hops delivered. Apha acids content is determined in state-run laboratories, production labs, and private laboratory facilities, depending on the testing capacity available. The procedure (sample division, storage) is explicitly laid down in the specification of the Arbeitsgruppe für Hopfenanalytik (*WG Hop Analytics),* which also specifies which labs conduct the analysis reliability checks, and gives the tolerance ranges permitted in the analysis results. With the aim of guaranteeing the quality of alpha acids analytics in the interests of hop growers, the multiple-lab analysis is organized, conducted and evaluated by the Bayerische Landesanstalt für Landwirtschaft in its capacity as a neutral body.

The role of the Hopfenring within the project is to take samples from 60 randomly chosen batches of hop on 9 or 10 different dates in the Hallertau region and hand them over to the LfL laboratory at Hüll.

5.6 Advisory service and training activities

Apart from conducting applied research into the technical aspects of production in hop growing, the remit of AG Hopfenbau/ Produktionstechnik (IPZ 5a) (*WG Hop Cultivation/ Production Techniques)* also includes processing test findings for practical implementation and providing support for hop farmers by dispensing specialist advice, running instruction sessions, study groups, training courses and seminars, giving lectures and talks, and making available press publications, both direct and via the internet. Organizing and running the downy mildew warning service and keeping warning service information updated are also part of their remit, as is collaborating with the various hop organizations, or offering training and expertise in support of their joint advisory service partners at Hopfenring (hop growers' syndicate).

The training and advisory activities carried out last year are outlined as follows:

5.6.1 Information in written form

- The *Green Pamphlet* Hop (das *Grüne Heft* Hopfen) for 2015 – hop growing, varieties, fertilization and plant protection management, harvest – was brought up to date in cooperation with AG Pflanzenschutz (*WG Plant Protection),* and in coordination with the information centres of the Federal States of Baden-Württemberg and Thuringia. A total of 2 420 copies were distributed to ÄELF and research facilities by the LfL, and to hop growers by Hopfenring Hallertau.
- Current information on hop growing and the warning service alerts were sent out to hop growers in 29 faxes via the Hopfenring multiple recipient fax (2015: 48 faxes in the Hallertau region + 1 for Spalt with 1 208 participants).
- In the context of the N_{min} soil audit, 2 848 results were checked for plausibility and cleared for dispatch to hop growers.
- Advisory service information and specialist articles for hop growers were published in 2 ER Hopfenring circulars and also in 8 monthly issues of the *Hopfen Rundschau.*

5.6.2 Internet and intranet

Warning service and advisory service information, specialist articles, and lectures were made available to hop growers via the internet.

5.6.3 Telephone advisory and information services

- The downy mildew warning service was set up for the period May 12 to August 31, 2015, by AG Hopfenbau/ Produktionstechnik (*WG Hop Cultivation/ Production Techniques*) in Wolnzach, in collaboration with AG Pflanzenschutz (*WG Plant Protection*) at Hüll and updated 76 times, for access on request, either via answerphone (on 08442/9257-60 and -61), or via the internet.
- The specialists from AG Hopfenbau/ Produktionstechnik supplied answers over the phone to very specialized questions regarding hop growing, in approximately 2 100 cases, or delivered advice in individual consultations and on the ground.

5.6.4 Lectures and talks, conferences, guided tours, training courses and meetings

- Weekly exchange of information during the growing season with the Hopfenring specialist advisors
- 9 hop cultivation meetings in conjunction with the ÄELF
- 55 specialist lectures
- 12 guided tours of trial sites for hop growers and the hop industry
- 5 conferences, trade events or seminars

5.6.5 Basic and continuing training courses

- Setting assignments for, and examining, 5 work projects as part of a master's certificate (vocational) exam
- 11 instruction sessions at the Landwirtschaftsschule (*Agricultural College*) Pfaffenhofen for students studying hop cultivation
- 1-day course in the summer term at the Pfaffenhofen Agricultural College
- Exam preparation for, and examinination of, agricultural trainees specializing in hop cultivation
- 1 informational event for vocational school students from Pfaffenhofen
- Running a BiLa seminar *Hop Cultivation* on 4 evenings
- 6 meetings of the study group *Hop Management*

6 Plant Protection Management in Hop

LD Wolfgang Sichelstiel, Dipl.-Ing. agr.

6.1 Pests and diseases in hop

6.1.1 Aphids

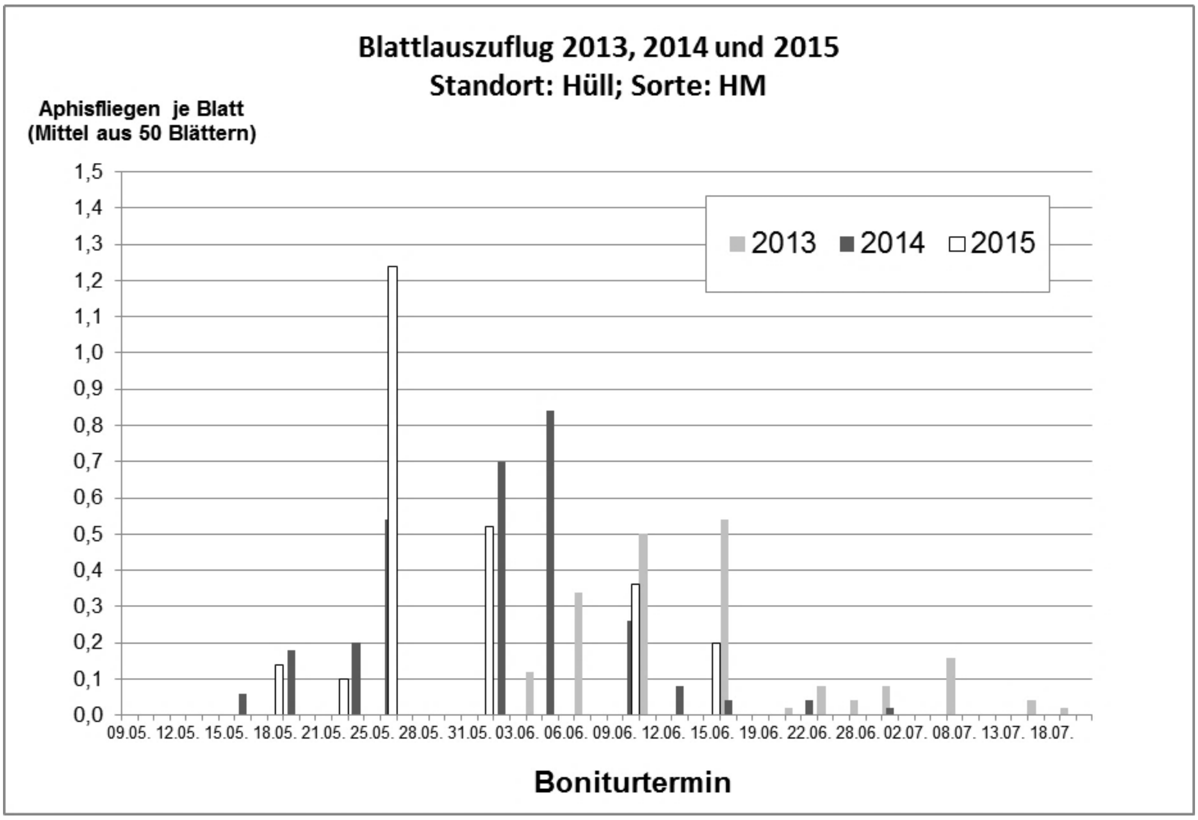


Fig. 6.1: Aphid migration

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

Date	Aphids per leaf			Spider mite index per leaf		
	Ø	min.	max.	Ø	min.	max.
01.06.	1,09	0,00	15,68	0,02	0,00	0,30
08.06.	4,49	0,00	96,80	0,03	0,00	0,20
15.06.	13,24	0,00	365,50	0,04	0,00	0,30
22.06.	1,32	0,00	6,92	0,08	0,00	0,70
29.06.	0,83	0,00	7,38	0,11	0,00	0,85
06.07.	0,15	0,00	1,34	0,10	0,00	0,85
13.07.	0,08	0,00	1,82	0,09	0,00	1,25
20.07.	0,03	0,00	0,66	0,05	0,00	1,05
27.07.	0,00	0,00	0,04	0,06	0,00	0,85
03.08.	0,01	0,00	0,06	0,02	0,00	0,50
	Main treatment dates June 16 – 30 and July 10 – 18 25 locations left untreated			Main treatment dates June 30 – July 24 2 locations left untreated		

As in the previous year, damage caused by hop aphid migration was very slight in 2015 and occurred only in isolated cases, so that very often no treatment was required at all. Over 80% of the hop yards under observation as part of the monitoring programme were completely free of aphids. Just under one fifth of the monitored areas exhibited slight to moderate infestation, so that spraying could be at least be justified – if only to be on the safe side.

The two-spotted spider mite, on the other hand, was able to take advantage of the cool weather conditions in May and June of 2015, and became established, albeit only sporadically at first, in the 30 monitored crops. It was not until the second half of June that increasing levels of infestation were recorded in many yards, but a single treatment succeeded in keeping it under control in almost all of them. In fact, two hop yards remained pest-free and needed no treatment at all. In one crop a second spider mite treatment was necessary.

6.1.2 Downy mildew

Tab. 6.2: Warning service for downy mildew and powdery mildew

Fax No.	Date	Info: primary downy mildew	Spray alerts			Powdery mildew
			Susceptible cultivars	All cultivars	Late cultivars	
15	06.05.	xxx				
17	12.05.	xx				
19	18.05.	xx				
20	28.05.	xx				x
21	10.06.			x		
25	25.06.					susc. cvs.
26	30.06.		x			
28	08.07.					susc. cvs.
32	20.07.					susc. cvs.
37	21.08.					susc. cvs.
38	09.09.		x		x	susc. cvs.
Number of spray alerts			2	1	+2	6

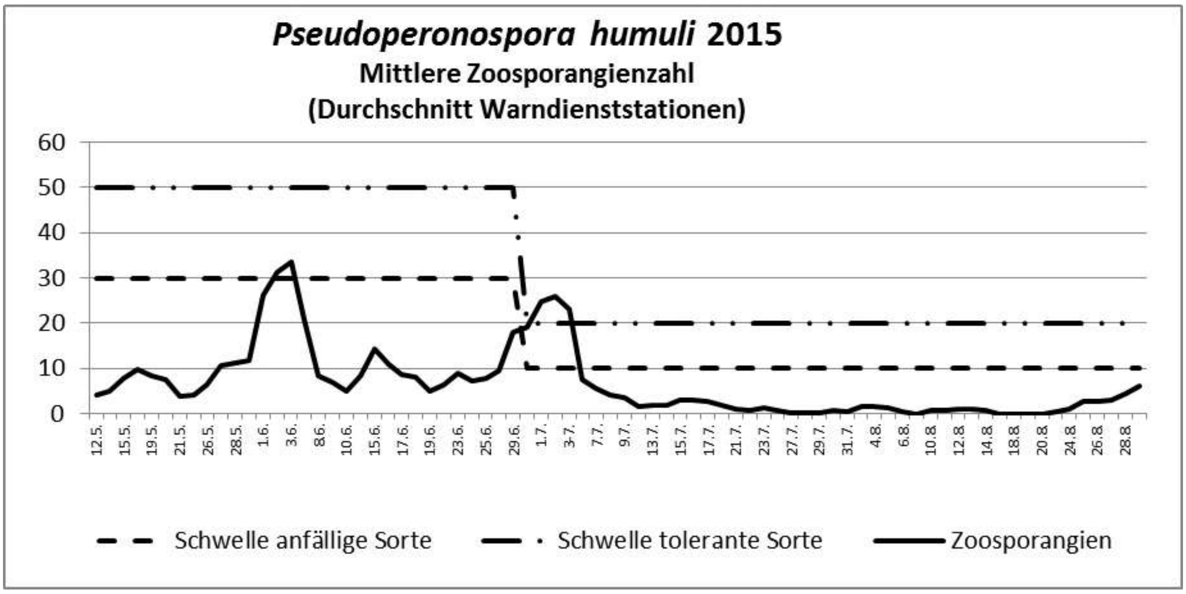


Fig. 6.2: Downy mildew warning service – zoosporangia migration

6.2 Deployment and establishment of predator mites for sustainable spider mite control in hop as a special agricultural crop

Objective

The two-spotted spider mite, *Tetranychus urticae,* is one of two major pests that infest farmed hops. In an attempt to keep it in check, acaricides are spread over large swathes of the hop-growing acreage, usually as a purely preventive measure. This happens regularly, not only in Germany but also throughout Europe, and in most other parts of the world. Sustainable spider mite control by means of populations of predator mites established in the crop, as is often practised in wine and fruit growing, is at present not viable in hop growing, because the parts of the plants above ground are more or less completely removed during harvesting, leaving no canopy where the beneficial insects can overwinter. However, in recent years, preliminary trials at Hüll have shown that using purpose-bred predator mites to suppress spider mites can deliver satisfactory results in hops.

One of the objectives of the pilot project, which has now been running for three years (approval for a follow-up project is already being sought), is to optimize deployment of purpose-bred predator mites in farmed hops. For this purpose, different methods of deployment and different species of predator mites from various different sources are being trialled and the results compared. Furthermore, the main aim of the project is to develop a standard method of creating winter habitats for the predators in undersown ground cover in the tractor lanes, which will enable indigenous species to maintain established populations over several growing seasons.

Fig. 6.3: Tall fescue grass (Festuca arundinacea) as crop-forming undersown ground cover in the tractor lane in the trial yard at Hüll after harvest in the autumn of 2014

Methods

As part of the project, structured trials in a total of 5 hop yards have been set up under conditions similar to those typical in commercial practice. Two of the yards are conventionally managed (located in: Hüll and Oberulrain) and two are organic hop farms (located in: Ursbach and Herpersdorf near Hersbruck). In different plots in 3 yards, a variety of ground cover crops were undersown, in particular tall fescue grass (*Festuca arundinacea),* (*Fig. 6.3*.), but also grassland mixture with meadow foxtail (*Alopecurus pratensis)* and annual bluegrass (*Poa annua),* as well as strawberries (*Fragaria x ananassa),* in an endeavour to encourage the survival over the winter of the established autochthonous predator mite species (*Typhlodromus pyri, Amblyseius andersoni*) released there in the various plots. In the remaining two yards, work is being done to ascertain the optimum annual numbers required, methods of release and appropriate deployment timing for the allocthonous, but highly efficient, predator mite species *Phytoseiulus persimilis* and *Neoseiulus californicus.* The different variants are assessed every two weeks during the growing season and then evaluated in an annual experminental harvest in each yard.

Results

In the three years of trials to date, work on the project has been hampered by the fact that, in 2013 and 2014, infestation pressure of the spider mites in the 5 trial yards was so low that virtually no results relevant to the key issues were established. It was not until the hot weather period in 2015 that spider mite populations actually developed in 3 of the 5 trial yards, allowing conclusive results to be obtained. In fact, about 80% of the trial plots in the conventionally managed trial yard in Oberulrain were sadly a write-off. Far better results were achieved at the site near Hersbruck and at Hüll. The latter are shown in the chart below and serve as an example:

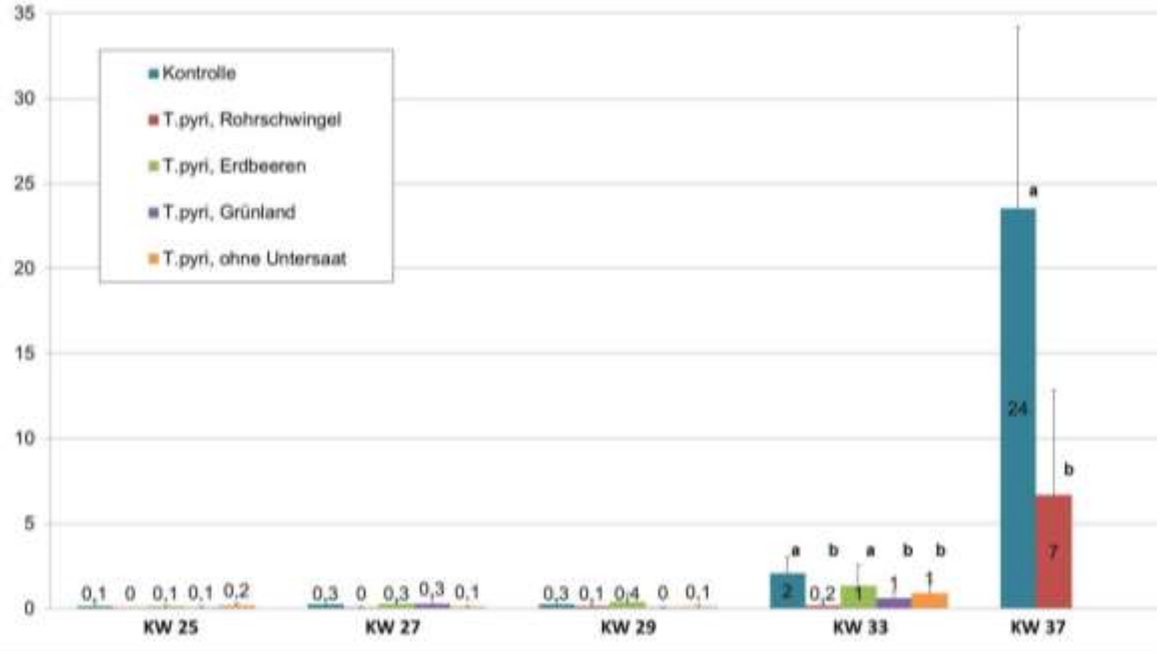


Fig. 6.4: Population development in 2015 (spider mites per leaf; n= 120) at Hüll site, cultivar HS. Variants: control, T.pyri + tall fescue grass, T.pyri + strawberries, T.pyri + grassland, T. pyri without ground cover. a,b: significant differences as per ANOVA (p = 0.5)

The predator mites, in this case, *T. pyri*, were distributed on wood chips from vineyards in the 22nd calendar week, before any spider mites were found. The first assessment took place in calendar week 25, infestation levels being between 0 (*T. pyri* and tall fescue grass) and 0.2 (*T.pyri* without undersown ground cover) spider mites per leaf, a degree of infestation that remained at a constant low until week 29. It was not until week 33 that the variants deviated, and, despite the low level of infestation, statistically significant differences were visible in 3 trial variants, by comparison with the control. Week 37 brought even greater differences, and, at the time of the final assessment, infestation in the control, at 24 spider mites per leaf, was approximately 3.5 times higher than in variant *T. pyri* and tall fescue grass (Fig. 6.4).

6.3 Monitoring the flight period of the Rosy Rustic moth, *Hydraecia micacea,* in hop, using lighted traps

Background

The Rosy Rustic moth is deemed only a minor pest in hop and, in the last decades, it has appeared only for limited periods of time and in only small localized numbers. However, after more and more reports of infestation by its caterpillars in 2012, more serious infestation by the moth was recorded in 2013 and 2014, resulting, in isolated cases, in significant econonomic losses. For the purpose of gathering comparative data covering incidence of the moth in hops, lighted traps were set up in 2015, in the same place for the third year running, as a means of monitoring the flight period.

Material and methods

In early August 2013, a lighted trap equipped with black light tube and twilight switch was installed for the first time at a height of 2 m on the edge of a hop yard near Steinbach (rural district of Kelheim), in parts of which over 50% of the plants had been affected that year. The trap was hung up in the field as early as June 25 in 2014, and from June 28 in 2015. The trap container was emptied daily. All the adult moths (imagoes) trapped were then identified and counted.

Results

A decision was made at short notice in 2013 not to start trapping the moths until the beginning of August and, as the graph in Fig. 6.5 shows, the start of the flight period was missed that year as a result. The maximum number of individuals caught in one night was 55 moths, the total for that year was 576. In the following year, 2014, thanks to early commencement of the study, it was possible to record the actual start of the flight period on July 20. The number caught then declined to a maximum of 7 moths per night and a total of 94 moths for the whole year. In 2015, the first moth was caught on July 31, the maximum catch in one night was 4 moths, and the total for the year was as low as 17. The flight period continued until the end of September in all three years. The findings show that the flight period of the Rosy Rustic moth, and the accompanying egg deposition necessary to ensure infestation the following year, can last in the Hallertau region from mid-July to early October, with its culmination in August. The evidence suggests that, as in previous decades (1969 – 70 and 1981 – 82), the numbers tend to explode over two to three years at maximum, subsequently declining again to numbers indicative of the normal infestation levels for a minor pest.

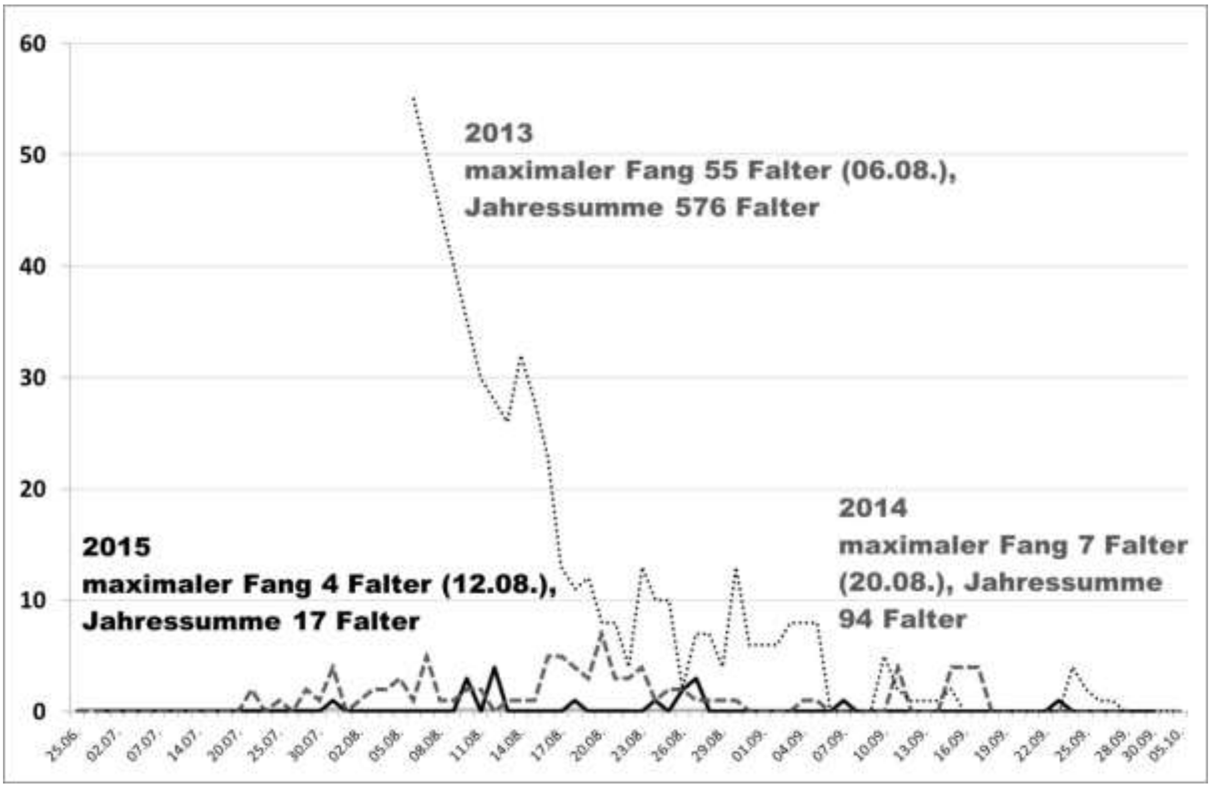


Fig. 6.5: Flight curve of the Rosy Rustic moth, Hydraecia micacea, near Steinbach, 2013 to 2015, based on the number of adult moths caught in the lighted trap

6.4 Extreme weather and hop cultivation

The year 2015 once more brought home to everyone involved in the hops sector how deeply dependent hop production is on weather conditions. The prolonged hot and dry weather produced poor harvests and low alpha acids levels throughout large parts of Europe, 2015 being the second year in five in which arid conditions caused considerable losses. The question now is: how great is the prospect of such extreme weather conditions being repeated in the future – in the light of climate change?

A collaborative project, *Agriculturally Relevant Extreme Weather and Possible Risk Management Systems,* was directed at assessing the likelihood of such occurrences in the future and the implications for German agriculture and forestry management. At the same time, the aim was to look into suitable management strategies to enable policy makers and commercial operations to cope with the changing situation. A sub-project entitled *Agriculturally Relevant Extreme Weather – Special Agricultural Crops* brought hop cultivation, too, within the scope of the project. Based on comprehensive research into the pertinent literature, a first phase identified the relevant extreme weather conditions and calculated the threshold levels for weather parameters beyond which yield and quality losses can be expected. As a result of systematic consultation and reference to expert opinion, it was possible to establish the nature of the extreme weather events, and estimate the specific thresholds, which have an impact on yields. Details of weather events known to have caused damage in the past were checked against data from the German meteorological service. In a second phase, it was possible, using this data, to draw conclusions regarding the connection between extreme weather and losses in quality and yield. Using climate modelling from the DWD (*German meteorological service*), it was also possible to make projections as to the likelihood of these extreme weather events occurring in the future.

As part of the sub-project covering hop, a commission of experts, comprised of 34 advisors, scientists, hop growers, and specialists from the hop industry, was consulted and asked to say which extreme weather events they thought impacted hop quality and yield results and what periods they considered critical. For this purpose, individual extreme weather events which pose a risk in the course of the year were put into categories and then ranked according to risk (no risk = 0; moderate risk = 1; serious risk = 2), enabling calculation of a risk score for each type of extreme event. The rankings for the Hallertau region, based on the consultation, are listed below (Tab. 6.3). In the opinion of the experts the greatest potential for damage is associated with severe drought, hail and arid conditions.

Tab. 6.3: Extreme weather ranked in order of relevance for the Hallertau region, based on consultation of experts and practitioners (n= 34)

ranked	Extreme weather event	Risk score +/- standard deviation	ranked	Extreme weather event	Risk score +/- standard deviation
1	**Serious drought**	**1.8 ± 1.1**	7	Torrential rain	6.4 ± 1.8
2	**Hail**	**2.3 ± 15**	8	Persistent rain	6.7 ± 2.1
3	**Arid conditions**	**2.9 ± 1.3**	9	Late frost	8.2 ± 1.7
4	Heat	3.7 ± 1.3	10	Early frost	10.7 ± 0.9
5	Gale-force winds	4.1 ± 2.1	11	Black/ winter frost	10.8 ± 11
6	Flooding/ waterlogging	5.9 ± 2.2	11	Wet snow	11.6 ± 0.6

In view of the months involved during which extreme weather can occur and cause damage, events like flooding, waterlogging, torrential rainstorms and persistent rainfall take on greater significance. The table in Fig. 6.7 presents the findings of the consultation.

The judgements from the experts helped to determine and underpin the defined critical threshold levels. For example, the critical aridity threshold for hop is reached when in one month the precipitation maximum is 30 mm/m², or less than 1mm of precipitation is received on 11 days. Severe drought occurs when, added to high temperatures and lack of precipitation, soil water levels fall below a usable field capacity of 35%. By defining extreme weather by means of threshold levels for each risk indicator, it is possible to work out frequency and probability of occurrence for a particular region. With the help of comparisons against past weather data and by using climate modelling from the German meteorological service, tendencies towards damaging weather events, both looking back to the past and for the future, become clear. For an overview of thresholds and extreme weather trends, please consult Tab. 6.4.

The risk of periods of severe drought, i.e. periods with precipitation of less than 1 mm and $T_{max} \geq 30$ °C lasting more than a week, increases on average as much as sevenfold between April and December, and from 0.04 times to 0.34 times over the whole period. For heat waves, too, i.e. at least 7 days with $T_{max} \geq 28$°C ; ≥ 30°C, a greatly increased risk is projected between June and August. In the past, the thresholds were exceeded with growing regularity. For the period June to August, the models show over 20 days at ≥ 28°C, and almost two weeks at ≥ 30°C by 2097, an increase of about 6 to 7 days over the course of a year. Fig. 6.6 illustrates how southern Germany is particularly badly affected.

a) 1962 - 1990 b) 1982 – 2010 c) 2071 - 2098

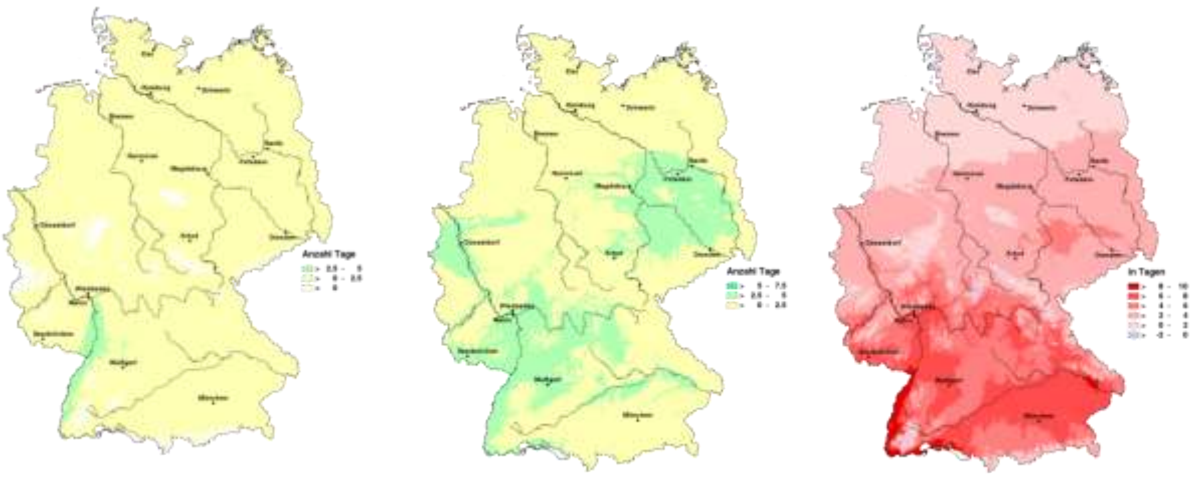


Fig. 6.6: Frequency with which Tmax ≥ 30°C is exceeded in August, in the past (a; b), and in the future (c) (trend up to 2098) – data derived from requests for access to climate models

Similarly, the future probability is increasing of over 25 mm per day of torrential rain falling between May and September, of arid periods occurring from June to August, and of incidence of moderately high winds of at least 10 m/s on a daily basis in May and September. No predictions can be made with regard to extreme events involving hail because there are no forecasting models available.

For further information on the impact on agriculture of extreme weather, please consult the final report of the collaborative project. The internet address:

http://literatur.ti.bund.de/digbib extern/dn055248.pdf.

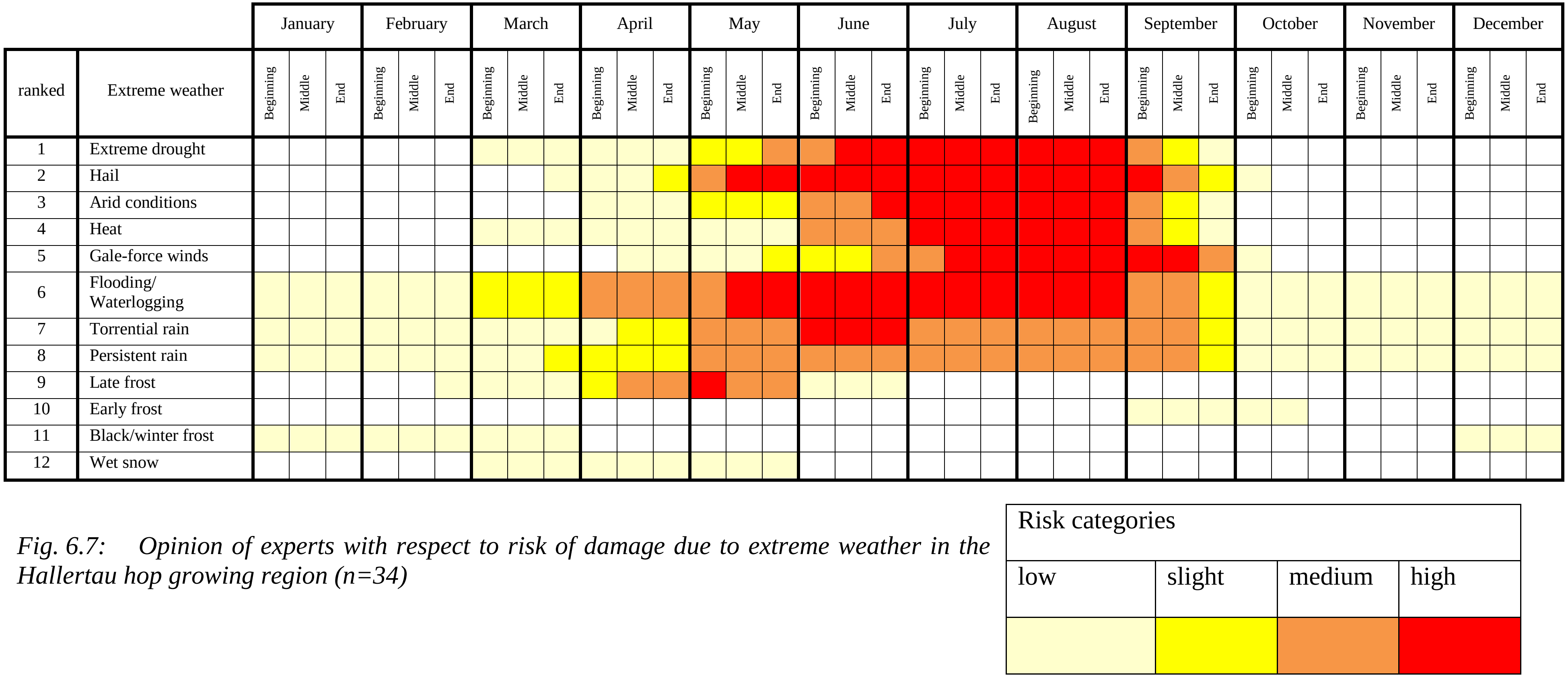


Fig. 6.7: Opinion of experts with respect to risk of damage due to extreme weather in the Hallertau hop growing region (n=34)

Tab. 6.4: Based on literature research and consultation with experts: specified threshold levels relevant to hop growing, the corresponding risk indicators, critical periods, trend in the past (change in the last 50 years, source DWD), and in the future (tendency towards change up to 2097/98, data derived from requests for access to climate model forecasts, source DWD)

	Threshold values	Risk indicator	Time period	Trend in the past	Trend in the future
Persistent rain	≥ 100 mm precipitation/m² * 1 w^{-1}	mm over ≥ 7 d	Mar -Sep	→	→
Extreme drought	nFK ≤ 35% + Tmax ≥ 30°C;	nFK (%) per d over ≥ 7 d	Apr- Sep	→↗*	↑*
	≤ 1mm precipitation/m²	Tmax (°C) per d over ≥ 7 d			
	(≥ 1 w - 2 w)	mm over ≥ 7 d			
	nFK ≤ 50%	nFK (%) per d			
Early frost	no info.	no info	no info	-	-
Hail	yes/no	hailstone size and duration	May- Sep	no forecasting models available	
Heat	Tmax ≥ 28-30°C (≥ 7 d)	° C (Tmax) over ≥ 7 d	Jun- Aug	↗	↑
Wet snow	no info	no info	no info	-	-
Late frost	Tmin ≤ -5°C	° C (Tmin) per d	Apr- May	↗	→↘
Torrential rain	≥ 25 mm precipitation/m² * h^{-1}	mm per h or per d	Mai -Sep	→↗	↗
Gale-force winds	≥ 9 Bft	max. wind force per d	Mai-Sep	→	→
Arid conditions	≤ 30 mm precipitation/m² * M^{-1}	mm per M	Jun- Aug	→	↗
(No precipitation)	< 1 mm precipitation/m² * 11 d^{-1}	mm over 11 d			
Flooding/	nFK ≥ 100% (≥ 1 w)	nFK (%) over ≥ 7 d	Mar- Sep	→↘ (Jan-Jul)**	↗ (Jan-May)**
Waterlogging				→↗ (Aug-Dec)**	
Black/winter frost	Tmin ≤ -20°C,-15°C, -10°C	° C (Tmin) per d	Jan- Apr	↘→	↘
					(→ - 10 °C Jan)
Cold snaps	Tmax ≤ 5°C	° C (Tmax) per d	Apr- Jun	↘	↘
Warm periods	Tmax ≥ 15°C - 20°C	° C (Tmax) per d	Mar-May (plant)	↗	↗
	Tmean ≥ 13°C (May)	° C (Tmean) per d	Apr-May (pest)	↗	↗

* ≤ 1 mm precipitation/m² und Tmax ≥ 30 °C, no nFK available for hop; ** Taken from requests for access to data relevant to agricultural crops - no model (nFK) available for hop

7 Hop Quality and Analytical Chemistry

ORR Dr. Klaus Kammhuber, Dipl.-Chemiker

7.1 General information

Working Group IPZ 5d carries out all chemical-analytical tests in the IPZ Hops Dept. that are needed to support issues arising from testing by the other Working Groups, especially WG Hop Breeding Research. Ultimately, hop is cultivated for its compounds, making hop analytics a key precondition for effective hop research. Present in hop are three groups of substances of value. In order of importance, these are the bitter compounds, the essential oils, and the polyphenols. Until now, the alpha acids have been considered to be the key element contributing to hop quality because they are a determinant for bittering potential; hop is added to beer on the basis of the alpha acids content (internationally, at present approx. 4.3 g alpha acids to 100 l beer). Alpha acids even play an increasingly important role in the way hops are paid for. Payment is made either by weight of the alpha acids (in kg), or based on a system specified in supplements to the supply contracts, whereby the price goes up or down according to whether alpha acids levels are above or below a specified neutral range.

Hop is generally considered to constitute the soul of a beer. It certainly fulfils multiple roles in this context (Fig. 7.1).

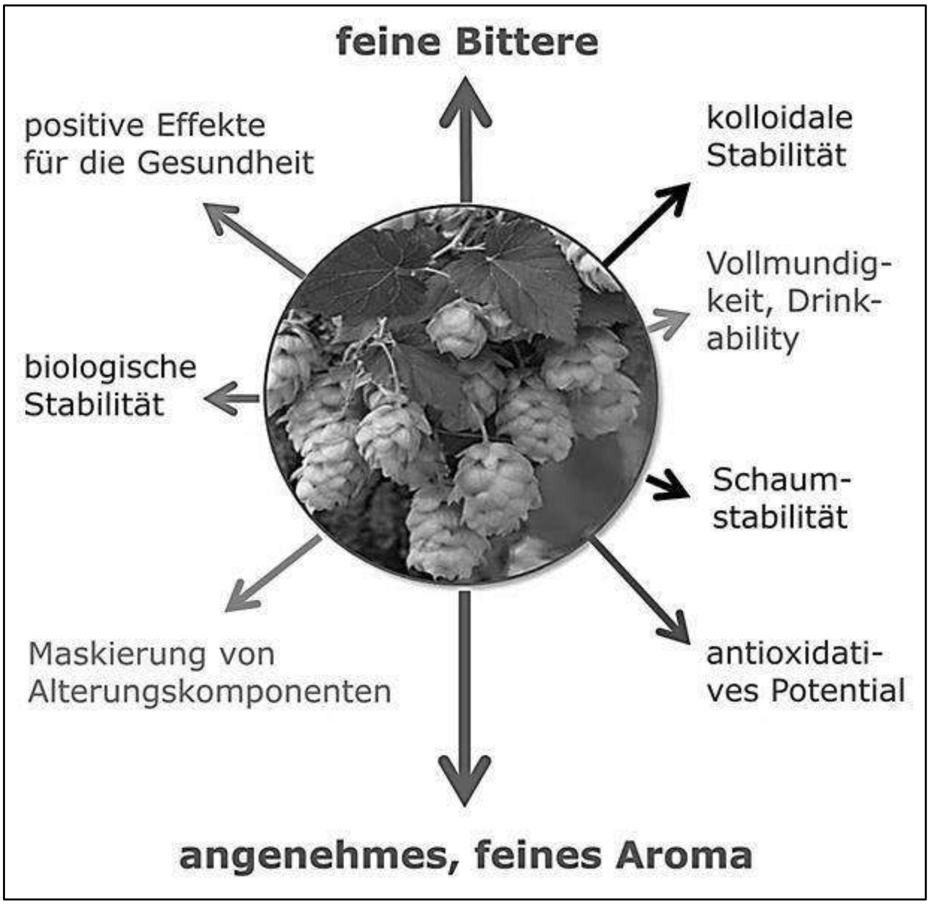


Fig. 7.1: The effect of hops in beer

7.2 The craft brewing movement - new opportunities

A new beer-brewing ideology has evolved in the USA, as a counter movement to the industrialization of beer production. The trend, known as the craft beer movement, eventually spread to Belgium, Scandinavia, and Italy, and has now reached Germany. Craft brewers want to return to producing strong-tasting beers brewed with skill and artistry. The movement has gained momentum, one positive effect being that beer is now a subject that is much more talked about. The craft brewers are looking for hops with special aromas, sometimes not even typical of hops, and these are grouped under the term *Special Flavor hops*. As a result, a more discerning appreciation of the different hop varieties and hop growing regions has developed.

Craft brewers use the technique of dry hopping, which involves adding hops, mainly on the basis of oil content, to the finished beer in the storage tanks,. The alcohol content of the beer acts as a solubilizing agent and predominantly polar substances are dissolved out of the hops. Alpha acids enter the solution only in trace amounts because they are not isomerized. Chiefly the low molecular esters and the terpene alcohols are transferred to the beer – the reason why dry hopped beers acquire fruity and flowery aroma signatures. Non-polar substances, like myrcene, are also dissolved in trace amounts. Polyphenols as a group, too, are polar, and easily soluble. The main limiting factors in dry hopping are nitrate content and water-soluble plant protection agents. On average, hop contains 0.9% nitrate, all of which is transferred to the beer. No evidence-based information is as yet available regarding input of plant protection agents. Hops used in dry hopping must meet very specific plant hygiene standards.

On the whole, the craft brewing movement represents a huge opportunity for hop growing and is set to bring about fundamental change in the hop industry. 20% of global hop production is used for 2% of world beer production. In the United States, the acreage devoted to hop increased from 12 670 hectares in 2010 to 17 815 hectares in 2015. It will be interesting to see how this development affects the German hop growing regions.

7.3 Optimization of constituent compounds as a breeding goal

7.3.1 Requirements of the brewing industry

The brewing industry accounts for 95% of hop output, making it currently the biggest consumer of hops and set to remain so in the future (*Fig. 7.2*).

Fig. 7.2: Use of hops

When it comes to hopping, brewers adhere to two completely different schools of thought. One view is that alpha acids must be acquired at the cheapest possible price, regardless of hop variety or growing region. The other view believes in encouraging beer diversity, where there is room for different hopping rates and different products, alongside an appreciation of varieties and growing regions, and where the cost factor is unimportant.

However, between these two schools of thought there are many shades of grey. The requirements of the brewing industry and the hop trade with regard to the constituent compounds in hop are changing continually. However, the concensus is that breeding programmes need to produce hops with the highest possible alpha acids levels capable of remaining as stable as possible in spite of the fluctuations in the crops from year to year. A low concentration of cohumolone is no longer deemed important as a quality criterion. In fact, in the context of downstream and beyond brewing products there is even a demand for high alpha varieties with high cohumulone levels.

7.3.2 Requirements of the craft brewers

Craft brewers are more interested in the aroma-active compounds. The essential oils in hop are composed of approx. 300 – 400 single different substances. There are many synergies. Some substances are perceived as being intensified, others cancel each other out. The sense of smell is a subjective perception, in contrast to chemical analysis, which delivers objective data. However, key substances need to be defined so that the quality of their aroma can be characterized analytically. Substances such as linalool, geraniol, myrcene, low molecular esters, and sulphur compounds are important for hop aroma. Craft brewers want hops with ‘exotic aromas’ like mandarin orange, melon, mango or redcurrant.

7.3.3 Alternative applications

To date, only 5% of the hop harvested is used in alternative applications, but there is scope for expansion in this area. The usefulness of the hop plant is not only confined to the cones, the other parts of the hop plant can also be put to good use. The woody inner parts of the hop bine, known as shives, make good material for safety insulation purposes and in composite insulation mats, thanks to their good insulating properties and excellent mechanical strength. The fibres can also be processed for use in moulded parts, for example as door panelling for cars. As yet, no large-scale technical applications have presented themselves. AUDI are interested in exploring the possibility of using the tannins from hop leaves for tanning leather. Tests are currently being carried out.

Where the cones are concerned, it is, above all, the antimicrobial properties of their bitter compounds that lend themselves best to alternative uses. The bitter compounds already have antimicrobial and preservative properties in catalytic amounts (0.001 – 0.1 % by weight), in the following ascending order: iso-α acids, α acids, and ß acids (*Fig. 7.3*).

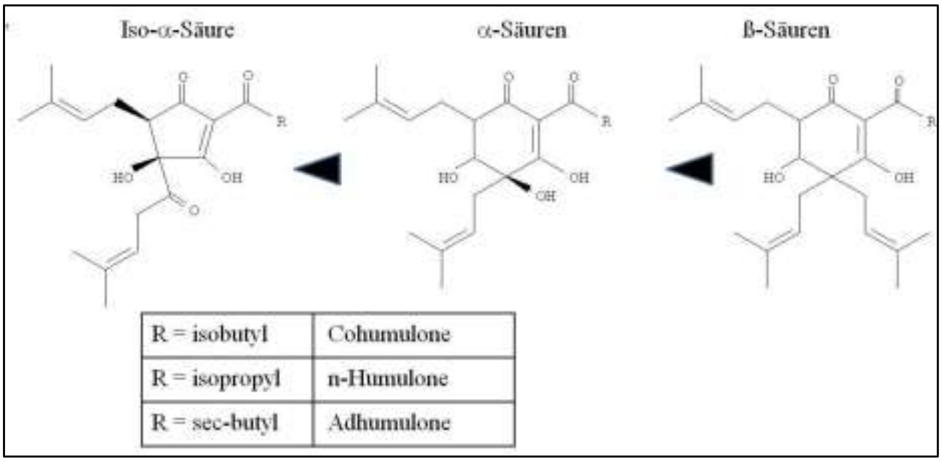


Fig. 7.3: Sequence of antimicrobial activity of iso-α acids, α acids and ß acids

They destroy the pH gradients at the cell membranes of bacteria, rendering the bacteria unable to absorb nutrients, with the result that they die. In fact, the iso-α acids in beer protect against *helicobacter pylori*, a bacterium which can trigger stomach cancer. The ß acids are especially effective against gram-positive bacteria such as listeriae and chlostridiae and in inhibiting growth in *mycobacterium tuberculosis.* This effect can be put to good use and bitter compounds can thus be employed as natural biocides wherever bacteria need to be kept at bay. In the sugar refining and ethanol industries, formalin is already successfully being replaced by ß acids. Thanks to their antimicrobial function, further possible applications are: use as a preservative in the food industry (for fish, meat and dairy products), in sanitization of biogenic waste (sewage sludge, compost), removing mould, improving hygiene and odours in animal litter, controlling allergens, and as an antibiotic in animal feed. In the future, it is likely that hop will be in greater demand for these applications. With a view to meeting this demand, Hüll is breeding for higher ß acids levels. The present record is approx. 20%. There is actually a breeding line that produces only ß acids and no α acids.

Hop is also of considerable interest to the health, spa, food additive, and functional food sectors, because it contains a large number of polyphenolic substances. With a polyphenol content of as much as 8%, hop is a polyphenol-rich plant. Work is currently being done to raise the xanthohumol levels. A breeding line with a xanthohumol content of 1.7% already exists. Other prenylated flavonoids, e.g. 8-prenylnaringenin (one of the most potent phytoestrogens) are present in only trace amounts in hop. Substances with a very high antioxidative potential are oligomeric proanthocyanidins (up to 1.3%) and glycosidically bound quercetin (up to 0.2%) and kaempferol (up to 0.2%). Multifidols are one of the principal components of hop, at up to 0.5% content. The name is derived from the tropical plant *jatropha multifida* – the compounds are found in its sap. The chemical structures are shown in *Fig. 7.4.* Multifidol glucoside itself has structure A. Mainly the B compound is contained in hop; the A and C compounds are also present, but in lower concentrations.

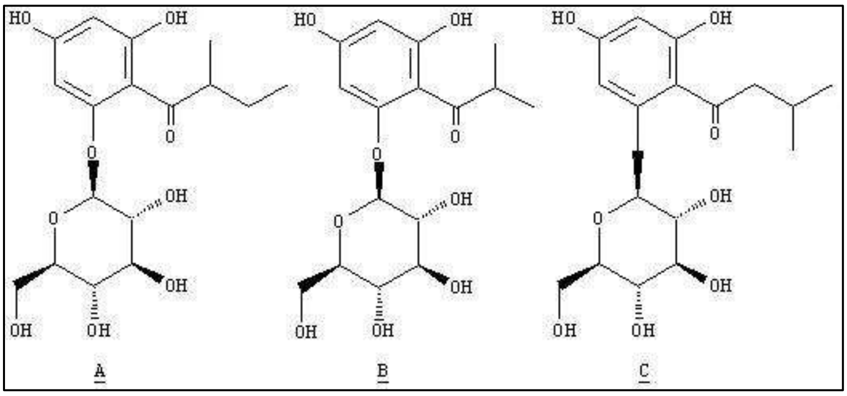


Fig. 7.4: Chemical structures of the multifidols

These substances could also be of interest to the pharmaceutical industry because of their anti-inlammatory properties.

In general, aroma hops have a higher polyphenol content than bittering hops. If specific components are called for, Hüll can respond at all times by breeding for the substances of interest in collaboration with WG Hop Quality/Analytics.

7.4 Global hop varieties

The essential oils from the global range of hops are analysed every year, using headspace gas chromatography; the bitter compounds are analysed via HPLC. Hüll has now switched to the new gas chromatography/mass spectrometry system, which meant that methods first had to be adapted to suit the new system and then optimized. For this reason, the chart for the global hop range for 2014 will not be published. After the 2015 harvest, the list will be available again on a regular basis.

7.5 Improving aroma analysis using the new gas chromatography/ mass spectrometry system

7.5.1 Sensory and chemical-analytical characterization

Why do we need expensive and complex chemical aroma analysis for hop? Obviously, the consumer relies on his/her own perception as the crucial factor in the decision about whether he/she finds food acceptable or not. Sensory perception, however, is always highly subjective. Generally speaking, aroma impressions can be characterized in two ways (*Fig. 7.5*).

Directly:
objective,
uses simile,
qualified,
specific,
didactic,
effective

Indirectly:
subjective,
emotional,
inventive,
uses metaphor,
allusive,
affective

Fig. 7.5: Sensory aroma characterization

In describing aroma impressions indirectly, metaphors are often used to compare them with other sensory impressions. The indirect way of speaking is imaginative and subjective, but subjective impressions can be understood in very different individual ways. They also very often convey personal and emotional content. This kind of language is frequently used in advertising and the media. Direct descriptions, in contrast, are less emotional and more objective. The comparisons are more concrete, relate more to the real world, and are easier to understand. A direct way of speaking is unquestionably more suited to conveying and communicating factual knowledge. Analytical chemistry concerned with aroma delivers qualitative as well as quantitive information about aroma compounds. (Fig. 7.6).

Concentrations of aroma compounds (qualitative and quantitative):
Objectification of the sensory impression,
scientific understanding of the background,
sensory evaluation and interpretation of the

Fig. 7.6: Aroma characterization using chemical-analytical techniques

Chemical aroma analysis is carried out with the aim of objectifying sensory impressions and helping to understand the science behind sensory analysis. To do this, it is important to analyse and interpret the data so that correlations can be made between analytical chemistry and sensory impressions. Some substances are key substances, yet it is also important to look at aroma holistically. Some aroma compounds synergize between themselves, some are intensified in their effect, others cancel each other out. As is the case with bittering agents, the matrix effects of the beer also play a part.

7.5.2 Chemical-analytical techniques in identifying aroma

Since April 2014, the lab at Hüll has been equipped with a gas chromatography/mass spectrometry system, with the aid of which they are now able to identify aroma compounds and characterize them in greater detail and depth. *Tab. 7.1* is a list of the substances which have been identified so far.

Tab. 7.1: Substances identified using the GC/MS system

Substance	RT	**Substance**	RT
2-Methyl-4-pentanone	10.36	S-Methyl thio isovalerate 2	23.12
3-Methyl-2-pentanone	10.58	Pentyl furan	23.41
α-Pinene	10.85	Trans-ß-ocimene	23.60
α-Thujene	11.02	Ethyl hexanoate	23.75
2-Methyl-3-buten-2-ol	11.48	Unidentified 1	24.20
Camphene	12.44	γ-Terpinene	24.35
Dimethyl disulphide	13.05	Methyl isoheptanoate	24.40
Propionic acid isobutyl ester	13.15	2-Methyl-1-pentene-3-ol	24.65
Hexanal	13.44	ß-Ocimene	25.00
Isobutyl isobutyrate	13.62	Methyl heptanoate	25.55
ß-Pinene	14.10	p-Cymene	26.55
Isobutanol	14.40	ß-Terpineol	27.40
Isoamyl acetate	15.40	2-Methyl butyl 2-methyl butyrate	27.42
3-Penten-2-one	16.45	Enanthic acid methyl ester	28.05
S-Methyl thiobutyrate	16.60	S-Methyl thio isovalerate 2	23.12
Myrcene	18.00	Tridecane	28.45
Butyric acid-2-methyl-isobutyl ester	19.20	Amyl isovalerate	28.64
α-Terpinene	19.35	2-Octene-4-one	29.05
Hexanoic acid methyl ester	20.00	Acetol	29.58
Propionic acid-(2)-methyl butyl ester	20.20	3-Methyl-2-buten-1-ol	30.68
2,3-Dimethyl-3-buten-2-ol	20.38	Int. standard	31.60
3-Methyl butyl isobutyrate	20.48	2-Pentenoic acid 3-ethyl methyl	31.80
Limonene	20.58	Methyl-2,4-dimethyl heptanoate	31.92

Substance	RT	**Substance**	RT
2-Methyl butyl isobutyrate	20.70	6-Methyl-5-hepten-2-one	32.05
Prenal	21.40	Methyl 6-methyl heptanoate	32.25
ß-Phellandrene	21.40	1-Hexanol	33.00
2-Methyl butanol	21.74	S-Methyl hexanethionate 2	33.00
S- unidentified	22.47	Unidentified	34.07
Isocyclocitral	34.55	2-Undecanone	46.94
acetic acid heptyl ester	34.70	ß-Cedrene	48.35
Dimethyl trisulphide	35.15	2-Methyl-3-pentanol	48.60
4-Mercapto-4-methyl-2-pentanone	35.40	Isobutyric acid	48.75
3-Hexenol	35.45	alpha-Bergamotene	49.10
2-Nonanone	35.75	ß-Cubebene	49.50
Caprylic acid methyl ester	35.90	ß-Caryophyllene	49.90
Nonanal	36.10	ß-Caryophyllene_int	49.90
Alloocimene	36.21	Undecanone	50.03
S-Methyl-hexanethionate	36,70	Aromadendrin	50.45
Citronellol	36.85	5,5-Dimethyl furanone	50.74
Perrilene	38.07	4-Decanoic acid methyl ester	51.74
Caprylic acid ethyl ester	39.20	Methyl geranate	52.10
Propionic acid heptyl ester	39.50	Undecanoic acid methyl ester	5323
Isobutyric acid heptyl ester	39.60	2-Dodecanone 2	53.51
Pelargonic acid methyl ester	39.86	Farnesene	54.13
1-Octen-3-ol	40.14	Humulene	54.35
α-Cubebene	40.50	4,7-Selinadien	54.70
Ylangene	42,24	γ-Muurolene	55.45
Citronellal	42.32	Cedrene	55.58
alpha-Copaene	42.85	Methyl 7,8-octadecadienoate	55.70
Pelargonic acid methyl ester	43.08	Viridiflorene	55.84
2-Decanone	43.20	Methyl geraniate	55.94
ß-Citral	43.84	2-Dodecanone 1	56.40
Farnesol	43.84	Valencene	56.75
S-Methyl heptanethionate	44.00	Epizonarene	56.85
ß-Bourbonene	44.60	α-Copaene	57.05
2-Nonanol	44.9	ß-Selinene	57.27

Substance	RT	**Substance**	RT
Benzaldehyde	45,29	Zingiberene	57.39
α-Gurjunene 1	45,34	α-Selinene	57,56
Methyl-4-nonenoat	45.40	Citral	58.06
Isobutyric acid octyl ester	46.40	α-Gurjunene 2	58.07
Linalool	46.70	α-Farnesene	59.00
Geranyl vinyl ether	46.88	Geranyl acetate	59.46
ß-Cadinene	59.50	Elixene	63.92
y-Cadinene	59.63	Calamenene	64.20
3,7-Selinadien	59.86	Geraniol	64.95
Curcumene	60.55	Tetradecanone	69.49
Methyl salicylate	60.79	α-Calacorene	69.51
α-Cadinene	61.01	2-Pentadecanone	71.60
α-Muurolene	61.61	Heptanoic acid	72.00
3,6-Dodecadioic acid methyl ester	61.96	Caryophyllene oxide 1	73.00
Tridecanone	62.67	ß-Santalol	74.50
Geranyl isobutyrate	62.84	Humulene-2-epoxide	75.52

RT = retention time

To date, a total of 143 substances have been identified, probably constituting more than 99% of the quantitatively predominant oil components in hop. Some entirely new substances have also been discovered, which have not yet been characterized in the relevant literature, for example perrilene, bergamotene, santalol etc.

7.5.3 Analysis of sulphur compounds

Sulphur compounds are present in the essential oils contained in hop only in trace amounts. However, they have significance for sensory impressions because their odour threshold values are very low. Sulphur compounds play a key role in Special Flavor hops. They can be measured highly selectively, using a flame photometric detector because, when sulphur atoms burn, they emit light with a wavelength of 394 mm (*Fig. 7.7*).

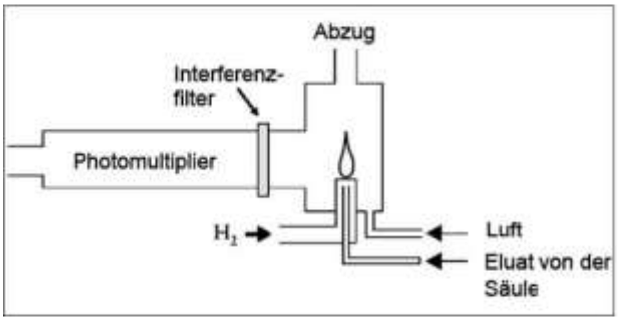


Fig. 7.7: Principle of a flame photometric detector

Fig. 7.8: A chromatogram of *Polaris*

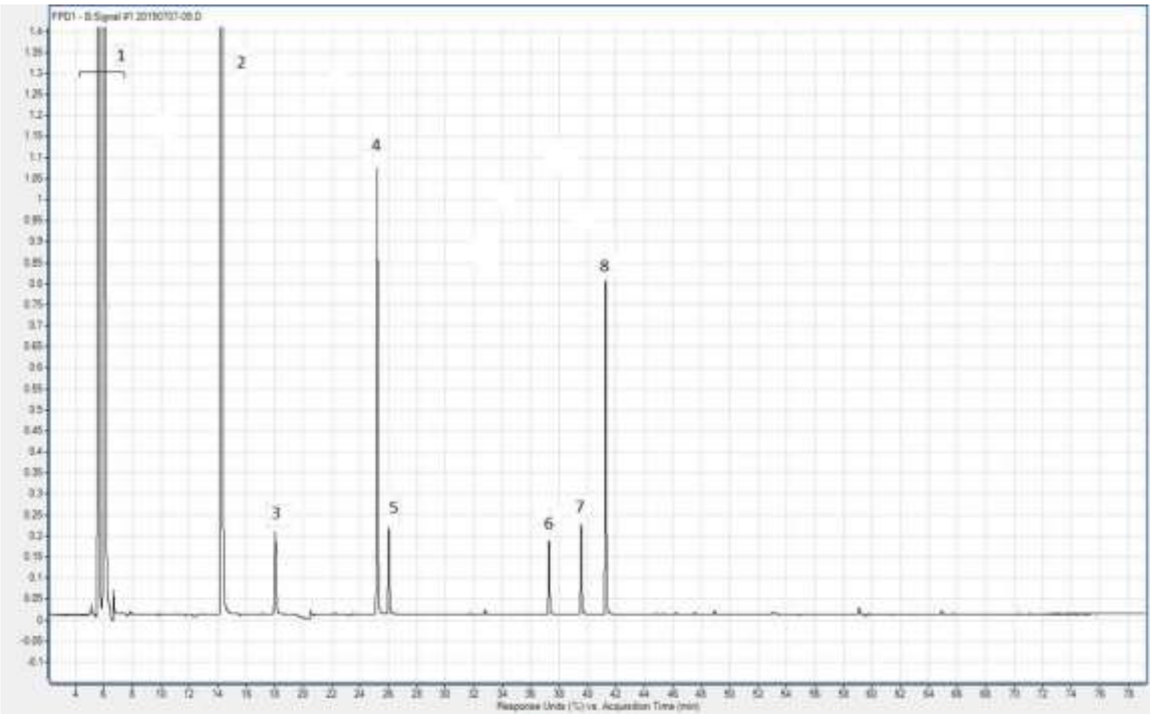


Fig. 7.8: Sulphur compounds in Polaris

It is immediately apparent that the hop does not have very many main sulphur compounds. They were clearly identified with the help of pure substances and comparisons with the mass spectra (*Tab. 7.2*).

Tab. 7.2: Main sulphur compounds in hop

1)	H_2S, methyl mercaptan, dimethyl sulphide
2)	Dimethyl disulphide
3)	S-Methyl thio butyrate
4)	S-Methyl thio isovalerate (isomer)
5)	S-Methyl thio isovalerate
6)	S-Methyl thio hexanoate (isomer)
7)	4-Mercapto-4-methyl-2-pentanone (blackcurrant)
8)	S-Methyl thio hexanoate

When the chromatogram is shown with higher sensitivity, it is possible to see that a few smaller peaks are still present, but it will be very difficult to identify them because they can no longer be detected in the mass spectrometer.

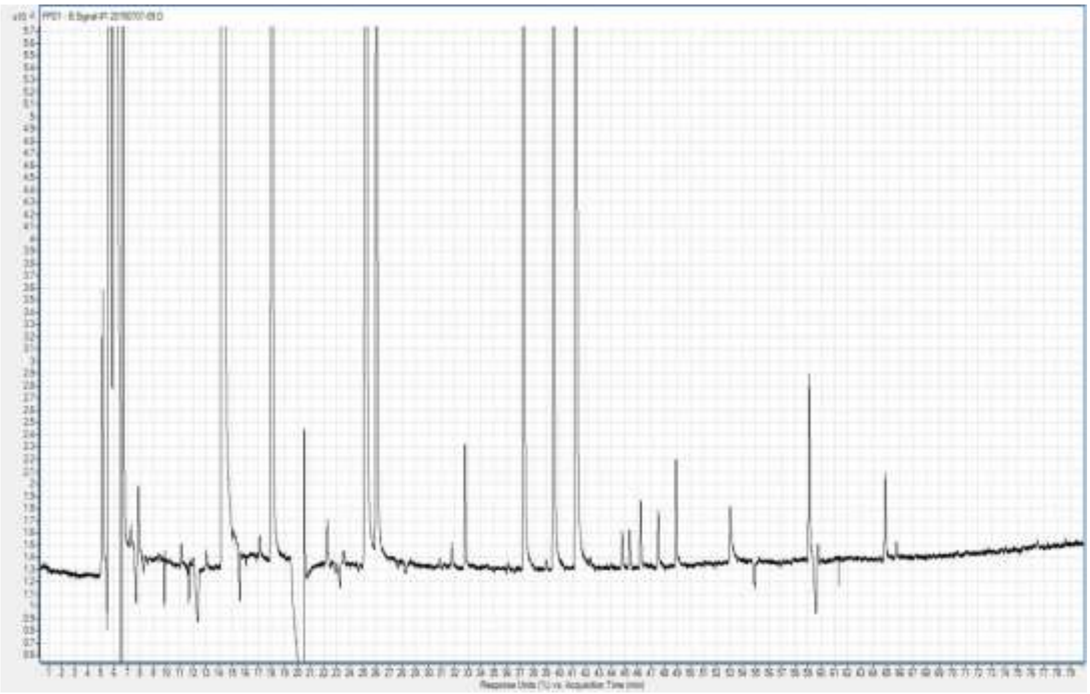


Fig. 7.9: Sulphur compounds in Polaris (higher resolution)

The very small peaks are concentrated in the ppb range and it is doubtful whether these secondary sulphur compounds contribute anything to sensory impressions.

A flame photometric detector is not really suitable for quantitative evaluations, because it does not produce linear signals. Fig. 7.10 shows a relative qualitative comparison between 4-MMP (4-mercapto-4-methyl-2-pentanone) in the new Hüll Special Flavor hops and in *Cascade*.

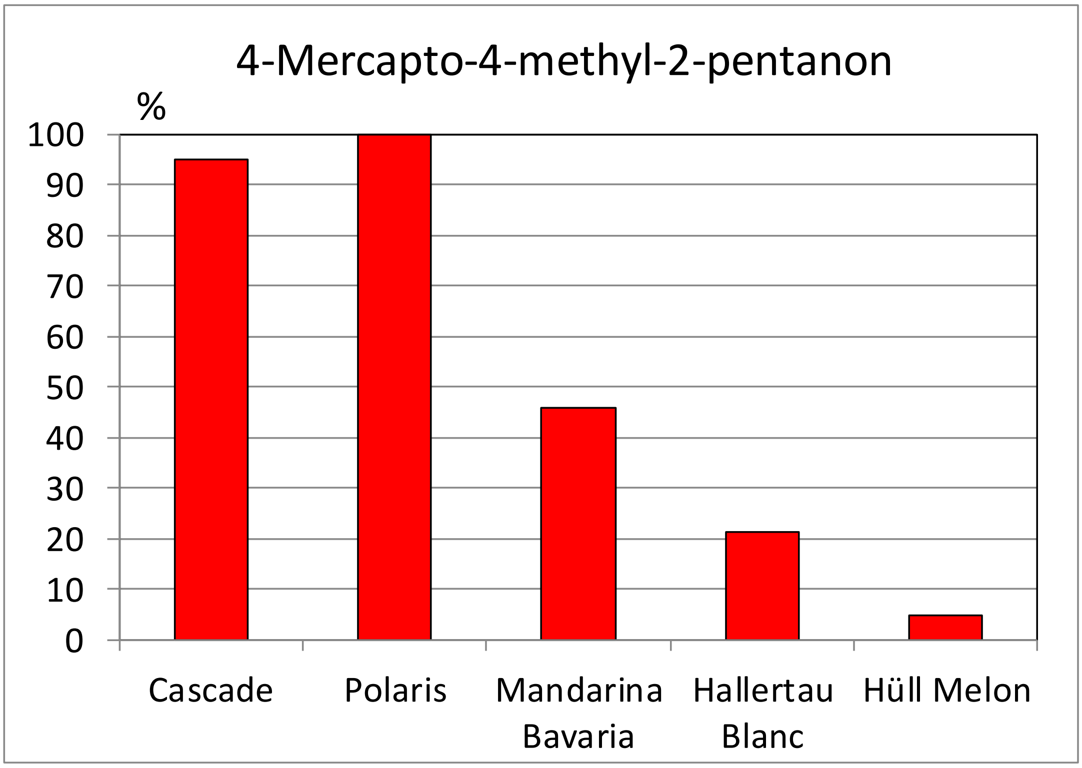


Fig. 7.10: Relative 4-MMP content in new Hüll Special Flavor hops compared to Cascade

4-MMP is not only present in *Cascade*, it is also found in the new Hüll Special Flavor hops. *Polaris* seems to contain more 4-MMP than *Cascade*. A systematic analysis of the world hop range will almost certainly produce some surprises.

7.5.4 Looking into biogenesis of sulphur compounds (Mr. Hundhammer, Diploma dissertation)

According to Kishimoto, the 4-MMP content in the American *Cascade* is greater than in the same type grown in Germany. The reason is that products containing copper are used in Germany but not in the USA. Copper can bind thiols – a fact that has long been known from experience in wine growing. However, a first task was directed at establishing whether sulphur compounds are also influenced by harvest timing. Since it was also planned to provide quantitative details, the substances chosen were dimethyl sulphide, S-methyl thio isovalerate, 4-mercapto-4-methyl-2-pentanone and S-methyl-thio hexanoate (*Tab. 7.3*). Standards for quantitative determination are available for these substances.

Tab. 7.3: Sulphur compounds examined

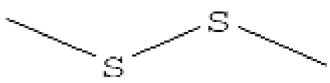
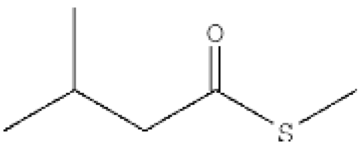
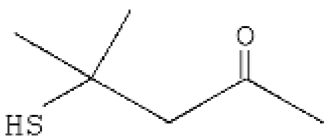
Substance	Formula	Characterization
Dimethyl disulphide		Dimethyl disulphide is a colourless liquid with a sulphur-type, cabbage-like smell
S-Methyl thio isovalerate		S-Methyl thio isovalerate is a clear, colourless liquid which, in concentrated form, produces lingering aroma impressions reminiscent of cheese, mushrooms or fermenting matter
4-Mercapto-4-methyl-2-pentanone		4-MMP is a key substance for blackcurrant aroma; in higher concentrations it is reminiscent of cat urine
S-Methyl thio hexanoate		S-Methyl thio hexanoate is present in its natural state in hop, but also in tropical fruits, and is used in dairies and in cheese production. It is a clear, transparent liquid with a fruity, tropical aroma.

Table *7.4* shows the cultivars and the harvest dates. The intention was to compare the new Hüll Special Flavor hops and *Cascade*.

Tab. 7.4: Selected cultivars and harvest dates (2015)

Cultivar	Location	T1	T2	T3	T4	T5	T6
Cascade	Stadelhof		25.08.	01.09.	08.09.	15.09.	22.09.
Mandarina Bavaria	Stadelhof		25.08.	01.09.	08.09.	15.09.	22.09.
Hallertau Blanc	Stadelhof		25.08.	01.09.	08.09.	15.09.	22.09.
Huell Melon	Stadelhof		25.08.	01.09.	08.09.	15.09.	22.09.
Polaris	Stadelhof	19.08.	25.08.	01.09.	08.09.	15.09.	22.09.

Quantitative evaluation was performed by means of the mass spectrometer, using the standard addition method. This method involves dividing a sample and then adding a specified amount to the compounds to be quantified, each time in increased concentrations (spiking). Fig. 7.11 gives an example – standard addition of dimethyl sulphide. Ideally, the measurement should produce linear calibration curves. Using regression analysis, it is possible to calculate the concentration of the analytes in the original sample. The optimal case would be if the concentrations for the calibration were on the same scale as the concentrations of the analytes in the sample itself. This presupposes that the content in the sample is known beforehand.

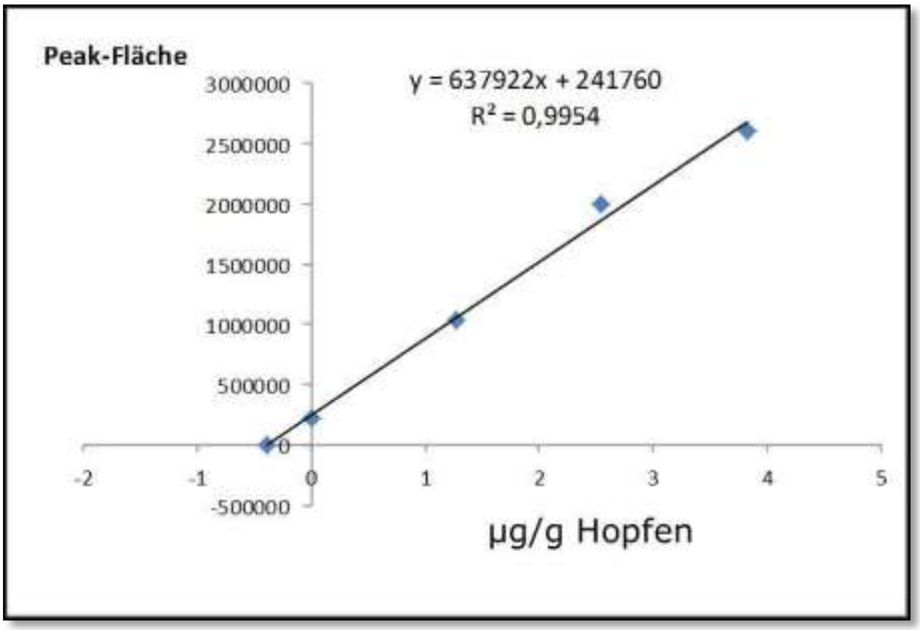


Fig. 7.11: Standard addition of dimethyl sulphide

The point at which the straight line intersects the x-axis represents the concentration of the substance sought in the sample.

4-MMP was not determinable because the mass spectrometer was not sensitive enough and the compound could not be detected in any of the samples; nor could any linear calibration curves be obtained. Thiols are far more reactive than the corresponding alcohols. It is conceivable that 4-MMP reacts with the proteins in the sample. The amino acid cysteine, in particular, can bind thiols via disulphide bridges. More work needs to be done on this. See *Figs. 7.12 – 17* for the evaluations and charts.

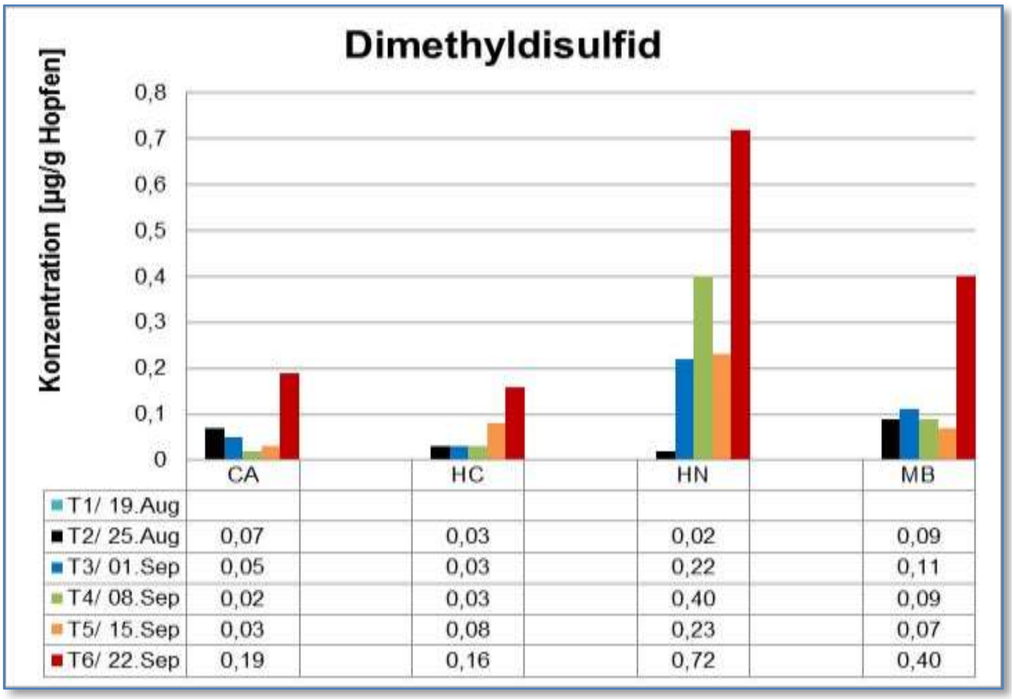


Fig. 7.12: Biogenesis of dimethyl disulphide in CA, HC, HN, MB

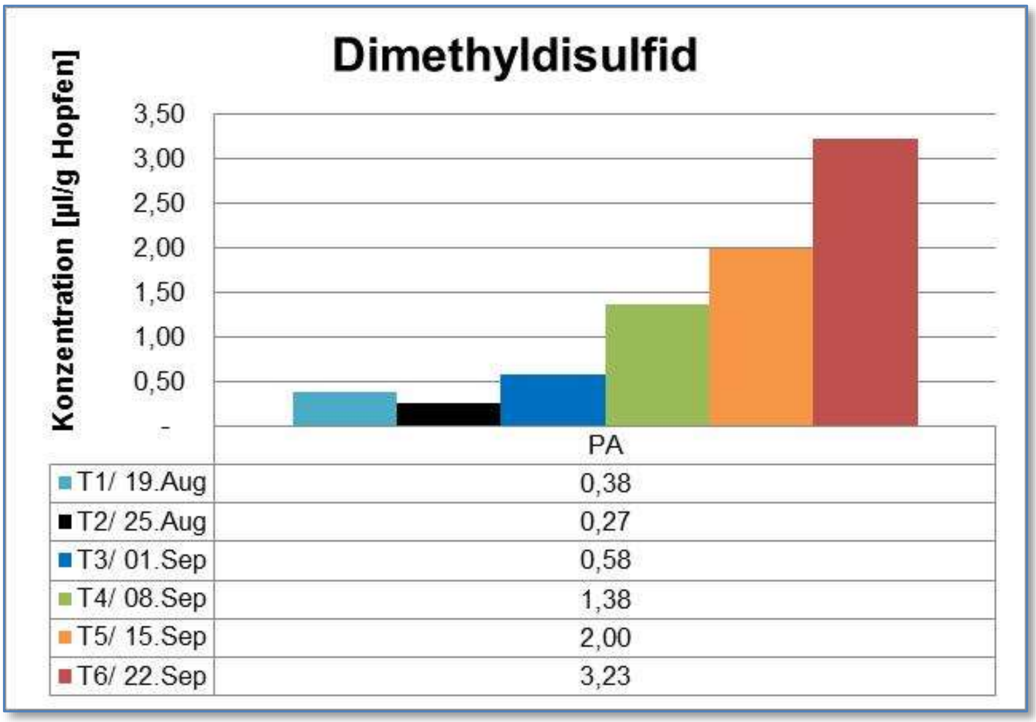
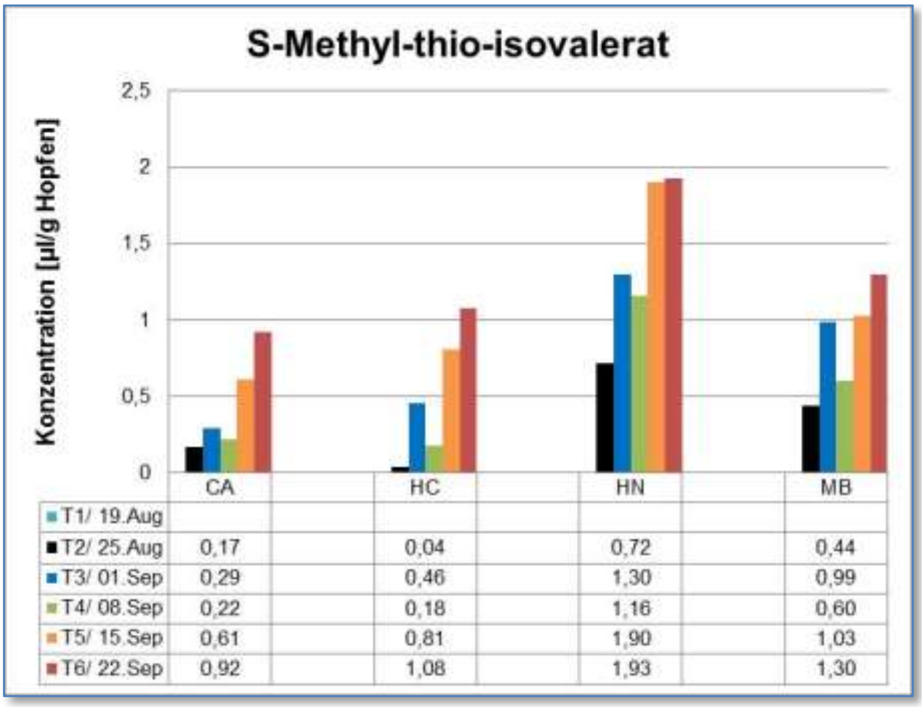
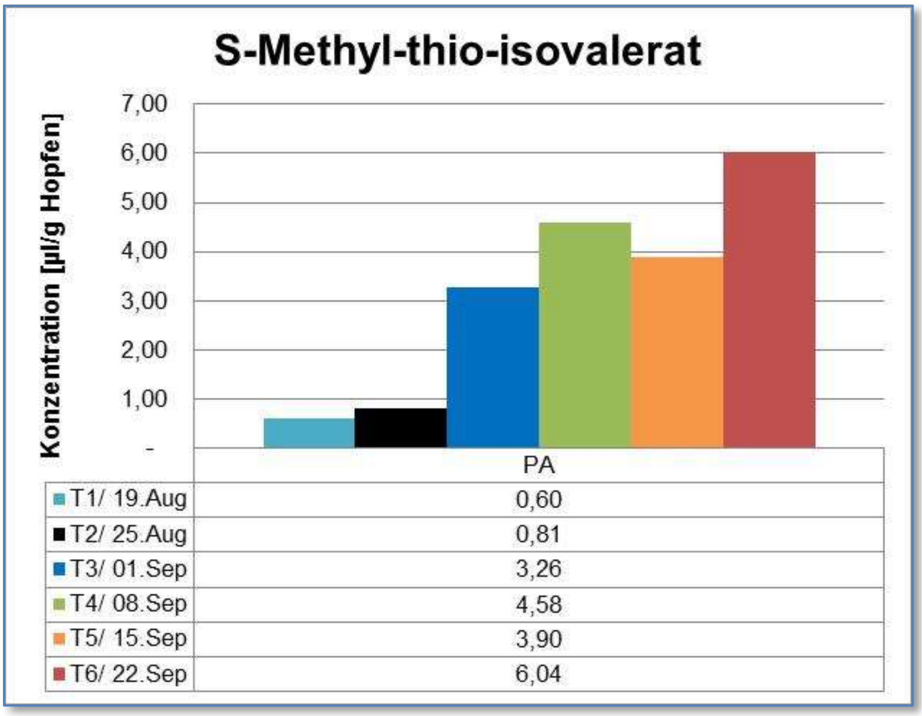


Fig. 7.13: Biogenesis of dimethyl disulphide in Polaris



	CA	HC	HN	MB
T1/ 19.Aug				
T2/ 25.Aug	0,17	0,04	0,72	0,44
T3/ 01.Sep	0,29	0,46	1,30	0,99
T4/ 08.Sep	0,22	0,18	1,16	0,60
T5/ 15.Sep	0,61	0,81	1,90	1,03
T6/ 22.Sep	0,92	1,08	1,93	1,30

Fig. 7.14: Biogenesis of S-Methyl thio isovalerate in CA, HC, HN, MB



	PA
T1/ 19.Aug	0,60
T2/ 25.Aug	0,81
T3/ 01.Sep	3,26
T4/ 08.Sep	4,58
T5/ 15.Sep	3,90
T6/ 22.Sep	6,04

Fig. 7.15: Biogenesis of S-Methyl thio isovalerate in Polaris

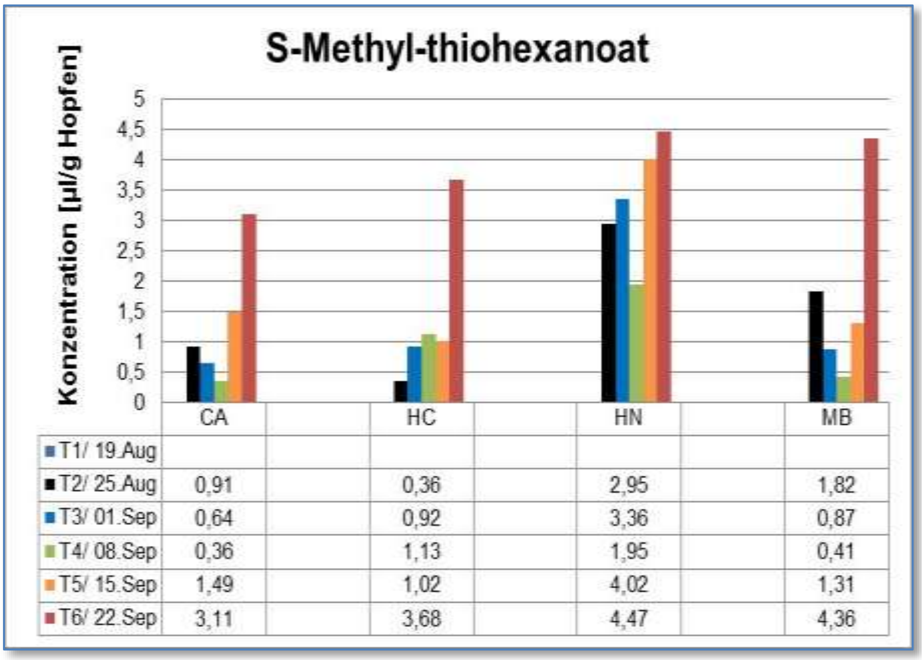


Fig. 7.16: Biogenesis of S-Methyl thio hexanoate in CA, HC, HN, MB

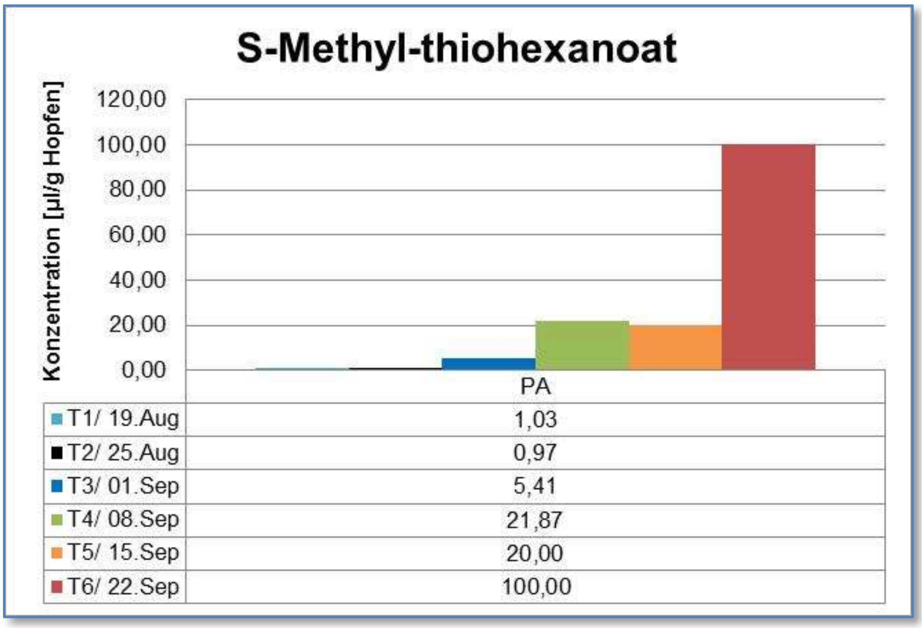


Fig. 7.17: Biogenesis of S-Methyl thio hexanoate in Polaris

Discussion:

Content and composition of the sulphur compounds quite definitely depend on the cultivar. Some cultivars have a high sulphur compound content, others a very low content. *Polaris* has very high sulphur compound levels and the findings are therefore given separately. Harvest timing also plays a key role. All sulphur compounds intensify significantly with later harvest dates, producing the familiar onion- and garlic-type aromas. Little is known, as yet, about the impact of environmental conditions. Further tests will be needed to find out more.

7.6 Multiple-laboratory ring analysis of the 2015 crop

Since 2000, hop supply contracts have included a supplementary agreement regarding α acids content. The price agreed in the contract applies when the α acids content is within what is termed a ‘neutral range’. If the content is above or below this range, the price paid is raised or lowered. The specification of WG Hop Analytics prescribes exactly how sampling should be carried out (sample division, storage), which labs can conduct analysis reliability checks and what tolerance ranges are permitted in the analysis results. In 2015, WG IPZ 5d was again tasked with organizing and evaluating the multiple-laboratory ring analysis in order to monitor the quality of α acids analytics.

In 2015, the following laboratories participated in the ring analysis:

- 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
- Bavarian State Research Center for Agriculture, Hops Department at Hüll

The ring analysis began in 2015 on September 8 and finished on November 6, with most of the hop batches having been analysed during this time. Altogether, ring analyses were performed nine times (9 weeks). The sample material was very kindly provided by Mr. Hörmannsperger (Hopfenring Hallertau). The samples were each taken from a single bale to ensure homogeneity as far as possible. For each analysis, the samples were ground in a hammer mill on the Monday, then divided using a sample divider, vacuum packed and delivered to the various labs. On the following days of the week, one sample per day was analysed. The results were then sent back to Hüll a week later for evaluation. In 2015, a total of 34 samples were analysed.

The evaluation findings were passed on to the individual labs as soon as possible. Fig. 7.18 is an example of what an ideal evaluation of a ring analysis should look like. The numbers beside the labs (1-7) in the following list do not correspond to the order in which the labs appear in the aforementioned list. The outlier test was calculated in accordance with DIN ISO 5725. Cochran’s test was applied for within-lab assessment; Grubbs’ test was used for inter-lab assessment.

Nr. 11: HHE (29.09.2015)

Labor	KW		mittel	s	cvr
1	2,64	2,65	2,65	0,007	0,3
2	2,61	2,64	2,63	0,021	0,8
3	2,77	2,80	2,79	0,021	0,8
4	2,76	2,73	2,75	0,021	0,8
5	2,60	2,64	2,62	0,028	1,1
6	2,76	2,89	2,83	0,092	3,3
7	2,70	2,77	2,74	0,049	1,8

mean	2,71
sr	0,043
sL	0,076
sR	0,087
vkr	1,60
vkR	3,22
r	0,12
R	0,24
Min	2,60
Max	2,89

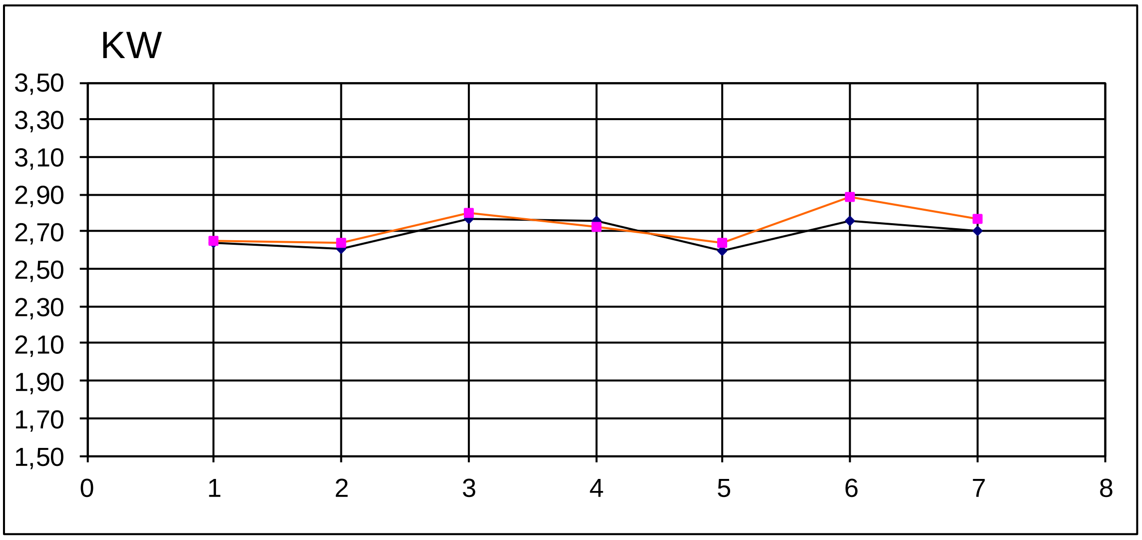


Fig. 7.18: Evaluation of a multi-lab ring analysis

The outliers in 2015 are shown in *Table 7.5*

Tab. 7.5: 2015 outliers

	Cochran		Grubbs	
Sample	α = 0.01	α = 0.05	α = 0.01	α = 0.05
5	0	0	0	lab 7
Total:	**0**	**0**	**0**	**1**

As of 2013 there are now 5 alpha classes and new tolerance limits. *Tab. 7.6* shows the new classes and the outliers in 2015.

Tab. 7.6: Updated alpha acids classes and tolerance limits; outliers in 2015

	< 5.0 % α acids	5.0 % - 8.0 % α acids	8.1 % - 11.0 % α acids	11.1 % - 14.0 % α acids	> 14.0 %
Critical difference range	+/-0.3 0.6	+/-0.4 0.8	+/-0,5 1.0	+/-0,6 1.2	+/-0,7 1.4
Outliers in 2015	1	1	0	0	1

In 2015, the permitted tolerance limits were overrun in two cases; one was a sample with an alpha acids content below 5.0%, and the other a sample with over 14%.

Fig. 7.19 shows all analytical results for each lab, as relative deviations from the mean (= 100%), differentiated by α acids levels <5%, >=5% and >10% and >=10%. The chart shows clearly whether the analysis results of a particular lab tend to be too low or too high.

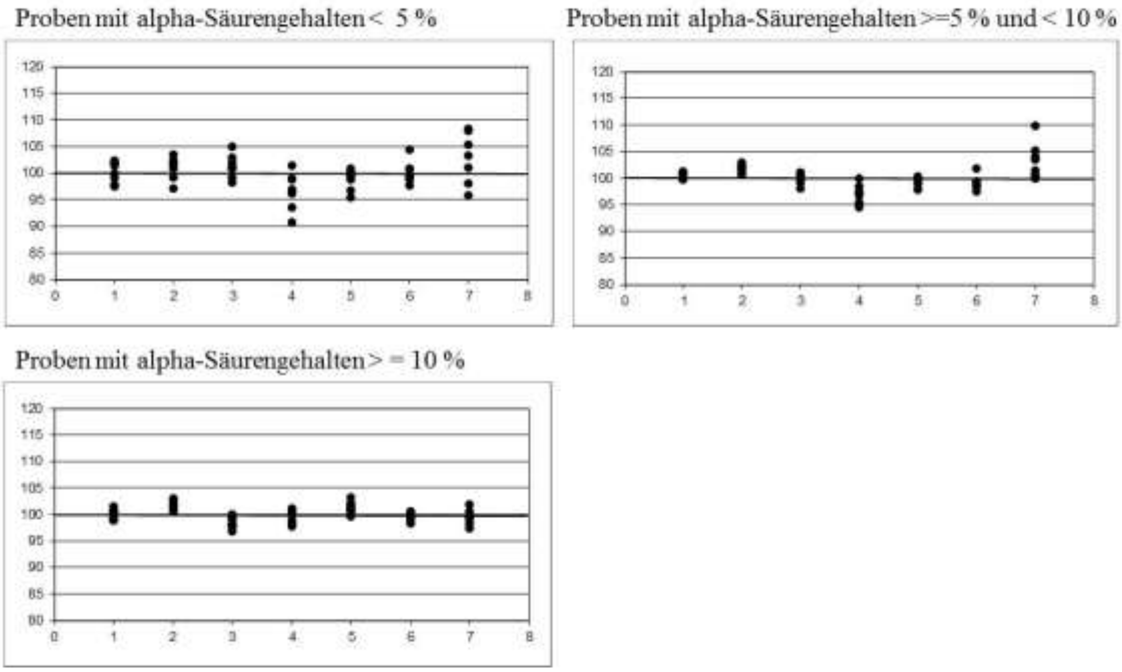


Fig. 7.19: Test results of the laboratories relative to the mean

The Hüll lab is number 5.

7.6.1 Evaluation of analysis reliability checks

Since 2005, analysis reliability checks have been carried out in addition to the multiple-laboratory ring analysis. These are evaluated by WG IPZ 5d and the findings sent back to the laboratories involved and to the Hop Growers' Association and the Hop Trade Association. A lab which does the initial analysis selects three samples per week, which are then analysed by three different labs, in accordance with the AHA specification.

The result of the initial analysis is validated when the mean value of the reliability check and the result of the initial analysis are within the tolerance limits (Tab. 7.6). *Tab. 7.7* gives the results for 2015. All initial test results since 2005 have been validated to date.

Tab. 7.7: Analysis reliability checks in 2015

Sample designation	Initial test laboratory	Initial test	Reliability checks			Mean value	Result validated
			1	2	3		
3429 HT	Agrolab	5.1	4.9	4.9	4.9	4.90	yes
3378 PE	Agrolab	6.0	5.9	5.9	6.0	5.93	yes
3597 TU	Agrolab	10.4	10.2	10.3	10.5	10.33	yes
KW 39 HHM	HHV AU	12.0	11.8	11.8	12.3	11.97	yes
KW 39 HTU	HHV AU	13.4	12.8	12.9	13.2	12.97	yes
KW 39 HHS	HHV AU	15.8	15.4	15.6	15.7	15.57	yes
QK 2539 HTU	NATECO2 Wolnzach	11.6	11.6	11.7	11.8	11.70	yes
QK 2583 HHS1	NATECO2 Wolnzach	13.3	13.2	13.3	13.6	13.37	yes
QK 2588 HHS2	NATECO2 Wolnzach	13.2	13.1	13.2	13.6	13.30	yes
KW 41 HHT 6321	HVG Mainburg	5.3	5.3	5.4	5.4	5.37	yes
KW 41 HPE 16085	HVG Mainburg	5.1	5.1	5.2	5.2	5.17	yes
KW 41 HHS 6665	HVG Mainburg	16.9	16.6	17.0	17.3	16.97	yes
7474 HC	Agrolab	6.8	7.2	7.2	7.3	7.23	yes
7415 HM	Agrolab	11.0	11.3	11.4	11.6	11.43	yes
7471 HS	Agrolab	14.1	14.2	14.2	14.6	14.33	yes
KW 43 HHM	HHV AU	12.7	12.6	12.6	12.7	12.63	yes
KW 43 HTU	HHV AU	11.2	11.0	11.1	11.3	11.13	yes
KW 43 HHS	HHV AU	17.3	16.9	17.0	17.1	17.00	yes
QK 3972 HNU	NATECO2 Wolnzach	8.0	7.8	8.0	8.0	7.93	yes
QK 3976 HHM	NATECO2 Wolnzach	11.2	10.9	11.0	11.1	11.00	yes
QK 3979 HTU	NATECO2 Wolnzach	9.4	9.2	9.3	9.4	9.30	yes
KW 45 87 49 HNU	HVG Mainburg	9.3	9.1	9.3	9.4	9.27	yes
KW 45 7451 HHS1	HVG Mainburg	13.7	13.5	13.6	13.9	13.67	yes
KW 45 17291 HHS2	HVG Mainburg	16.0	15.8	15.9	16.2	15.97	yes
3429 HT	Agrolab	5.1	4.9	4.9	4.9	4.90	yes
3378 PE	Agrolab	6.0	5.9	5.9	6.0	5.93	yes
3597 TU	Agrolab	10.4	10.2	10.3	10.5	10.33	yes

7.7 Production of pure α acids and their orthophenylenediamine complexes for verifying and calibrating the HPLC standard

In the autumn of 2010, the international calibration extract ICE 3 was introduced by the AHA. In this context, it was the task of the laboratory at Hüll to produce α acids of the highest possible purity (< 98%), needed to calibrate and verify the extract as standard. The stability of the calibration extract is tested twice yearly by the AHA laboratories. The orthophenylenediamine complex is first prepared from a CO_2 hop extract with a high α acids content by reaction with orthophenylenediamine (*Fig. 7.20*).

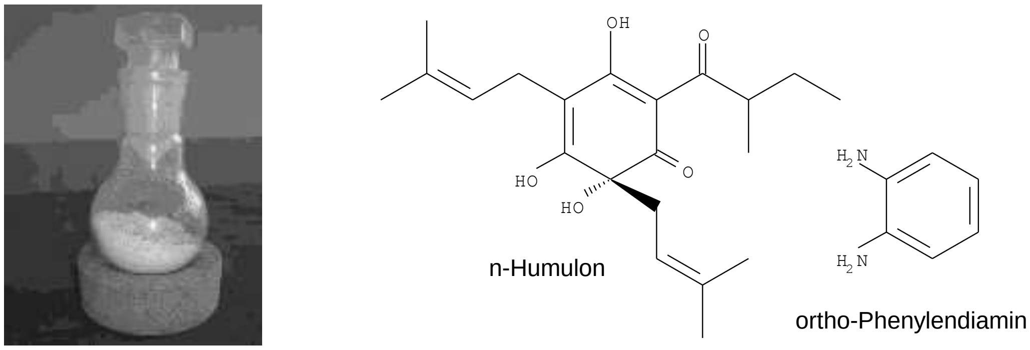


Fig. 7.20: Orthophenylenediamine complex and its chemical structure

This complex can be purified through repeated recrystallization processes. The pure α acids are then released from the complex. The complex itself has proved to be very stable and can be used as a standard for ICE calibration.

7.8 Analyses for WG IPZ 3d Medicinal and Aromatic Plants

The following special analyses were performed on behalf of IPZ 3d Medicinal and Aromatic Plants:

Leonorus japonicus
Leonurine: 181 duplicate determinations

Saposhnikovia divaricata
Prim-O-glucosylcimifugin and 5-O-methylvisamminosid: 9 duplicate determinations

Salvia miltiorrhiza
Tanshinone IIA and salvianolic acid B: 29 duplicated determinations

7.9 Verification of varietal authenticity

Verification of varietal authenticity is a mandatory task for WG IPZ 5d to provide administrative assistance for the food control authorities.

Varietal verifications for the food control authorities (Landratsämter – *rural district administration offices)*	36
Number not accepted	0

8 Publications and Specialist Information

8.1 Overview of PR activities

	Number		Number
Practice-relevant information and scientific papers	35	Guided tours	75
LfL publications	2	Exhibitions/ posters	4 / 23
Press releases	-	Basic and continuing training courses	16
Radio and TV broadcasts	-	Diploma dissertations	-
Conferences, trade events and seminars	29	Participation in working groups	32
Lectures and talks	97	Foreign guests	375

8.2 Publications

8.2.1 Practice-relevant informationen and scientific papers

Graf, T., Beck, M.; Mauermeier, M.; Ismann, D.; Meier, M.; Baumgartner, A.; Potner, J. ; Schmidhalter U. (2015): A new approach for predicting the water balance of hops. Acta Horticulturae, Acta Horticulturae, Hrsg.: International Society of Horticultural Science

Hanke, St.; Schüll, F., Seigner, E.; Engelhard, B.; Lutz, A. (2015): Systematische Brauversuche mit neuen Zuchtstämmen aus Hüll - Systematic Brewing Trials with New Breeding Lines from Hüll. Hopfenrundschau International, 2015/2016, Hrsg.: Verband Deutscher Hopfenpflanzer, 92 - 95

Hanke, St.; Schüll, F., Seigner, E.; Lutz, A. (2015): Zuchtstämmen auf den Zahn gefühlt - Teil 2: weiterführende Brauversuche. Brauwelt Wissen, Nr. 42-43, Hrsg.: Fachverlag Hans Carl GmbH, 1230 - 1234

Hommes, M., Schaarschmidt, R.; Mösch, S.; Hirsch, J.; Reineke, A.; Schwarz, J. ; Sprick, P.; Ufer, T.; Weihrauch, F.; Wrede, A. (2015): Rüsselkäfer in Baumschulen und Staudengärtnereien - Wichtige Arten, Bestimmung und Bekämpfung mittels entomopathogener Nematoden. JKI Datenblätter – Pflanzenkrankheiten und Diagnose, 2015, 1, Hrsg.: Julius Kühn-Institut, 1 - 7

Jereb, M., Schwarz, J.; Weihrauch, F. (2015): Use and establishment of predatory mites for sustainable control of two-spotted spider mite (Tetranychus urticae) in hop: report of the second season. DGaaE-Nachrichten, 29(1), Hrsg.: Deutsche Gesellschaft für allgemeine und angewandte Entomologie, 27 - 27

Kammhuber, K. (2015): Ergebnisse von Kontroll- und Nachuntersuchungen für Alphaverträge der Ernte 2014. Hopfen Rundschau, 09, Hrsg.: Verband Deutscher Hopfenpflanzer, 359 - 361

Lochner, H., Portner, J. (2015): Agrarwirtschaft-Fachstufe Landwirt. Berufschullehrbuch, 10. überarbeitete Auflage, Hrsg.: blv Buchverlag, 197 - 205

Lutz, A., Seigner, E. (2015): Innovationen rund um die Hopfenzüchtung, 3, 1556 - 1558

Lutz, A.; Kammhuber, K., Hainzlmaier, M.; Kneidl, J.; Petzina, C.; Wyschkon, B. (2015): Bonitierung und Ergebnisse für die Deutsche Hopfenausstellung 2015, 12, Hopfen-Rundschau, Hrsg.: Verband Deutscher Hopfenpflanzer, 477 - 479

Lutz, M. (2015): Feldtag am Betrieb Mehrl rund um das Thema Hopfenputzen - Modellvorhaben "Demonstrationsbetriebe integrierter Pflanzenschutz im Hopfenbau. Hopfen-Rundschau, 66. Jahrgang; Nr. 7, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 273 – 274

Lutz, M. (2015): Feldtag am Betrieb Obster aus Buch rund um das Thema Spinnmilbenbekämpfung. Hopfen-Rundschau, 66. Jahrgang; Nr. 8, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 328 - 329

Münsterer, J. (2015): Neue EDV-Version der Bayerischen Hopfenschlagkartei (HSK). Hopfen-Rundschau, 66. Jahrgang; Nr. 6, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 220

Münsterer, J., Kammhuber, K.; Presl ,T. (2015): Erntezeitpunkt, Trocknungstemperatur-was beeinflusst das Hopfenaroma. Brauwelt, Brauwelt, Nr. 33, Brauwelt, Hrsg.: Hans Carl Verlag, 958 - 960

Portner, J. (2015): Hopfen 2015 - Grünes Heft. LfL-Information, 2015, Hrsg.: Bayerische Landesanstalt für Landwirtschaft (LfL)

Portner, J. (2015): Internationale Grüne Woche 2015 in Berlin mit LfL-Stand. Hopfen-Rundschau, 66. Jahrgang; Nr. 2, Hrsg.: Verband deutscher Hopfenpflanzer, 60 - 69

Portner, J. (2015): Gezielte Stickstoffdüngung des Hopfens nach DSN (Nmin). Hopfen-Rundschau, 66. Jahrgang; Nr. 4, Hrsg.: Verband deutscher Hopfenpflanzer, 136

Portner, J. (2015): Übermittlung von Angaben im Hopfensektor. Hopfen-Rundschau, 66. Jahrgang; Nr. 5, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 179 - 180

Portner, J., Brummer, A. (2015): Nmin-Untersuchung ´15. Hopfen-Rundschau, 66. Jahrgang; Nr. 5, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 181

Portner, J., Seigner, E. (2015): Hop Stunt Viroid- und Zitrusviroid-Monitoring. Hopfen-Rundschau, 66. Jahrgang; Nr. 5, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 182

Portner, J. (2015): Zwischenfruchteinsaat im Hopfen für KuLaP-Betriebe (A33) mit dem alten Mulchsaatverfahren spätestens bis 30. Juni. Hopfen-Rundschau, 66. Jahrgang; Nr. 6, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 220

Portner, J. (2015): Peronosporabekämpfung. Hopfen-Rundschau, 66. Jahrgang; Nr. 6, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 221

Portner, J. (2015): Rebenhäcksel baldmöglichst ausbringen!. Hopfen-Rundschau, 66. Jahrgang; Nr. 8, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 327

Portner, J. (2015): Berufsschüler besuchen Hopfenforschung in Hüll. Hopfen-Rundschau, 66. Jahrgang; Nr. 8, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 327

Portner, J., Kammhuber, K. (2015): Fachkritik zur Moosburger Hopfenschau 2015. Hopfen-Rundschau, 66. Jahrgang; Nr. 10, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 388 - 393

Schätzl, J. (2015): Pflanzenstandsbericht April 2015. Hopfen-Rundschau, 66. Jahrgang; Nr. 5, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 182

Schätzl, J. (2015): Pflanzenstandsbericht Mai 2015. Hopfen-Rundschau, 66. Jahrgang; Nr. 6, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 222

Schätzl, J. (2015): Pflanzenstandsbericht Juni 2015. Hopfen-Rundschau, 66. Jahrgang; Nr. 7, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 275

Schätzl, J. (2015): Pflanzenstandsbericht Juli 2015. Hopfen-Rundschau, 66. Jahrgang; Nr. 8, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 329

Schätzl, J. (2015): Pflanzenstandsbericht August 2015. Hopfen-Rundschau, 66. Jahrgang; Nr. 9, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 362

Schüll, F., Hanke, S.; Seigner, E.; Lutz, A.; Becker, T. (2015): Zuchtstämmen auf den Zahn gefühlt - TEIL 1 – Screening. Brauwelt Wissen, 41, Hrsg.: Fachverlag Hans Carl GmbH, 1186 - 1189

Seigner, E. (2015): Sortenliste des Internationalen Hopfenbaubüros - 2014. Hopfen-Rundschau, 01, Hrsg.: Verband Deutscher Hopfenpflanzer, 18 - 28

Seigner, E., Seigner, L.; Lutz, A. (2015): Monitoring von gefährlichen Viren und Viroiden in deutschen Hopfengärten. Brauwelt Wissen, Nr. 26, Hrsg.: Fachverlag Hans Carl GmbH, 757 - 760

Seigner, E.; Lutz, A. (2015): Kreuzungsprogramm mit der Landsorte Tettnanger - Cross-breeding program with the landrace Tettnanger. Hopfenrundschau International, 2015/2016, Hrsg.: Verband Deutscher Hopfenpflanzer, 66 - 67

Seigner, L., Seigner, E., Lutz, A. (2015): Monitoring of dangerous virus and viroids in German hop gardens. Brauwelt International, VI, Vol. 33, 376-379.

Weihrauch, F., Jereb. M. (2015): Einsatz und Etablierung von Raubmilben zur nachhaltigen Spinnmilbenkontrolle in der Sonderkultur Hopfen - BÖLN-Projekt 2812NA014; 2. Zwischenbericht 2014

8.2.2 LfL Publications

Name	WG	LfL publications	Title
Hops Department IPZ 5	IPZ 5	LfL Information	Annual Report 2015 – Special Crop: Hop
Portner, J.	IPZ 5a	LfL Information	Hop 2015 – Green Pamphlet

8.3 Conferences, lectures and talks, guided tours, exhibitions

8.3.1 Conferences, trade events and seminars

Organized by	Subject	Participants	Date/Venue
Portner, J.; Graf, T.; Lutz, M.; Fischer, E.; IPZ 5a	Internationale Grüne Woche (Green Week) 2015 in Berlin	Consumers	15.01.15 Berlin
Münsterer, J.; IPZ 5a	Workshop on hop drying	Hop growers with hop kilns	22.01.15 Wolnzach
Portner, J.; IPZ 5a	Meeting of hop working committee (AK-Hopfen)	Group members	29.01.15 Untermantel-kirchen
Lutz, A.; IPZ 5c;	Beer tasting and brewing trials with Hüll breeding lines	Hop expert group, hop industry	03.02.15 Freising
Portner, J.; IPZ 5a	Meeting of hop working committee	Group members	02.03.15 Haunsbach
Portner, J.; IPZ 5a	Advisory panel meeting	Hopfenring panel members	03.03.15 Aiglsbach
Portner, J.; IPZ 5a	Meeting of hop working committee	Group members	09.03.15 Mitterstetten
Portner, J.; IPZ 5a	Meeting Green Pamphlet review	Hop scientists and consultants	10.03.15 Wolnzach
Portner, J.; IPZ 5a	Meeting, expert advisory panel and plant protection equipment technology specialists from JKI	Hop scientists and consultants	11.-12.03.15 Monheim
Lutz, A.; IPZ 5c	Beer tasting with Hüll breeding lines from large-scale growing trial	Brewers, hop traders, hop growers	17.03.15 Freising
Portner, J.; Lutz, M.; IPZ 5a	Working conference and project council meeting DIPS	Project leads and staff of model project: Demonstration Farms -Integrated Plant Protection; sub-project: Hop	18.-19.03.15 Berlin
Portner, J.; IPZ 5a	Meeting IPS Hop Demonstration Farms	Demonstration Farms – Hop - Integrated Plant Protection	16.04.15 Wolnzach
Weihrauch, F.; Jereb, M.; Wörner, L.; IPZ 5b	Summer outing of organic hop growing task force	International organic hop growers and hop scientists	07.-08.07.15 Obernai, Alsace, FR
Lutz, A.; Seigner, E.; IPZ 5c	GfH expert group	Hop and brewing industries	16.07.15 Hüll

Organized by	**Subject**	**Participants**	**Date/Venue**
Portner, J.; IPZ 5a	Advisory panel meeting Hallertau Hop Growers' Association	Panel members and guests of Hallertau Hop Growers' Association	16.07.15 Aiglsbach
Portner, J.; IPZ 5a	IHB International Hop Growing Congress	Int. hop growers, experts from the hop and brewing industries	26.-30.07.15 Bad Gögging
Weihrauch, F.; Wörner, L.; IPZ 5b	Meeting, Commodity Expert Group (CEG) Minor Uses in Hops	International hop plant protection experts	27.07.15 Bad Gögging
Portner, J.; IPZ 5a	Meeting of hop working committee	Group members	03.08.15 Einthal
Weihrauch, F.; IPZ 5b	Administrative Meeting of the Scientific-Technical Commission (STC) of the (IHGC) International Hop Growers' Convention	International hop scientists	05.08.15 Yakima, WA, USA.
Weihrauch, F.; IPZ 5b	IVth Humulus Sympo-sium of the International Society for Horticultural Science (ISHS)	International hop scientists and experts from the hop and brewing industries	05.-08.08.15 Yakima, WA, USA.
Lutz, A.; Seigner, E.; Kneidl, J.; Ismann, D.; IPZ 5c	Hop expert group	Members of the GfH expert group	14.10.15 Hüll
Sichelstiel, W.; Weihrauch, F.; Wörner, L.; IPZ 5b	Meeting, Commodity Expert Group (CEG) Minor Uses in Hops	International hop plant protection experts	09.11.15 Nürnberg
Sichelstiel, W.; IPZ 5b	Meeting of the Chairs of Commodity Expert Groups	Chairs of Commodity Expert Groups	16.11.15 Brüssel
Portner, J.; IPZ 5a	Meeting of hop working committee	Group members	16.11.15 Haunsbach
Portner, J.; IPZ 5a	Awards ceremony of Moosburger Hopfenschau	Award winners from the Moosburg Hop Show from Kelheim rural district	17.11.15 Kelheim
Portner, J.; IPZ 5a	Meeting of advisory panel Hallertau Hop Growers' Association	Panel members and guests of Hallertau Hop Growers' Association	20.11.15 Nieder-lauterbach
Portner, J.; Sichelstiel, W.; Seigner, E.; Lutz, A.; Kammhuber, K..; Weihrauch, F.; IPZ 5	GfH Annual review session	Management board of Society of Hop Research and scientists from the Hops Department of the LfL	26.11.15 Hüll
Portner, J.; IPZ 5a	Meeting of hop working committee	Group members	14.12.15 Aiglsbach
Portner, J.; IPZ 5a	Advisory panel meeting Hopfenring	Panel members and guests of Hopfenring	15.12.15 Osterwaal

8.3.2 Lectures and talks

WG	Name	Title	Organizer/ Attendees	Date	Venue
IPZ 5a	Fuß, S.	Comparing PPP authorization status in AUT and GER	Mühlviertel Hop Growers' Cooperative 55 hop growers from Austria	27.02.15	4170 Haslach
IPZ 5a	Fuß, S.	Hop stripping and weed /grass control in 2015	Elbe-Saale Hop Growers' Association 45 hop growers from the Elbe-Saale hop growing region	03.06.15	Gävernitz
IPZ 5a	Fuß, S.	Hop picking techniques	International Hop Growers'Convention, Hop Growers' Asso-ciation, Hop Trade Association, 170 international hop growers,experts from the hop and brewing industries	28.07.15	Alt-dürnbuch, Biburg
IPZ 5a	Fuß, S.	Sensor spray for individualized treatment of plants/ spraying equipment innovations	Internat. Hop Growers' Convention , Hop Growers' Association, Hop Trade Association 170 international hop growers, experts from the hop and brewing industries	29.07.15	Hüll
IPZ 5a	Fuß, S.	Sensor spray for individualized plant treatment	Freising rural district and Association of German Hop Growers e.V. ,120 guests of the Hop Tour 2015	27.08.15	Hüll
IPZ 5a	Fuß, S.	Economics of hop production in Elbe-Saale 2015	Elbe-Saale Hop Growers' Association 40 hop growers from the Elbe Saale region	02.12.15	Höfgen
IPZ 5a	Graf, T.	New developments in hop research	TUM 15 staff from WG Plant Nutrition	06.03.15	Freising
IPZ 5a	Graf, T.	Irrigation experiments in hop	ISHS 100 international hop research scientists	05.08.15	Yakima
IPZ 5a	Graf, T.	Investigation of the rootstock and water reserves in hop	ISHS 50 international research scientists	07.08.15	Yakima
IPZ 5a	Graf, T.	Irrigation experiments in hop	ISHS 50 international hop research scientists	07.08.15	Yakima
IPZ 5a	Graf, T.	Irrigation manage-ment in hop growing	LfL 20 German Soil Science Society (DBG) attendees	05.09.15	Neustadt (Donau)

WG	Name	Title	Organizer/ Attendees	Date	Venue
IPZ 5a	Graf, T.	The root system in hop	AELF 70 root research scientists from Austria, Switzerland, and Germany	14.09.15	Pfaffen-hofen
IPZ 5a	Lutz, M.	First experiences with model project: *Demonstration Farms - Integrated Plant Protection in Hop Growing*	Beiselen GmbH 25 agricultural trade employees	30.01.15	Hebronts-hausen
IPZ 5a	Lutz, M.	First experiences with model project: *Demonstration Farms - Integrated Plant Protection in Hop Growing*	Lfl + AELF Roth 18 hop growers	02.02.15	Heders-dorf
IPZ 5a	Lutz, M.	First experiences with model project: *Demonstration Farms – Integrated Plant Protection in Hop Growing*	LfL + AELF Roth 40 hop growers	02.02.15	Spalt
IPZ 5a	Lutz, M.	First experiences with model project: *Demonstration Farms – Integrated Plant Protection in Hop Growing*	LfL + AELF Pfaffenhofen 40 hop growers	03.02.15	Lindach
IPZ 5a	Lutz, M.	First experiences with model project: *Demonstration Farms – Integrated Plant Protection in Hop Growing*	LfL + AELF Pfaffenhofen 120 hop growers	04.02.15	Nieder-lauterbach
IPZ 5a	Lutz, M.	First experiences with model project: *Demonstration Farms – Integrated Plant Protection in Hop Growing*	LfL + AELF Erding 60 hop growers	05.02.15	Osselts-hausen
IPZ 5a	Lutz, M.	First experiences with model project: *Demonstration Farms – Integrated Plant Protection in Hop Growing*	LfL 35 hop growers	06.02.15	Ober-hatzkofen
IPZ 5a	Lutz, M.	First experiences with model project: *Demonstration Farms –Integrated Plant Protection in Hop Growing*	LfL + AELF Abensberg 45 hop growers	09.02.15	Biburg

WG	Name	Title	Organizer/ Attendees	Date	Venue
IPZ 5a	Lutz, M.	First experiences with model project: *Demonstration Farms – Integrated Plant Protection in Hop Growing*	LfL + AELF Abensberg 140 hop growers	10.02.15	Mainburg
IPZ 5a	Lutz, M.	First experiences with model project: *Demonstration Farms – Integrated Plant Protection in Hop Growing*	LfL 40 hop growers	13.02.15	Tetten-wang
IPZ 5a	Lutz, M.	First experiences with model project: *Demonstration Farms –Integrated Plant Protection in Hop Growing*	Society of Hop Research 35 attendees - GfH Board and Technical-Scientific working committee	14.04.15	Wolnzach
IPZ 5a	Lutz, M.	Experience with model project: *Demonstration Farms – Integrated Plant Protection in Hop Growing*	International Hop Growers' Convention 140 attendees from 14 hop growing nations (from politics, hop trade associations, state-run institutions, hop growers)	30.07.15	Bad Gögging
IPZ 5a	Lutz, M.	Experience with model project: *Demonstration Farms – Integrated Plant Protection in Hop Growing*	Association of German Hop Growers e.V. 70 attendees	28.08.15	Geiben-stetten
IPZ 5a	Münsterer, J.	New findings on performance improve-ment and energy efficiency in hop drying facilities	LfL+AELF Roth 18 hop growers	02.02.15	Heders-dorf
IPZ 5a	Münsterer, J.	New findings on performance improve-ment and energy efficiency in hop drying facilities	LfL+AELF Roth 40 hop growers	02.02.15	Spalt
IPZ 5a	Münsterer, J.	New findings on performance improve-ment and energy efficiency in hop drying facilities	LfL+ AELF Pfaffenhofen 48 hop growers	03.02.15	Lindach
IPZ 5a	Münsterer, J.	Knowledge Gives Us the Edge: Rosy Rustic Moth – Fact and Fiction	LfL+ AELF Pfaffenhofen 48 hop growers	03.02.15	Lindach

WG	Name	Title	Organizer/ Attendees	Date	Venue
IPZ 5a	Münsterer, J.	New findings on performance improvement and energy efficiency in hop drying facilities	LfL+ AELF Pfaffenhofen 120 hop growers	04.02.15	Nieder-lauterbach
IPZ 5a	Münsterer, J.	New findings on performance improvement and energy efficiency in hop drying facilities	LfL+AELF Erding 60 hop growers	05.02.15	Osselts-hausen
IPZ 5a	Münsterer, J.	New findings on performance improvement and drying efficiency in hop drying facilities	LfL 35 hop growers	06.02.15	Ober-hatzkofen
IPZ 5a	Münsterer, J.	New findings on performance improvement and drying efficiency in hop drying facilities	LfL+AELF Abensberg 45 hop growers	09.02.15	Biburg
IPZ 5a	Münsterer, J.	New findings on performance improvement and drying efficiency in hop drying facilities	LfL+AELF Abensberg 140 hop growers	10.02.15	Mainburg
IPZ 5a	Münsterer, J.	New findings on performance improvement and drying efficiency in hop drying facilities	LfL 40 hop growers	13.02.15	Tetten-wang
IPZ 5a	Münsterer, J.	Knowledge Gives Us the Edge: Rosy Rustic Moth- Fact and Fiction	LfL 40 hop growers	13.02.15	Tetten-wang
IPZ 5a	Portner, J.	Review of Fertilizer Ordinance – amendments for hop growers	Fa. Beiselen 15 agricultural trading reps	30.01.15	Hebronts-hausen
IPZ 5a	Portner, J.	Authorization status of plant protection agents for hop 2015	Fa. Beiselen 15 agricultural trading reps	30.01.15	Hebronts-hausen
IPZ 5a	Portner, J.	Review of Fertilizer Ordinance – amendments for hop growers	LfL+AELF Roth 18 hop growers	02.02.15	Heders-dorf
IPZ 5a	Portner, J.	Review of Fertilizer Ordinance – amendments for hop growers	LfL+AELF Roth 40 hop growers	02.02.15	Spalt
IPZ 5a	Portner, J.	Review of Fertilizer Ordinance – amendments for hop growers	LfL+ AELF Pfaffenhofen 48 hop growers	03.02.15	Lindach
IPZ 5a	Portner, J.	Authorization status of plant protection agents for hop 2015	LfL+ AELF Pfaffenhofen 48 hop growers	03.02.15	Lindach

WG	Name	Title	Organizer/ Attendees	Date	Venue
IPZ 5a	Portner, J.	Review of Fertilizer Ordinance – amendments for hop growers	LfL+ AELF Pfaffenhofen 120 hop growers	04.02.15	Nieder-lauterbach
IPZ 5a	Portner, J.	Review of Fertilizer Ordinance – amendments for hop growers	LfL+AELF Erding 60 hop growers	05.02.15	Osselts-hausen
IPZ 5a	Portner, J.	Review of Fertilizer Ordinance – amendments for hop growers	LfL 35 hop growers	06.02.15	Ober-hatzkofen
IPZ 5a	Portner, J.	Review of Fertilizer Ordinance – amendments for hop growers	LfL+ AELF Abensberg 45 hop growers	09.02.15	Biburg
IPZ 5a	Portner, J.	Review of Fertilizer Ordinance – amendments for hop growers	LfL+ AELF Abensberg 140 hop growers	10.02.15	Mainburg
IPZ 5a	Portner, J.	Review of Fertilizer Ordinance – amendments for hop growers	LfL 40 hop growers	13.02.15	Tetten-wang
IPZ 5a	Portner, J.	Plant protection news – hop 2015	30 IGN hop growers	20.05.15	Nieder-lauterbach
IPZ 5a	Portner, J.	Sustainable hop production from an economic standpoint	IGN 60 growers and guests from the hop and brewing industries	20.08.15	Nieder-lauterbach
IPZ 5a	Portner, J.	Expert Review: Hop 2015	Stadt Moosburg a.d. Isar 100 hop and barley exhibitors and guests of the Moosburg Hop Show	17.09.15	Moosburg a.d. Isar
IPZ 5a	Schätzl, J.	Plant Protection News 2015	AELF Roth+LfL 43 hop growers and guests from Spalt	03.06.15	Spalt
IPZ 5a	Schätzl, J.	Downy mildew warning service	Hop Growers' Association/LfL 90 attendees of the International Hop Growing Congress	29.07.15	Hüll
IPZ 5a	Schätzl, J.	Downy mildew warning service	Freising Rural District 70 hop growers from the area	04.08.15	Lutzmanns dorf
IPZ 5a	Schätzl, J.	Downy mildew warning service	Young Hop Growers, LfL 90 hop growers	05.08.15	Lutzmanns dorf
IPZ 5b	Weihrauch, F.	Knowledge Gives Us the Edge: Rosy Rustic Moth- Fact and Fiction	LfL + AELF Roth 18 hop growers	02.02.15	Heders-dorf
IPZ 5b	Weihrauch, F.	Knowledge Gives Us the Edge: Rosy Rustic Moth -Fact and Fiction	LfL + AELF Roth 40 hop growers	02.02.15	Spalt

WG	Name	Title	Organizer/ Attendees	Date	Venue
IPZ 5b	Weihrauch, F.	Authorization status of plant protection agents for hop 2015	LfL + AELF Roth 18 hop growers	02.02.15	Heders-dorf
IPZ 5b	Weihrauch, F.	Authorization status of plant protection agents for hop 2015	LfL + AELF Roth 40 hop growers	02.02.15	Spalt
IPZ 5b	Weihrauch, F.	Minimizing the use of copper-containing fungicides in organic hop growing: latest trial results 2014	Bioland 30 organic hop farmers and consultants	03.02.15	Berching - Kloster Plank-stetten
IPZ 5b	Weihrauch, F.	Knowledge Gives Us the Edge: Rosy Rustic Moth -Fact and Fiction	LfL + AELF Pfaffenhofen 120 hop growers	04.02.15	Nieder-lauterbach
IPZ 5b	Weihrauch, F.	Authorization status of plant protection agents for hop 2015	LfL + AELF Pfaffenhofen 120 hop growers	04.02.15	Nieder-lauterbach
IPZ 5b	Weihrauch, F.	Knowledge Gives Us the Edge: Rosy Rustic Moth -Fact and Fiction	LfL + AELF Erding 60 hop growers	05.02.15	Osselts-hausen
IPZ 5b	Weihrauch, F.	Authorization status of plant protection agents for hop 2015	LfL + AELF Erding 60 hop growers	05.02.15	Osselts-hausen
IPZ 5b	Weihrauch, F.	Knowledge Gives Us the Edge: Rosy Rustic Moth -Fact and Fiction	LfL 35 hop growers	06.02.15	Ober-hatzkofen
IPZ 5b	Weihrauch, F.	Authorization status of plant protection agents for hop 2015	LfL 35 hop growers	06.02.15	Ober-hatzkofen
IPZ 5b	Weihrauch, F.	Knowledge Gives Us the Edge: Rosy Rustic Moth -Fact and Fiction	LfL + AELF Abensberg 45 hop growers	09.02.15	Biburg
IPZ 5b	Weihrauch, F.	Authorization status of plant protection agents for hop 2015	LfL + AELF Abensberg 45 hop growers	09.02.15	Biburg
IPZ 5b	Weihrauch, F.	Knowledge Gives Us the Edge: Rosy Rustic Moth -Fact and Fiction	LfL + AELF Abensberg 140 hop growers	10.02.15	Mainburg
IPZ 5b	Weihrauch, F.	Authorization status of plant protection agents for hop 2015	LfL + AELF Abensberg 140 hop growers	10.02.15	Mainburg
IPZ 5b	Weihrauch, F.	Introduction to the CEG Minor Uses in Hops	Internat. Hop Growers' Convention , Hop Growers' Association, Hop Trade Association 120 international hop growers, experts from the hop and brewing industries	27.07.15	Bad Gögging

WG	Name	Title	Organizer/ Attendees	Date	Venue
IPZ 5b	Weihrauch, F.	*Demonstration Farms – Integrated Plant Protection* – the fundamentals	Internat. Hop Growers' Convention, Hop Growers' Association, Hop Trade Association 100 international hop growers, experts from the hop and brewing industries	30.07.15	Bad Gögging
IPZ 5b	Weihrauch, F.	Rosy rustic moth as a hop pest in the Hallertau: history and current situation	International Society for Horticultural Science, Hopsteiner 65 international attendees from hop research and the hop/ brewing and industries	07.08.15	Yakima, WA, USA
IPZ 5b	Weihrauch, F.	Review of the season in hop cultivation and results of copper monitoring 2010-2015	JKI and BÖLW 65 representatives from federal and provincial plant protection agencies and plant prot.industry	29.10.15	Berlin
IPZ 5b	Weihrauch, F.	Deployment and establishment of predator mites in hop growing – status quo 2015	DGaaE und DPG 60 scientists from universities and federal agencies, consultants from official plant protection services, producers of beneficial insects	01.12.15	Hannover
IPZ 5b	Weihrauch, F.	Organic hop research in Hüll and organic hop growing in Germany and worldwide	LfL & LVÖ 30 project staff and other players in organic agricultural systems	04.12.15	Freising-Dürneck
IPZ 5b	Wörner, L.	Authorization status of plant protection agents in hop growing	BMEL 18 attendees of the Hop Growing Dialogue	26.0315	Berlin
IPZ 5b	Wörner, L.	Plant protection issues and potential solutions in hop growing	Association of Hop Growers e.V. 70 guests of the Hop Tour	28.08.15	Geiben-stetten
IPZ 5c	Lutz, A.	Properties of the breeding lines in the large-scale growing trial	GfH board meeting 12 attendees, GfH Chief Executive	19.03.15	Hüll
IPZ 5c	Lutz, A.	Presentation of four new breeding lines selected for prelimin-ary screening brewing trials	GfH 25 members of the GfH Techn.-Scientific working committee	14.04.15	Wolnzach

WG	Name	Title	Organizer/ Attendees	Date	Venue
IPZ 5c	Lutz, A.	Assessment of the two breeding lines from the large-scale growing trial	GfH 25 members of the GfH Techn.-Scientific working committee	14.04.15	Wolnzach
IPZ 5c	Lutz, A.	Insights on the new breeding lines from the large-scale growing trial	LfL 25 attendees, GfH hop expert group	16.07.15	Hüll
IPZ 5c	Lutz, A.	Insights on four breeding lines in screening brewing trials	LfL 25 attendees, GfH hop expert group	16.07.15	Hüll
IPZ 5c	Lutz, A.	Growing Herkules and the Special Flavor varieties	Internat. Hop Growers' Convention , Hop Growers' Association, Hop Trade Association 170 international hop growers, experts from the hop and brewing industries	28.07.15	Alt-dürnbuch, Biburg
IPZ 5c	Lutz, A.	The Hüll Special Flavor hops	German Hop Growers' Association and Hopfenland Hallertau Tourismus 120 guests of the Hop Tour 2015	27.08.15	Reicherts-hausen
IPZ 5c	Lutz, A.	Hop 2015	German Hop Growers' Association and Hopfenland Hallertau Tourismus 50 politicians, the hop and brewing industries	27.08.15	Nandlstadt
IPZ 5c	Lutz, A.	The Hüll Special Flavor hops and their flavor in beer	LfL und TUM 150 attendees BTU-Convention	08.09.15	Freising
IPZ 5c	Lutz, A.	New insights on breeding lines from the large-scale growing trial	IPZ 5c; GfH 23 attendees, GfH hop expert group	14.10.15	Hüll
IPZ 5c	Lutz, A.	Hop breeding and Hüll hops	Altweihenstephaner Brauerbund 35 students, Old Weihenstephan Brewers` Federation	29.10.15	Freising
IPZ 5c	Seigner, E.	Cross-breeding with Tettnanger landrace	Ministry for Rural Affairs and Consumer Protection 15 attendees, ministry, hop growers	11.03.15	Stuttgart

WG	Name	Title	Organizer/ Attendees	Date	Venue
IPZ 5c	Seigner, E.	Marker-assisted selection breeding in hop	LfL 25 attendees, IPZ-work session with the LfL centres of expertise	17.03.15	Freising
IPZ 5c	Seigner, E.	Faster availability of virus-free hops	Scientific Station for Brewing Munich 30 attendees, brewing industry	25.06.15	München
IPZ 5c	Seigner, E.	The LfL Hop breeding programmes	HVG: 32 attendees, HVG supervisory board and advisory panel Association of German Hop Growers	23.07.15	Spalt
IPZ 5c	Seigner, E.	Report from the Scientific-Technical Commission of the IHGC (IHB)	International Hop Growers' Convention 60 attendees, IHB board	30.07.15	Bad Gögging
IPZ 5c	Seigner, E.	Phenotyping powdery mildew resistance to genome-wide association mapping	HVG Hop Producer Group 10 project partners Universität Hohenheim and sponsors	07.12.15	Wolnzach
IPZ 5c	Seigner, E.	Cross-breeding and mapping population	HVG Hop Producer Group 10 project partners Universität Hohenheim and sponsors	07.12.15	Wolnzach
IPZ 5d	Kammhuber, K.	'Analytical and sensorial characterization of the new Hüll *Special Flavor Hops'*	International Society for Horticultural Science, Hopsteiner 65 attendees, inter-national hop research, brewing and hop industries	08.08.15	Yakima, WA, USA

8.3.3 Guided Tours

WG	Guide(s)	Subject/title	Visitors	Date	No.
IPZ 5	Fuss, S. Lutz, A.	Low trellis systems	Engineers	12.03.15	2
IPZ 5	Lutz, A. Seigner, E. Kammhuber, K.	'Hop research, hop breeding, aroma analytics'	Brewers	16.03.15	2
IPZ 5	Lutz, A. Seigner, E. Kammhuber, K. Weihrauch, F.	'Hop breeding, Special Flavor hops, aroma analytics, plant protection'	AB InBev, top management	19.03.15	6
IPZ 5	Seigner, E. Kammhuber, K. Weihrauch, F.	'Hop research of the LfL'	Tsingtao Management	16.04.15	4

WG	Guide(s)	Subject/title	Visitors	Date	No.
IPZ 5	Seigner, E. Kammhuber, K.	'Hop research, breeding activities, hop genome analysis'	Suntory	17.04.15	2
IPZ 5	Seigner, E. Kammhuber, K. Weihrauch, F.	Research at the Hop Research Center at Hüll	former Hohenheimers	21.05.15	35
IPZ 5	Lutz, A. Schätzl, J.	Hop Research Center Hüll, hop breeding, plant cultivation	Vocational College Pfaffenhofen	12.06.15	15
IPZ 5	Lutz, A. Weihrauch, F.	LfL hop research, breeding, plant protection	Universität für Bodenkultur Vienna, Plant Breeding	25.06.15	30
IPZ 5	Lutz, A. Weihrauch, F.	LfL hop research, hop breeding, plant protection	Frau Meyer, Association of German Hop Growers	01.07.15	1
IPZ 5	Seigner, E. Lutz, A. Kammhuber, K.	LfL hop research, hop breeding, plant protection, chemical analysis of hop	TUM, students of brewing	07.07.15	50
IPZ 5	Doleschel, P. Lutz, A. Kammhuber, K. Weihrauch, F.	LfL hop research, hop breeding, plant protection, chemical aroma analysis	Freisinger Mitte und OB Eschenbach	10.07.15	10
IPZ 5	Seigner, E. Kammhuber, K.	'Hop research of the LfL, hop breeding, innovative hop varieties and chemical analysis'	AB InBev Global Innovations Dept.	16.07.15	2
IPZ 5	Lutz, A. Schätzl, J.	LfL hop research, breeding and plant cultivation	Agricultural College Pfaffenhofen, students	24.07.15	15
IPZ 5	Portner, J. Fuß, S. Graf, T. Münsterer, J. Weihrauch, F. Jereb, M. Schätzl, J. Wörner, L. Kammhuber, K. Seigner, E.	Hop spraying techniques, tool for automated wire suspen-sion, irrigation, drying/ conditioning, harvesting techniques, biological and integrated plant protection, chemical analysis of hop, hop breeding	Attendees of IHGC Congress	29.07.15	150
IPZ 5	Seigner, E. Lutz, A. Kammhuber, K. Sichelstiel, W.	Research at the Hop Research Center Hüll	Members of the Phytomedicinal Society	20.08.15	30
IPZ 5	Doleschel, P. Lutz, A. Seigner, E.	Hop breeding, plant protection, climate change, chem. analysis of hop	Terra X film director and team	21.08.15	2
IPZ 5	Fuss, S. Lutz, A.	Low trellis construction, hop varieties, production techn.	Low trellis specialist	26.08.15	1
IPZ 5	Seigner, E.	'Hop research, hop breeding'	BSG (Brewers Supply Group) USA	03.09.15	5
IPZ 5	Seigner, E. Kammhuber, K.	'Hop research, hop breeding, aroma analytics'	Trip Kloser and team	04.09.15	4
IPZ 5	Seigner, E. Kammhuber, K.	'Hop research of the LfL, hop breeding, hop analytics'	Brewers, Polar Brewery und TU Berlin	08.09.15	4

WG	Guide(s)	Subject/title	Visitors	Date	No.
IPZ 5	Seigner, E. Kammhuber, K. Lutz, A.	‘Hop research, hop breeding, aroma analytics’	Brewers, SixPoint Brewery	08.09.15	2
IPZ 5	Seigner, E. Kammhuber, K.	Hop aroma and hop breeding	Journalists	11.09.15	13
IPZ 5	Seigner, E.	‘Hop research of the LfL, hop breeding, plant protection, aroma analysis’	AB InBev	20.09.15	53
IPZ 5	Lutz, A. Seigner, E.	Hop varieties	BayWa, hop growers	30.09.15	2
IPZ 5	Seigner, E. Sichelstiel, W.	LfL hop research, hop breeding, plant protection	Guests‘ guide, Stadt Mainburg	08.10.15	6
IPZ 5	Seigner, E. Kammhuber, K.	‘Hop research of the LfL; hop breeding, aroma analytics, plant protection’	Global Product Innovation Team	14.10.15	2
IPZ 5	Lutz, A. Sichelstiel, W.	Hop research and hop breeding	Young business leaders of the Bavarian Brewers’ Federation	30.10.15	12
IPZ 5	Lutz, A. Sichelstiel, W.	Hop research, breeding, plant protection, chemical aroma analysis	High school students from the Margarete-Steiff-Gymnasium	30.10.15	15
IPZ 5a	Schätzl, J.	Informational event	Vocational students	09.02.15	15
IPZ 5a	Portner, J.	Cover cropping in hop, extent of mulch cover	Test teams from the ÄELF	08.06.15	10
IPZ 5a	Schätzl, J.	Informational event – current plant protection and downy mildew warning service	Vocational students from rural districts PAF/FS/EI/KEH	12.06.15	13
IPZ 5a	Schätzl, J.	Current information on plant protection/final measures, on-site inspection of hops	Hop growers and guests	17.07.15	56
IPZ 5a	Schätzl, J.	Diseases and pests, downy mildew warning service, current plant protection	Students from the Agricultural College PAF	24.07.15	14
IPZ 5a	Portner, J.	Automated hop picking, downy mildew warning service	Hop growers from Freising rural district	04.08.15	60
IPZ 5a	Portner, J. Wörner, L.	Automated hop picking, LfL powdery mildew trial, downy mildew warning service	Hop growers	05.08.15	90
IPZ 5a	Portner, J. Wörner, L.	Automated hop picking, LfL powdery mildew trial, downy mildew warning service	Hop growers from VlF Kelheim	06.08.15	35
IPZ 5a	Schätzl, J.	General plant protection situation, final measures, on-site inspection of hops	Hop growers and the trade, brewers	21.08.15	60
IPZ 5a	Portner, J. Graf, T.	Hop Research Center Hüll, soil profiles and protection against erosion, irrigation and root system in hop	German Soil Science Society	05.09.15	20

WG	Guide(s)	Subject/title	Visitors	Date	No.
IPZ 5a	Portner, J. Fuß, S.	Technical aspects of hop production, technical plant protection equipment	Dr. T. Pelzer (JKI-Gerätetechnik)	10.09.15	1
IPZ 5a	Portner, J. Fuß, S.	Hop Research Center Hüll, technical plant protection equipment for hop	WG Application techniques in vertical crops	13.10.15	10
IPZ 5b	Weihrauch, F.	Biological plant protection, organic hop growing	Dr. F. Beran, MPI Jena	19.05.15	1
IPZ 5b	Weihrauch, F.	Plant protection in hop growing	A. Muñoz, Barth-Haas Group	02.06.15	1
IPZ 5b	Weihrauch, F.	Plant protection in hop growing	Aspiring hop growers from Italy	03.07.15	3
IPZ 5b	Weihrauch, F.	Plant protection in hop growing , hop growing in general	G. Alandry, journalist with *CropLife*, London	04.-05.09.15	1
IPZ 5c	Lutz, A.	Special Flavor breeding	Craft brewers	15.01.15	2
IPZ 5c	Lutz, A.	New breeding lines	Veltins brewery, growers	28.01.15	2
IPZ 5c	Lutz, A.	New breeding lines	Riegele brewery, hop growers	30.01.15	2
IPZ 5c	Lutz, A.	'Hop research, hop breeding, hop aroma'	R2 Group	10.03.15	1
IPZ 5c	Lutz, A.	Hop research	Emeritus Prof. G. Weber, Universität Hohenheim	13.03.15	1
IPZ 5c	Lutz, A. Seigner, E.	Hop drying, pelleting sytem, new breeding lines	Veltins brewery and hop growers	16.03.15	2
IPZ 5c	Lutz, A.	'Hop research, Special Flavor hops'	Firestone Walker, brewers	17.03.15	2
IPZ 5c	Lutz, A.	Hop breeding and new varieties	Communications scientist	09.05.15	1
IPZ 5c	Lutz, A.	LfL hop research, breeding, Hop aromas	Students of brewing	15.05.15	20
IPZ 5c	Lutz, A.	LfL hop research, hop breeding, chemical aroma analysis	Hochschule Weihenstephan-Triesdorf, students of brewing technology	15.06.15	15
IPZ 5c	Lutz, A. Seigner, E.	LfL hop research, hop breeding, chemical aroma analysis, hop growing, plant protection	HVG Hop Sales Cooperative, personnel	16.06.15	4
IPZ 5c	Lutz, A. Seigner, E.	LfL hop research, hop breeding and hop growing	Prof. Caspari, Colorado State University	16.06.15	2
IPZ 5c	Lutz, A.	LfL hop research, hop breeding, chemical aroma analysis, beer tasting	Senior management conference	29.06.15	25
IPZ 5c	Lutz, A.	LfL hop research, breeding, chemical aroma analysis	Hopfenveredlung St. Johann, HVG Hop Sales Cooperative	22.07.15	3

WG	Guide(s)	Subject/title	Visitors	Date	No.
IPZ 5c	Lutz, A. Seigner, E.	LfL hop research, cross-breeding with Tettnanger landrace, chemical aroma analysis	Hop growers from Tettnang	28.07.15	40
IPZ 5c	Lutz, A. Seigner, E.	Hop breeding, chemical aroma analysis	Journalist with the *Donaukurier* paper	11.08.15	1
IPZ 5c	Seigner, E. Lutz, A.	‘Hop research of the LfL, hop breeding, hop analytics, plant protection’	Sapporo	12.08.15	2
IPZ 5c	Lutz, A.	Harvest timing for different hop varieties	ISO hop farms, Hopfenring	19.08.15	70
IPZ 5c	Lutz, A.	Hop varieties, harvest timing	BayWa	26.08.15	10
IPZ 5c	Lutz, A.	Varieties, harvest timing, new breeding lines	Barth Group	01.09.15	8
IPZ 5c	Lutz, A. Seigner, E.	Information on breeding lines	HVG Hop Sales Cooperative	02.09.15	2
IPZ 5c	Lutz, A.	‘Special Flavor hops‘	US Hop Sales and Distribution	10.09.15	4
IPZ 5c	Lutz, A. Seigner, E.	Hop breeding	Hop breeders, UK	28.09.15	1
IPZ 5c	Seigner, E.	Hop research	Dr. Darby, hop breeder	28.09.15	1
IPZ 5c	Lutz, A. Seigner, E.	‘Special Flavor Hops‘	Three Floyds Brewing	30.09.15	4
IPZ 5c	Lutz, A.	‘Hop research, hop breeding, Special Flavor hops’	YO-HO Brewing Company, Jap. Craft Brewery	05.10.15	4
IPZ 5c	Lutz, A.	Special Flavor hops	US brewer, Urban Chestnut Brewing Company	06.10.15	1
IPZ 5c	Lutz, A.	Study assignment: Special Flavor hops	High school student from Hallertau Gymnasium	02.11.15	1
IPZ 5c	Seigner, E.	‘Hop research of the LfL, hop breeding, Special Flavor hops’	AB InBev, management und brewers	04.11.15	16
IPZ 5c	Lutz, A.	‘Hop research of the LfL’	Students from Technical College for Agriculture	04.12.15	20
IPZ 5c IPZ 5d	Lutz, A. Kammhuber, K. Seigner, E.	‘Hop research, hop breeding, plant protection, hop analytics’	AB InBev global brewmasters	21.08.15	40

8.3.4 Exhibitions and posters

Event	Exhibit/subjects/poster	Organizer	Duration	WG
IHGC Congress (IHB-Kongress)	Developing and optimizing a fully automated hop picking machine Fully automated wire suspension tool for use in hop growing Downy mildew warning service Model and demonstration project: *Demonstration farms – integrated plant protection* Sensor technology for reducing use of plant protection products Developing methods of controlling hop flea beetle Psylliodes attenuatus in organic hop cultivation Deployment and establishment of predator mites for sustainable control of spider mites Minimizing use of copper-containing plant protection products in organic and integrated hop growing Hop drying Conditioning hops Special Flavor hops: Mandarina Bavaria Hüll Melon Hallertau Blanc Developing a new variety of hop Herkules – the new high alpha variety from Hüll Breeding varieties from the Hop Research Center at Hüll Cross-breeding with Tettnanger landrace Compounds of value in hop and their chemical analysis What effect does hop have on beer? Hop is not only essential for brewing beer, it is also a medicinal plant	Internationales Hopfenbaubüro (IHGC)	28.07.15	IPZ 5

Event	Exhibit/subjects/poster	Organizer	Duration	WG
Hop Tour 2015	Marker-assisted selection in hop	German Hop Growers'Association and Tourismus Hallertau	27.08.15	IPZ 5
Craft Brewers Conference	German Special Flavor Hops from Hüll	Brewers' Association; Oregon, USA	14.04.15	IPZ 5c
Meeting of GfH hop expert group	Overview - Hüll Special Flavor hops	GfH	16.07.15	IPZ 5c

8.4 Basic and continuing training

Name, WG	Topic	Target group
Portner, J. IPZ 5a	18.02.2015 – Oral exam, Wolnzach	2 farmers
Portner, J. IPZ 5a	01.04.2015 – Master's certificate exam – topic assignment, Koppenwall	1 farmer
Portner, J. IPZ 5a	02.04.2015 - Master's certificate exam – topic assignment Hohenried	1 farmer
Portner, J. IPZ 5a	02.04.2015 – Master's certificate exam – topic assignment, Eutenhofen	1 farmer
Portner, J. IPZ 5a	02.04.2015 – Master's certificate exam – topic assignment, Bettbrunn	1 farmer
Portner, J. IPZ 5a	29.04.2015 – Master's certificate – oral exam, Wolnzach	2 farmers
Portner, J. IPZ 5a	19.06.2015 – Master's certificate – oral exam, Wolnzach	1 farmer
Portner, J. IPZ 5a	22.06.2015 – Master's certificate exam – follow-up visit, Hohenried	1 farmer
Portner, J. IPZ 5a	25.06.2015 – Master's certificate exam – follow-up visit, Koppenwall	1 farmer
Portner, J. IPZ 5a	26.06.2015 – Master's certificate exam – follow-up visit, Bettbrunn	1 farmer
Portner, J. IPZ 5a	26.08.2015 – Master's certificate exam – follow-up visit, Allakofen	1 farmer
Portner, J. IPZ 5a	26.08.2015 – Master's certificate exam – follow-up visit, Eutenhofen	1 farmer
Portner, J. IPZ 5a	13.10.2015-16.10.2015 – Instruction in hop growing, LS Pfaffenhofen	20 farmers
Portner, J. IPZ 5a	05.11.2015-26.11.2015 – BiLa Seminar on hop growing, Abensberg	20 farmers
Schätzl, J. IPZ 5a	12.06.2015 – Informational event for vocational students, Hüll	13 farmers
Schätzl, J. IPZ 5a J.	24.07.2015 – 1-day course on hop, Hüll/Eja	14 farmers

8.5 Participation in working groups, memberships

Name	Function	Organization
Fuß, S.	Member	Board of examiners – Qualified Agriculturalist at Landshut authority for continuing education
Kammhuber, K.	Member	Working Group for Hop Analytics (AHA)
Kammhuber, K.	Member	European Brewery Convention (hop sub-committee) analysis committee
Kammhuber, K.	Member	Association of German Chemists (GDCH)
Münsterer, J.	Member	Board of examiners – Qualified Agriculturalist at Landshut authority for continuing education
Portner, J.	Member	WG Sustainability in hop growing
Portner, J.	Member	JKI – Advisory panel – equipment approval procedure for assessing plant protection equipment
Portner, J.	Member	JKI – Federal states WG - Monitoring Plant Protection Equipment
Portner, J.	Member	Boards of Examiners Niederbayern, Oberbayern-Ost, Oberbayern-West, for Master's certificate Qualified Agriculturalist
Schätzl, J.	Member	Board of examiners – Qualified Agriculturalist at Landshut authority for continuing education
Schätzl, J.	Member	Board of examiners – Qualified Agriculturalist at authority for continuing education Erding and Freising region
Seefelder, S.	Member	Society for Hop Research e.V.
Seefelder, S.	Member	KG PR activities of the LfL
Seigner, E.	Member	Society for Hop Research e.V.
Seigner, E.	Member	Society for Plant Breeding
Seigner, E.	Member	International Society of Horticultural Science (ISHS)
Seigner, E.	Chair and Secretary	Scientific-Technical Commission of the IHGC
Sichelstiel, W.	Member	DPG, German Phytomedicinal Society
Sichelstiel, W.	Chair	EU Commodity Expert Group Minor Uses Hops
Sichelstiel, W.	Member	Society for Hop Research e.V.
Weihrauch, F.	Member	Consortium of Bavarian Entomologists e.V.
Weihrauch, F.	Member	British Dragonfly Society
Weihrauch, F.	Member	DgaaE, German Society for General and Applied Entomology
Weihrauch, F.	Responsible for bibliography	DGaaE, WG Neuroptera
Weihrauch, F.	Member	DgaaE, WG Beneficial Arthropods and Entomopathogenic Nematodes
Weihrauch, F.	Member	DgfO, German Society for Orthopterology
Weihrauch, F.	Member	DPG, German Phytomedicinal Society
Weihrauch, F.	Member	Society for Hop Research e.V.
Weihrauch, F.	Member	Entomological Society of Munich e.V.
Weihrauch, F.	Member of the Editorial Board	Worldwide Dragonfly Society
Weihrauch, F.	Member	Red List Working Group - Germany's Neuroptera
Weihrauch, F.	Member	Red List Working Groups - Bavaria's Dragonflies and Neuroptera

9 Personnel at IPZ 5 - Hops Department

The following members of staff were employed at the Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, at Hüll, Wolnzach, and Freising in 2015 (WG = Working Group)

IPZ 5

Coordinator:
LD Sichelstiel Wolfgang

Hertwig Alexandra
Krenauer Birgit

IPZ 5a

WG Hop Cultivation/Production Techniques
(*AG Hopfenbau/, Produktionstechnik*)
LD Portner Johann

Fischer Elke
LA Fuß Stefan
Dipl.-Biol. (Univ.) Graf Tobias
LA Münsterer Jakob
Dipl.-Ing. (FH) Lutz Maria
LR Schätzl Johann

IPZ 5b

WG Plant Protection in Hop Growing
(*AG Pflanzenschutz im Hopfenbau*)
LD Sichelstiel Wolfgang

LTA Ehrenstraßer Olga (until 31.03.2015)
BTA Eisenbraun Daniel (as of 01.04.2015)
Felsl Maria
Dipl.-Ing. (FH) Jereb Marina
LI Meyr Georg
Weiher Johann
Dr. rer. nat. Weihrauch Florian
M.Sc. Wörner Laura

IPZ 5c

WG Hop Breeding Research
(*AG Züchtungsforschung Hopfen*)
RD Dr. Seigner Elisabeth

Brummer Brigitte (as of 01.09.2015)
Dandl Maximilian
BTA Eisenbraun Daniel (until 31.03.2015)
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
Pflügl Ursula
Presl Irmgard (until 31.05.2015)
ORR Dr. Seefelder Stefan (until 31.10.2015)
Suchostawski Christa

IPZ 5d

WG Hop Quality and Analytics
(*AG Hopfenqualität und –analytik*)
ORR Dr. Kammhuber Klaus

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