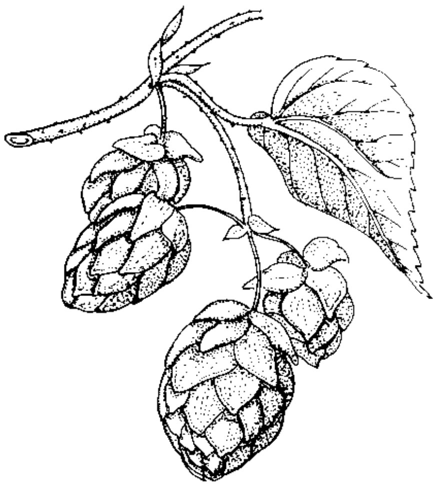
Bayerische Landesanstalt für Landwirtschaft

Gesellschaft für Hopfenforschung e.V.

Annual Report 2018

Special Crop: Hops



Bavarian State Research Center for Agriculture

- Institute for Crop Science and Plant Breeding -

and

Society of Hop Research e.V.

March 2019

LfL-Information

Publishing 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
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First edition:	March 2019
Nominal fee:	5,-- €

Foreword

Each year is different; and each year brings new challenges for hop growing. Generally speaking, there is no denying that climate change is upon us, and hot, arid summers are becoming increasingly common. 2018, too, was characterized by global warming. For the initial two-thirds of March it was still definitely winter, but then spring arrived and went straight into summer with no transition period. The growing season was atypically warm and dry, with the result that the hops soon started flowering and the hop harvest began earlier than ever before. Yields were slightly below average and alpha acids content considerably below average, underlining the up-to-the minute importance of research into irrigation. First and foremost, breeding research is crucial to addressing the problems of adapting to climate change. The new cultivars from Hüll, *Mandarina Bavaria*, *Hallertau Blanc*, *Herkules*, and *Polaris*, demonstrated once again their enhanced stress tolerance in the face of the extremes of 2018's weather conditions.

As regards pests and diseases, 2018 saw serious problems with powdery mildew and persistent infestation by the two-spotted spider mite. The success of the referendum on biodiversity will certainly not be conducive to making plant protection agents readily available. Added to this, the fertilizer ordinance will demand huge efforts on the part of farmers in order to protect our groundwater. A project run by Working Group Hop Farming/Production Techniques is in the process of establishing the basics of selective, needs-oriented fertilization, making the most efficient use of plant nutrients. At the same time, work is underway to look closely at nitrogen dynamics in hop-growing soils and the effect the use of crop residues has on this, with the aim of optimizing fertilizer management and avoiding water contamination.

Working Group IPZ 5d Hop Quality/Hop Analytics plays an important interdisciplinary role in performing all the analytical tests required by the other Working Groups, for the breeding unit in particular. In the last few years, the Society of Hop Research *(Gesellschaft für Hopfenforschung*) has invested heavily in analytics equipment. In 2018, the purchase was approved of an automatic liquid sampler to complement the gas chromatography/mass spectrometry system so that water vapour distillates can now be analysed.

The euphoria surrounding craft beers and special flavor hops has now become rather muted. At present, we are seeing a glut of these hop varieties, which is affecting both price and demand. Aside from this development, the market for hop is pleasingly positive. Supply contract cover is high, and prices, especially for hops sold on the spot market, are very good. In fact, the demand for bittering hops cannot be fully met.

The challenges facing hop will most certainly accumulate in the next few years. However, LfL hop research is well-placed to rise to these challenges and devise solutions to the problems ahead that will benefit hop growing in both Bavaria and Germany as a whole. The annual report which follows presents in detail all the research activities of the Hüll research facility. Successful research cannot be done without the hard work, commitment and creativity contributed by all the staff at Hüll, Wolnzach and Freising, so, at this point, I would like to express our special thanks to everyone involved.

Dr. Michael Möller
Chief Executive,
Society of Hop Research

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

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1 Research Projects and Key Research Priorities, Hops Department

1.1 Current Research Projects

Model Project: Demonstration Farms - Integrated Plant Protection, sub-project Hop Farming 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)*
Funded by:	Bundesministerium für Ernährung und Landwirtschaft (BMEL) über die Bundesanstalt für Landwirtschaft und Ernährung (BLE) *(Federal Ministry of Food and Agriculture (BMLE) managed by the Federal Institute for Food and Agriculture (BLE))*
Project lead:	J. Portner
Project staff:	R. Obster
Collaboration:	Julius Kühn-Institut (JKI) Zentralstelle der Länder für EDV-gestützte Entscheidungshilfen und Programme im Pflanzenschutz (*Central Institution for Decision Support Systems in Crop Protection and Crop Production* (ZEPP)) 5 Demonstration farms (growing hops) in the Hallertau region
Duration:	01.03.2014 – 30.04.2019

Objective

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

Its objective was 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 (IPS) had to be adhered to and non-chemical plant protection measures given preference – inasfar as these were available and their use was practicable. The demonstration farms were to act nationwide as torchbearers in the context of the project, by familiarizing not only the hop grower community but also advisors and the general public with all the latest measures and findings in line with the IPS scheme.

See 5.2 for more information on implementation, activities and results.

Improvement of nutrient use efficiency in hop through fertilization systems with fertigation (ID 5612)

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft Institut für Pflanzenbau und Pflanzenzüchtung (IPZ 5a) *(Bavarian State Research Center for Agriculture* *Institute for Crop Science and Plant Breeding (IPZ 5a))*
Funded by:	Erzeugergemeinschaft HVG e. G. *(HVG Hop Producer Group)*
Project lead:	J. Portner
Project staff:	J. Stampfl, S. Fuß
Collaboration:	Prof. Dr. T. Ebertseder, Hochschule Weihenstephan-Triesdorf Prof. Dr. F. Wiesler, LUFA Speyer Hop farms in the Hallertau region
Scheduled to run:	2017 – 2020

If it is to deliver stable yields and consistently good quality, the speciality field crop hop requires high-maintenance treatment when it comes to the water it receives. What is crucial is not only the amount of water absolute, but also how the rainfall is distributed over time. In the light of the above, irrigation can play an important part in securing yields and minimizing risks, not only in drought years but also in years when rainfall is unevenly distributed over a longer period.

Apart from ensuring that plants are supplied with water, irrigation systems can also act as a vehicle for plant nutrient input via the water, thus enabling selective control of quantity and timing. This technique, known as fertigation, is used in agriculture predominantly in extremely arid regions of the world (e.g. the Yakima Valley in the USA). The practice of fertigation makes it possible to tailor nutrient supply to suit plant requirements in the course of the growing season and it has an added advantage in that it can avoid adverse environmental effects by minimizing nutrient export into other ecosystems (into the groundwater, for example). In the Hallertau region, most of the plant nutrients are distributed by broadcasting granulate fertilizer over the surface of the soil. In dry conditions especially, this means there is a risk of the fertilizer not being absorbed in time, so that it remains unused in the ground.

Under this project, experiments are being carried out on hop at the LfL in the period 2017 to 2019, with a view to establishing the best methods of irrigation and fertigation to promote nitrogen use efficiency

Project objectives

- to optimize N fertilization by choosing the most appropriate application rates and times
- to develop bespoke fertigation-assisted N fertilization systems whereby application takes place depending on:
    - è uptake of the hop plant as growth progresses
    - è natural N delivery
- to establish methods of measuring the current plant N status
- to improve N efficiency and minimize export of N to other ecosystems

Fig. 1.1: Drip irrigation of hops

Fig. 1.2: Fertilizer input with fertigation of hops

Methodology

- set up and carry out fertilization and irrigation trials with accuracy and precision in the period 2017 to 2019 on different varieties and in different locations
- harvest from field trial plants to determine dry matter of cones and residual plant parts
- analysis of nutrient content of cones and residual plant parts
- calculate level of N extraction to assess N utilization
- take soil samples in spring and autumn for N_{min} analysis
- determine development of biomass and nutrient uptake in current hop varieties over the growing season
- apply pre-determined weekly amounts of nitrogen via irrigation water at the time when uptake rates are highest *(*Fig. 1.3*)*
- carry out SPAD meter and multispectral measuring to determine current N status
- investigate the effect different water application methods have with different N fertilization systems
- use climate models in combination with soil humidity sensors to control drip irrigation to suit location requirements

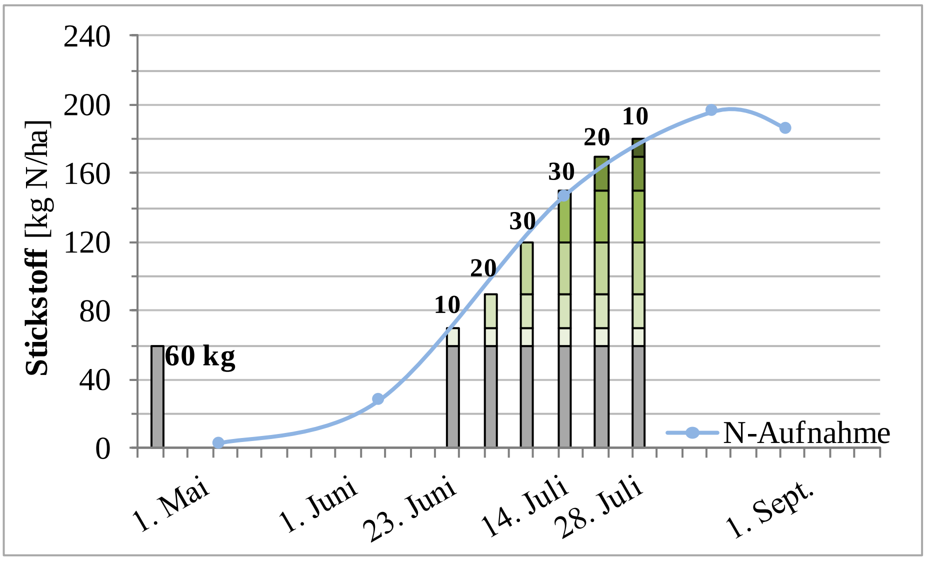

Fig. 1.3: N fertilization system with fertigation (1/3 broadcast, 2/3 fertigation), N uptake in hop over the growing season

Results

First results from the project in 2017 and 2018 show that yields and quality can be optimized selectively by customizing N fertilization systems through fertigation. Furthermore, in the variants with fertigation a greater total amount of dry matter was registered at harvest than in the reference variants where N was applied by broadcasting. When the calculated amounts of N extraction were compared, it became clear that nitrogen utilization can be greatly improved if pre-determined quantities of N are applied via fertigation at specific key times. *(Fig.1.4)*. Thus drip irrigation and fertigation-assisted fertilizing systems can help minimize the risk of N export to other ecosystems, e.g. nitrate leaching into the groundwater.

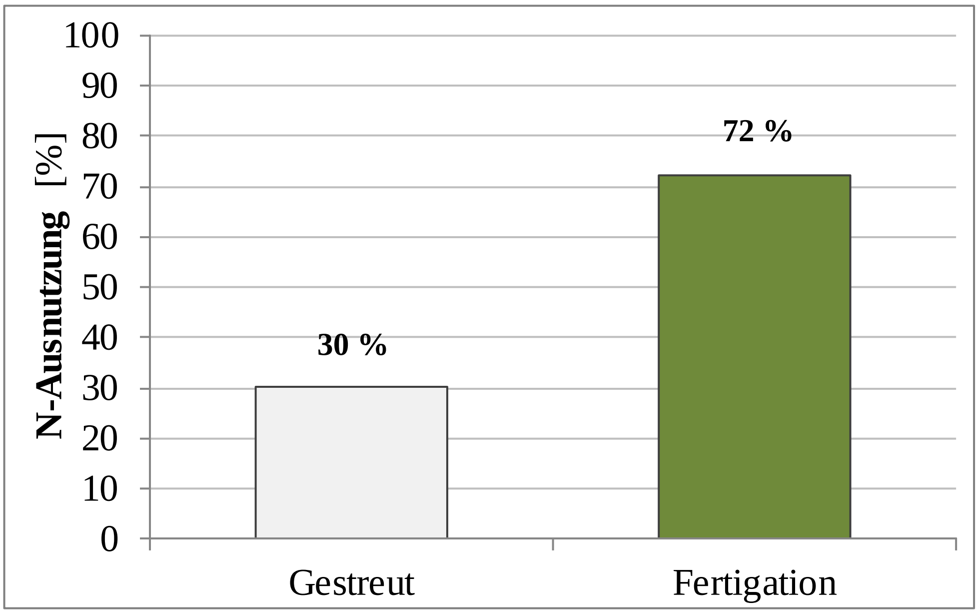

Fig.1.4: N utilizaton shown as a percentage of the nitrogen applied;
N fertilization = 100 kg N/ha; surface irrigation of both trial variants

Nitrogen dynamics in different types of hop-growing soils with different systems of fertilization (ID 6054)

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft Institut für Pflanzenbau und Pflanzenzüchtung (IPZ 5a) *(Bavarian State Research Center for Agriculture Institute for Crop Science and Plant Breeding)*
Funded by:	Erzeugergemeinschaft HVG *(HVG Hop Producer Group)*
Project lead:	J. Portner
Project staff:	A. Schlagenhaufer
Collaboration:	Hop farms in the Hallertau region
Scheduled to run:	01.03.2018 - 28.02.2021

Situation at the outset

Land use in the Hallertau region is in large part devoted to growing hop. Hop is a speciality crop with high added value, requiring high-input intensive farming. Nitrogen fertilizer, especially, was used in large quantities in the past. At the same time, the bodies of groundwater in many areas of the Hallertau have been shown to have a high concentration of nitrates. It is therefore reasonable to suppose that there is a connection to be made to hop farming, especially since N_{min} soil audits in springtime often reveal high levels of nitrogen. It is quite possible that the practice of returning chopped hop bine residues to the land or of distributing other organic fertilizers in autumn is contributing to these raised nitrogen levels. The nitrogen remaining or released in the soil is no longer absorbed by the hops in the autumn and is then vulnerable to displacement or nitrate leaching.

Objective

Within the context of this project, the nitrogen dynamics in the hop-producing soils of 21 hop farms are to be examined; this will involve intensive N_{min} testing: in spring before the start of the growing season, in autumn post harvest, and in winter. The purpose is also to establish how much nitrogen fertilizer the plots require and how much N fertilizer is actually applied, and to calculate an operational nutrient balance. It will then be possible to estimate the extent of nitrogen displacement and potential losses during the growing season for different types of farming businesses, diverse fertilization schemes, and various soil types and to develop strategies for optimizing nitrogen management in hop farming. The idea is to do this is such a way as to achieve the very best quality yields in compliance with the regulations of the fertilizer ordinance, without compromising the effectiveness of water pollution control.

Methodology

On each of the 21 farms, 3 sub-plots were selected. The 63 sub-plots represent the diversity of the varieties grown in the Hallertau region, as well as reflecting the wide range of different systems of farming and fertilizer application. N_{min} sampling is done as growth commences in March, post harvest in October, to assess how much nitrogen remains in the soil, and during the dormant period in the winter, to check for any winter displacement. Standard procedure is to sample to a soil depth of 90 cm for available nitrogen in the form of ammonia and nitrate. The sample is then divided into three 30 cm-sections to facilitate a better assessment of displacement in the different soil layers. Each farm is given individual advice on fertilization issues. Records are kept of rates and times of all applications of nitrogen fertilizer.

At harvest, samples are taken from cones and residual plant parts in order to calculate exactly how much nitrogen has been removed. This means that a nutrient balance specific to each plot can be determined, linked to the N_{min} levels in the soil.

Fig.1.5: Participating farms in the Hallertau region

Experimental composting and recycling of chopped hop bine residues to optimize nutrient use efficiency of organically bound nitrogen (ID 6141)

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft Institut für Pflanzenbau und Pflanzenzüchtung (IPZ 5a) *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding) (IPZ 5a)*
Funded by:	Erzeugergemeinschaft HVG *(HVG Hop Producer Group)*
Project lead:	J. Portner
Project staff:	A. Schlagenhaufer, J. Stampfl, S. Fuß
Collaboration:	Prof. Dr. Meinken, Institut für Gartenbau *(Horticultural Research Institute)* Hochschule Weihenstephan-Triesdorf Prof. Dr. Ebertseder, Fakultät Nachhaltige Agrar-und Energiesysteme *(Faculty of Sustainable Agriculture and Energy Systems)* Hochschule Weihenstephan-Triesdorf M. Stadler, Fachzentrum Agrarökologie *(Centre of Expertise for Agroecology),* AELF Pfaffenhofen a. d. Ilm
Scheduled to run:	01.09.2018 - 31.12.2021

Situation at the outset

In the Hallertau hop-growing region, 903 farms work 16 780 hectares of hops. During on-farm harvesting approximately 230 000 tonnes of bine residues are produced, roughly 80% of which is currently returned to the hop yards as farm manure after harvesting operations have been completed. However, these bine residues contain substantial amounts of nitrogen. In implementing the new fertilizer ordinance, the farmer is required to use the nitrogen in the bine residues as efficiently as possible, preventing losses to other ecosystems. To this purpose, extensive composting and fertilizing trials involving the bine residues are to be conducted to examine N release and N efficiency.

Objective

The first stage of the project involves the development and trialling of practicable and environment-friendly methods of composting hop bine residues, to comply with the strict regulations of the fertilizer ordinance governing the timing and permitted rates of application of agricultural fertilizers in autumn and to avert eventual N losses over the winter. During the second stage of the project, field experiments are to be conducted to examine the efficacy and loss potential of the organically bound nitrogen in the bine residues. The different methods will be judged in terms of their economy, ecology, and practicability.

The aim is to establish a legally compliant, practicable, and environmentally friendly method of composting bine residues with maximum utilization of organically bound nitrogen.

Methodology

The trial setup for the project envisages four work packages (AP 1-4). Forming the basis for the trial are small-scale composting experiments (AP 1) (clamp size approx. 1.5 m²) to find the basic conditions for an aerobic composting process. At the same time, in a further experiment, bine residues will simply be deposited in a heap post harvest, as is common practice at present; or they will be composted aerobically, composted using the Witte technique (MC composting), or converted into silage (AP 2). The composting experiment conducted under real-world conditions has several aims. One aim is to test, on a small scale, whether the insights gained can be translated into practice. The second aim is to compare the aerobic composting process with the other three variants to establish its practicability and its potential for conserving the nitrogen contained in the bine residues. Also, these experiments deliver the material for the sub-plot experiments to establish the N efficiency of the four different materials (heaped hop bine residues, aerobic compost, MC compost, silage) which constitute the third part of the project (AP 3). The material is also needed for the fourth part of the project, namely the field trials to investigate the soil N dynamics in hop yards (AP 4). All four parts of the project were begun in the autumn of 2018, at the same time as the hop harvest.

Fig.1.6: AP 2: from left to right: aerobic compost, MC compost, silage, conventional heap

Fig.1.7: AP 3: Application of bine residues in the autumn on a sub-plot planted to winter rye

Development of optimal air distribution systems when redesigning a special belt dryer to dry hops (ID 6055)

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft Institut für Pflanzenbau und Pflanzenzüchtung (IPZ 5a) *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding (IPZ 5a))*
Funded by:	Erzeugergemeinschaft HVG *(HVG Hop Producer Group)*
Project lead:	J. Portner
Project staff:	J. Münsterer
Collaboration:	HTCO GmbH, Freiburg, J. Satzl, Fa. Fuß, C. Euringer
Duration:	2014 - 2018

Situation at the outset and objective

Owing to the continuing expansion of the acreage under hop, drying capacity on many hop farms can no longer keep pace with the quantities of hop being harvested. This often means that it is imperative for those drying capacities to be augmented. It is thanks to new findings from trials focused on optimizing belt drying and the insights gained in practice that hop drying in a belt dryer now, for some farming businesses, offers an interesting economical alternative to kiln drying.

In the last few years, instead of building a new kiln, many a farmer had opted to purchase a second-hand belt dryer. However, the number of used belt dryers on the market is limited, so this means that there will soon be an increased demand for belt dryers that have been specially designed for drying hop.

The decisive factor determining the uniformity of the drying process is the way in which the air is distributed. A further air-flow simulation, as described in the Annual Report 2017, was to be used to optimize the hitherto common air distribution systems or to develop novel systems. The idea is to adjust the air inlets so that the drying air is directed as evenly as possible onto the belts transporting the hop.

See 5.3 for details of methodology and findings.

Crossbreeding with Tettnanger landrace

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtungsforschung Hopfen (IPZ 5c) und AG Hopfenqualität/Hopfenanalytik (IPZ 5d) *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Breeding Research (IPZ 5c) and WG Hop Quality/Hop Analytics (IPZ 5d)*
Funded by:	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)* Gesellschaft für Hopfenforschung e.V. (2011-2014) *(Society of Hop Research)*
Project leads:	Dr. E. Seigner, A. Lutz
Project staff:	AG Züchtungforschung Hopfen *(WG Hop Breeding Research)*: A. Lutz, J. Kneidl, D. Ismann, H. Graßl and team AG Hopfenanalytik *(WG Hop Analytics)*: Dr. K. Kammhuber, C. Petzina, B. Wyschkon, M. Hainzlmaier and S. Weihrauch
Collaboration:	Hopfenversuchsgut Straß des Landwirtschaftlichen Technologiezentrums (LTZ) (*Straß Hop Experimental Station of the LTZ*), Baden-Württemberg: F. Wöllhaf, B. Bohner, G. Bader
Scheduled to run:	01.05.2011 - 31.12.2020

Objective

The aim is to develop a hop variety with a traditional noble aroma similar to that of Tettnanger landrace through classical crossbreeding with Tettnanger, and, at the same time, significantly to improve yield potential and fungal resistance in the newly bred variety compared with the original Tettnanger.

For details of methods and results, see 4.3

Development of healthy, high-yielding hops with high alpha acids content, particularly suited to cultivation in the Elbe-Saale region

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtungsforschung Hopfen (IPZ 5c) *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Breeding Research (IPZ 5c))*
Funded by:	Thüringer Ministerium für Infrastruktur und Landwirtschaft *(Thuringian Ministry of Infrastructure and Agriculture)* Ministerium für Landwirtschaft und Umwelt Sachsen-Anhalt *(Ministry of Agriculture and the Environment in Saxony-Anhalt)* Staatsministerium für Umwelt und Landwirtschaft Sachsen *(State Ministry of the Environment and Agriculture in Saxony)* Erzeugergemeinschaft Hopfen HVG e.G. *(HVG Hop Producer Group)*
Project leads:	Dr. E. Seigner, A. Lutz
Project staff:	AG Züchtungforschung Hopfen *(WG Hop Breeding Research)*: A. Lutz, J. Kneidl, D. Ismann, H. Grebmair and team AG Hopfenanalytik *(WG Hop Analytics)*: Dr. K. Kammhuber, C. Petzina, B. Wyschkon, M. Hainzlmaier, S. Weihrauch
Collaboration:	Hopfenpflanzerverband Elbe-Saale e.V. *(Elbe-Saale Hop Growers'Association)* Thüringer Landesanstalt für Landwirtschaft (TLL) *(State Center for Agriculture, Thuringia)* Berthold hop farm
Scheduled to run:	01.01.2016 - 31.12.2019

Objective

The aim of this project is to breed and test new robust and high-yielding hop breeding lines with high alpha acids content and broad-spectrum resistance characteristics that make the hops resistant chiefly to crown rot pathogens and mean they are also suitable for production in the very special conditions of the Elbe-Saale region. In addition, it is hoped that a better attunement to climatic conditions and improved nutrient use efficiency can be attained. The latter is relevant, above all, in the context of the fertilization ordinance.

To achieve this, new high alpha breeding lines are being developed, while, at the same time, already pre-selected lines from the ongoing Hüll high alpha breeding programme are being tested by three growers in the Elbe-Saale hop-producing region to establish their suitability for that particular location.

See 4.4 for details of operational implementation and insights gained thus far.

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 (IPZ 5c) *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Breeding Research (IPZ 5c))*
Funded by:	Gesellschaft für Hopfenforschung e.V. (2013 - 2014; 2017 - 2019) *(Society of Hop Research)* Erzeugergemeinschaft Hopfen HVG e.G. (2015 - 2016) *(HVG Hop producer Group)*
Project leads:	Dr. E. Seigner, A. Lutz
Project staff:	AG Züchtungforschung Hopfen *(WG Hop Breeding Research)*: A. Lutz, J. Kneidl EpiLogic: S. Hasyn
Collaboration:	Dr. F. Felsenstein, EpiLogic GmbH, Agrarbiologische Forschung und Beratung, Freising
Scheduled to run:	01.01.2013 - 31.12.2019

Objective

Increased resistance to diseases, in particular to powdery mildew, continues to be the top priority in developing new breeding lines. To this purpose, seedlings from all the breeding programmes are screened every year for powdery mildew resistance in the greenhouse at Hüll, and then in the laboratory by means of a special leaf assay. PM isolates of all the currently known virulence genes are made available by EpiLogic, Agrarbiologische Forschung und Beratung, Freising, allowing the diverse work in connection with breeding for resistance to mildew to be performed.

Fig.1.8: Seedling trays for resistance screening in the greenhouse, inoculator plants standing between the trays

Fig. 1.9: Leaf assay at EpiLogic: in a petri dish 2 leaves of each test hop are examined against a leaf of the highly susceptible cultivar Northern Brewer (the first leaf at the very top in the photo)

Description of the work

8 previously characterized single-spore isolates of *Sphaerotheca macularis*, the fungus causing powdery mildew on hop, were used with the greenhouse and laboratory resistance testing systems for the following:

- characterisization of the virulence properties of the PM isolates
- testing of all seedlings for PM resistance in the greenhouse at Hüll
- testing for PM resistance, using the detached leaf assay in the EpiLogic laboratory
- assessment of the virulence situation in the hop-growing region and evaluation of the resistance sources via the detached leaf assay

For details of all work connected with breeding for PM resistance go to
http://www.lfl.bayern.de/ipz/hopfen/116878/index.php.

Tab. 1.1: Overview of 2018 PM resistance testing with defined virulence PM isolates

2018	Greenhouse tests		Leaf tests in the lab	
	Plants	**Assessments**	**Plants**	**Assessments**
Seedlings from xx crosses	approx.100.000 by mass sceening		-	-
Breeding lines*	130	327	174	1 317
Varieties*	49	195	4	15
Wild hop*	2	8	0	0
Virulences PM isolates	-	-	12	437
Total (individual tests)	**181**	**530**	**190**	**2 299**

Mass screening in plant trays; individual tests = selection as individual plants in pots
*in part data for the GHop Project (marker-assisted breeding)

Research into and work on the problem of *Verticillium* on hop

Managing *Verticillium* wilt disease in the German hop-growing regions is a long-term undertaking. Research and the guidance provided by the LfL are of crucial importance in supporting hop growers in their struggle to control *Verticillium*.

Molecular detection of *Verticillium* with the aim of producing healthy planting material

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 Züchtungsforschung Hopfen und (IPZ 5c)
(WG Hop Breeding Research and (IPZ 5c))

Funded by: Erzeugergemeinschaft Hopfen HVG e.G.
(HVG Hop Producer Group)

Project lead: Dr. E. Seigner

Project staff: AG Züchtungforschung Hopfen *(WG Hop Breeding Research)*:
P. Hager, R. Enders, A. Lutz, J. Kneidl

Collaboration: AG Pflanzenschutz im Hopfenbau *(WG Hop Plant Protection)*:
S. Euringer
Dr. S. Radišek, Slovenian Institute of Hop Research and Brewing, Slovenia

Scheduled to run: from 2008 - 30.05.2020

For details see 4.5

Monitoring for dangerous viroid infections on hop in Germany

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenschutz, *(Bavarian State Research Center for Agriculture, Institute for Plant Protection)* AG Virologie (*WG Virology*) (IPS 2c) und Institut für Pflanzenbau und Pflanzenzüchtung *(Institute for Crop Science and Plant Breeding*), AG Züchtungsforschung Hopfen (IPZ 5c) *(WG Hop Breeding Research IPZ 5c))*
Funded by:	Wissenschaftliche Station für Brauerei in München e.V. *(Scientific Station for Brewing in Munich)*
Project leads:	Dr. L. Seigner, Institut für Pflanzenschutz (IPS 2c) *(Institute for Plant Protection (IPS 2c))*; Dr. E. Seigner, A. Lutz (IPZ 5c)
Project staff:	K. Einberger (IPS 2c); A. Lutz, J. Kneidl (IPZ 5c)
Collaboration:	Dr. S. Radišek, Slovenian Institute of Hop Research and Brewing, Slovenia AG Hopfenbau und Produktionstechnik, IPZ 5a *(WG Hop Farming/Production Techniques, IPZ 5a))* AG Pflanzenschutz im Hopfenbau, IPZ 5b *(WG Hop Plant Protection, IPZ 5b))* Local hop consultants Hopfenring e.V. Commercial hop farms Eickelmann propagation facility, Geisenfeld
Duration:	March - December 2018

Objective

For some years now, hop production in Germany has been under threat of infection from two dangerous viroid diseases, namely hop stunt viroid (HpSVd) and citrus viroid IV (CBCVd = citrus bark cracking viroid). Infection with these two viroids leads to dramatically stunted growth in hops and results in drastic economic losses due to reduced yields and alpha acids levels.

Since the symptoms often do not appear until years later, and especially since both viroids are easily spread as well as being untreatable, there is a grave danger that any introduction of one or both viroids into German hop farming would result in considerable economic losses. The nationwide LfL viroid monitoring scheme, in place since 2008, with financial support since 2011 from the Scientific Station for Brewing in Munich *(Wissenschaftliche Station für Brauerei in München e.V.),* makes a substantial contribution towards preventing disease and safeguarding hop production in Germany. It means that first infections with a viroid can be detected, foci of primary infection eradicated, and a spreading of the dreaded pathogens prevented.

In addition, hops produced by meristem tissue culture or derived from advanced research into eliminating pathogens were also examined for viruses and viroids as part of the project.

Method

205 samples were collected from different growing regions in Germany, from commercially run farms, LfL breeding yards and a GfH propagation facility. To cap the high costs involved, monitoring was carried out on a random basis rather than universally, with representative samples being screened in crucial locations, whereby plants that looked particularly problematic were chosen. Foreign cultivars were also examined, as well as plants from abroad held in quarantine for EU plant variety registration testing at Hüll.

Screening for HpSVd and CBCVd was done by Real-time RT-(reverse transcriptase) PCR. The samples were tested for HpSVd using the primers and gene probe as published by Luigi and Faggioli (2013), and tested for CBCVd using the primers and gene probe (not published) developed by Seigner. With each sample, an internal hop-specific mRNA-based control (Botermans et al., 2013) was run parallel to the RT-PCR to make sure that it was functioning correctly.

In order to check whether virus elimination was successful, the hops were screened after meristem culture for AHpLV, ApMV, HpLV, HpMV and HpLVd, using ELISA, RT-PCR or Real-time RT-PCR (Seigner et al., 2014; Gucek et al. 2016), but not for HpSVd and CBCVd, because the two latter have so far not been widespread in Germany.

Results

In 2018 a total of 205 hop samples from commercial farms etc. were examined.

Source	Location	Number of samples	HSVd positive	CBCVd positive
Commercially run farms	Hallertau	30	0	0
	Tettnang	10	0	0
	Elbe-Saale	2	0	0
Breeding yards	Hüll variety register	66	0	0
	Hüll variety yard	16	0	0
Quarantine prior to plant variety registration	Greenhouse Freising	81	0	0
Total		205	0	0

Not a single sample tested positive for hop stunt viroid or citrus viroid. Since 2008 around 2800 samples have been tested for HpSVd, and, since 2013, roughly 1350 samples for CBCVd. The nine cases of HpSVd infection found in one location in 2010 remain the only positive results to date. At the time, the focus of infection was eradicated.

With the aim of verifying their virus- and viroid-free status after meristem culture, young tissue-culture plants were examined for the various pathogens before being transferred to soil. Hops resulting from new research into virus and viroid elimination were also examined as part of the project.

The viroid threat is still considerable, due to the global infection situation, importation, the transfer of plant material from infected areas, and the lack of quarantine regulations. It is conceivable that nests of infection already in place have not yet been detected because of the relatively coarse grid pattern applied in the monitoring process.

German hop growers are really keen to import and grow flavor hops from the USA, a country where hop is known to be susceptible to HpSVd, and this also greatly increases the risk of introducing it into Germany. The fact that HpSVd was discovered in the summer of 2016 in various cultivars imported from the USA and subsequently grown in the EU underlines the seriousness of the problem. In consequence, strict and close monitoring for HpSVd and CBCVd will need to continue in future.

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Acknowledgement

Our thanks go to Dr. Sebastjan Radišek of Slovenia for his support in this work.

Marker-assisted breeding for hop ─ genome-based marker-assisted breeding for quality hops of the future

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding)*
Funded by:	Funds from the Federal Government's earmarked capital at the Landwirtschaftliche Rentenbank
Funding code:	Landwirtschaftliche Rentenbank: 837 150 (BLE Aktenzeichen *(reference)*: 28RZ4IP025)
Project leads:	Dr. M. H. Hagemann, Universität Hohenheim (project overall) Dr. E. Seigner (LfL)
Project staff:	AG Züchtungsforschung Hopfen (IPZ 5c) *(WG Hop Breeding Research (IPZ 5c))*: A. Lutz, J. Kneidl, E. Seigner and team AG Hopfenqualität/Hopfenanalytik (IPZ 5d) *(WG Hop Quality/ Hop Analytics (IPZ 5d))*: Dr. K. Kammhuber, C. Petzina, B. Wyschkon, M. Hainzlmaier und S. Weihrauch AG Genom-orientierte Züchtung (IPZ 1d) *(WG Genome-oriented Breeding IPZ 1d)),* Prof. Dr. V. Mohler AG Züchtungsforschung Hafer und Gerste (IPZ 2c) (*WG Breeding Research Oats and Barley (IPZ 2c)*), Dr. T. Albrecht

Project partners:	Universität Hohenheim, Institut für Nutzpflanzenwissenschaften, FG Ertragsphysiologie der Sonderkulturen *(Institute for Crop Science, FG Yield Physiology of Speciality Crops)*: Dr. M. H. Hagemann, Prof. Dr. J. Wünsche
	Institut für Pflanzenzüchtung, Saatgutforschung und Populationsgenetik *(Institute for Plant Breeding, Seed Research and Population Genetics)*: Prof. Dr. G. Weber em.
	Gesellschaft für Hopfenforschung e.V.: W. König *(Society of Hop Research)*
	Hopfenverwertungsgenossenschaft HVG e.G.: Dr. E. Lehmair *(Hop Sales Cooperative)*
Scheduled to run:	01.08.2017 - 31.07.2020

Objective

Marker-assisted breeding is an innovative tool that is to be made available to German hop breeding research as a complement to the conventional selection process. By using the latter in combination with the novel genome-based technique it is possible to produce robust new, high- yielding varieties faster and more efficiently for the hops and brewing industry.

The project is focused on laying the groundwork for deployment of genome-based selection procedures when choosing parent plants for crossbreeding and evaluating the progeny of a cross. This selection method, based on molecular markers, will make it possible to estimate the breeding value of not only female but also male hops, a decisive step forward. Until now, it has not been possible to assess male hops in terms of yield and brewing attributes because there are no cones, so that their value as cross partners has always been unclear.

Procedure

First, phenotypic data such as resistances, agronomic performance traits, and cone components are identified by means of a reference collection, then all hops are genotyped, i.e. their genetic material is sequenced.

Using a biostatistical technique ─ association mapping ─ the DNA sections (molecular markers) are linked to the different phenotypic traits, thus identifying marker-trait relationships. Thanks to the linking of genetic markers with traits of interest, via the reference collection, it is possible to develop a prediction model with the help of which the phenotypic characteristics of new selection candidates can be surmised solely on the basis of their genetic data (genotype).

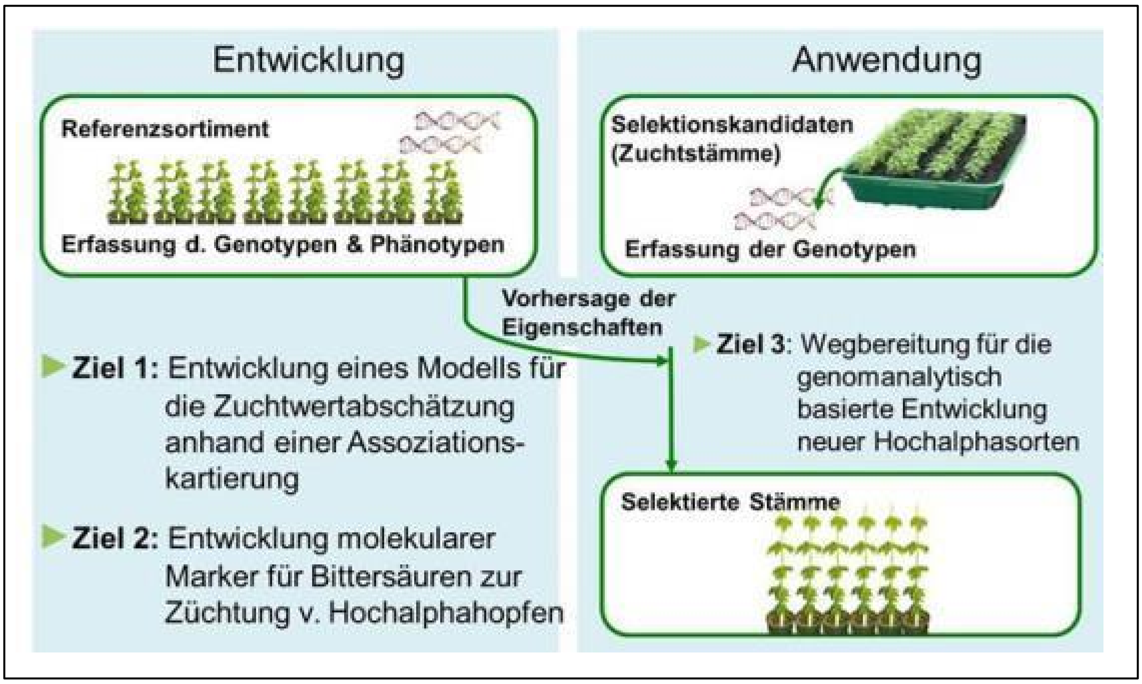

Fig.1.10: Development of a model for estimating breeding value through association mapping and developing molecular markers for bitter acids, with the objective of breeding new high alpha varieties on the basis of genome analysis. (Diagram: Dr. T. Albrecht)

Stage 2: August 2017 – July 2020

In collaboration with research partners Universität Hohenheim (UHOH), Gesellschaft für Hopfenforschung (GfH) *(Society of Hop Research)*, and Hopfenverwertungsgenossenschaft (HVG) *(Hop Sales Cooperative)*, the following work is being carried out:

- continued phenotyping of the reference collection: collecting data on resistances, agronomic performance traits and cone compounds in different locations and for different years; providing historical data, in part dating to the 1990s.
- molecular studies of bitter acids synthesis and its regulation
- association mapping: biostatistical linking of phenotypic data (resistances, agronomic performance traits, cone compounds) with the genotypic data of the hop reference collection to identify simple and complex marker-trait relationships.
- developing a prediction model to estimate breeding value (genomic selection).

Funding provided from the Federal Government's earmarked capital at the Landwirtschaftliche Rentenbank.

rentenbank

Marker-assisted breeding for hop – sub-project PM resistance for genome-wide association mapping

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Züchtungsforschung Hopfen (IPZ 5c) *(Bavarian State Research Center for Crop Science and Plant Breeding, WG Hop Breeding Research) (IPZ 5c)*
Funded by:	Wissenschaftsförderung der Deutschen Brauwirtschaft (Wifö) *(Scientific Funding from the German Brewing Industry)*
Funding code:	R444
Project leads:	Dr. E. Seigner, A. Lutz
Project staff	AG Züchtungsforschung *(WG Breeding Research)*: A. Lutz, J. Kneidl, E. Seigner and team AG Züchtungsforschung Hafer und Weizen *(WG Breeding Research Oats and Barley)* (IPZ 2c), Dr. T. Albrecht
Collaboration:	EpiLogic Agrarbiologische Forschung und Beratung, Freising Dr. F. Felsenstein and Stefanie Hasyn
Duration:	01.01.2016 - 31.12.2017 (financial support)

Objective

Thanks to the reliable screening systems for PM resistance both in the greenhouse and via the detached leaf assay in the lab, it is also possible to make meaningful assessments of individual plants in the mapping population. These phenotypic data are then combined with the genetic data from the project *Marker-assisted Breeding for Hop* in order to develop preliminary QTL (quantitative trait loci) mapping for various different PM resistance genes.

Method

- PM resistance screening system in the greenhouse
- detached leaf assay in the lab at EpiLogic (see Seigner et al., 2002)
- QTL combining of resistance data with SNP data

Results

In a first step, 304 F1 individual plants from a special mapping population were examined in the greenhouse for resistance, using virulence-defined PM isolates. Leaves from seedlings which had not exhibited PM infections in the greenhouse and were deemed resistant were differentiated using two special PM strains via the EpiLogic detached leaf assay. In order to verify the assessments, one hundred and forty-three F1 hops again underwent PM resistance screening the following year in the greenhouse and in the lab at EpiLogic.

It has so far not been possible to start QTL combining of the PM resistance data because provision by the Max Planck Institute of the genetic (SNP) data for the mapping population has been considerably delayed. Thus, also the sub-project is still to be completed.

Reference

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Research into and work on the problem of *Verticillium* on hop

Managing *Verticillium* wilt disease in the German hop-growing regions is a long-term undertaking. The research conducted and the guidance provided by the LfL play a crucial role in aiding hop growers in their struggle to control *Verticillium.*

Research into and work on producing *Verticillium*-free hops using meristem tissue culture

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung *(Bavarian State Center for Agriculture, Institute of Crop Science and Plant Breeding)*
	AG Züchtungsforschung Hopfen und (IPZ 5c) *(WG Hop Breeding Research and (IPZ 5c)*
Funded by:	Erzeugergemeinschaft Hopfen HVG e.G. *(HVG Hop Producer Group)*
Project lead:	Dr. E. Seigner (till Oct. 2015 Dr. S. Seefelder)
Project staff:	AG Züchtungforschung Hopfen *(WG Hop Breeding Research):* P. Hager, R. Enders, A. Lutz, J. Kneidl
Collaboration:	AG Pflanzenschutz im Hopfenbau *(WG Plant Protection in Hop Production)*: S. Euringer
	Dr. S. Radišek, Slovenian Institute of Hop Research and Brewing, Slovenia
Scheduled to run:	from 2008 – 30.05.2020

For details of this work see 4.5 and 4.6.

Sanitizing *Verticillium*-contaminated soils and selecting breeding material for *Verticillium* tolerance

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 Pflanzenschutz im Hopfenbau (IPZ 5b) *(WG Hop Plant Protection (IPZ 5b))*
Funded by:	Gesellschaft für Hopfenforschung (GfH) e.V. *(Society of Hop Research)*
	Erzeugergemeinschaft Hopfen HVG e.G *(HVG Hop Producer Group)*
Project lead:	S. Euringer
Project staff:	K. Lutz, IPZ 5 b

Collaboration:	AG Züchtungsforschung Hopfen *(WG Hop Breeding Research)*: A. Lutz, J. Kneidl, Dr. E. Seigner AG Hopfenbau/Produktionstechnik *(WG Hop Farming/Production Techniques)*: S**.** Fuss Dr. S. Radišek, Slovenian Institute of Hop Research and Brewing, Slovenia
Scheduled to run:	01.06.2017 – 30.05.2020

See 6.2 for more information.

Sanitizing *Verticillium*-contaminated soils through biological soil decontamination (BBE)

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 Pflanzenschutz im Hopfenbau (IPZ 5b) *(WG Hop Plant Protection (IPZ 5b))*
Funded by:	Erzeugergemeinschaft Hopfen HVG e.G *(HVG Hop Producer Group)* Gesellschaft für Hopfenforschung (GfH) e.V. *(Society of Hop Research)*
Project lead:	S. Euringer
Project staff:	K. Lutz, IPZ 5 b
Collaboration:	AG Züchtungsforschung Hopfen *(WG Hop Breeding Research)*: A. Lutz, J. Kneidl, Dr. E. Seigner AG Hopfenbau/Produktionstechnik *(WG Hop Farming/Production Techniques)*: S**.** Fuss Dr. S. Radišek, Slovenian Institute of Hop Research and Brewing, Slovenia
Scheduled to run:	2018 - 2019

Objective

The objective of the project is to evaluate how far biological (anaerobic) soil decontamination (BBE) works as a practicable control option against *Verticillium* wilt disease. The requirement: is its implementation practicable and, at the same time, economically viable? The benchmark goal is the sanitizing of *Verticillium*-infected soils through the absence of host plants (4-5 Jahre).

Method

A hop yard heavily infected with mild and lethal strains of *Verticillium* was dug up in the spring using a spindle grubber. Based on a testing scheme adapted to suit the documented *Verticillium* infection, a biological soil decontamination operation (BBE) was carried out (over 4 weeks in the summer). This involved working the product Herbie 72 into the soil to a depth of 40 cm and watering with 40 litres/m². The areas were then covered with exceptionally airtight sheeting.

Results

Gas measurement showed that oxygen levels can be kept to under 3% under the sheeting. The areas treated with Herbie 72 plus water had substantially lower oxygen levels. First germination after removal of the sheeting was of exclusively dicotyledonous plants. No grasses germinated. It is not yet possible to make any judgements as to the efficacy in controlling *Verticillium.*

Minimizing the use of copper-based plant protection agents in organic and integrated hop production

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Hopfenökologie (IPZ 5e *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Ecology (IPZ 5e))*
Funded by:	Erzeugergemeinschaft Hopfen HVG e.G. *(HVG Hop Producer Group)*
Project lead:	Dr. F. Weihrauch
Project staff:	M. Obermaier, A. Baumgartner, M. Felsl, Dr. F. Weihrauch
Collaboration:	Loibl Naturland organic farm, Schweinbach; Agrolytix GmbH, Erlangen
Scheduled to run:	01.03.2014 - 28.02.2021 (extension of the project)

Objective

According to an assessment by the Umweltbundesamt *(German Federal Environment Agency)*, inter alios, of the toxicological impact on both environment and users, plant protection agents containing copper should no longer be in general use. At the European level, copper as an active substance is also considered to be highly problematic and, in the last few years, its availablity for plant protection (see listing in Annex I) has only ever been extended for the short term. In December 2018, certification for copper was renewed, but only for a grace period of seven years at maximum, until 31 January 2026. During this time, plant protection products containing copper must disappear from the market the minute suitable equivalents or better active substances are available. For this reason, member states are required to do their utmost to develop ways of further reducing the use of copper.

At present, organic systems growing virtually every kind of produce are not yet in a position to forego copper as an active substance. A four-year test programme managed by BÖLN *(Federal Programme for Ecological Agriculture)*, which ran from 2010 to 2013, investigated how far copper levels in hop could be reduced per season without causing losses. The currently permitted spray rate of 4.0 kg Cu/ha/per year needed to be reduced by at least a quarter to 3.0 kg Cu/ha/year.

In the wake of the successful completion of the first project, this follow-up project aims to take a critical look at the 3.0 kg Cu/ha/year achieved thus far and to examine how far a further reduction in the use of copper is possible. However, findings from 2016 have shown that, in years with extreme conditions, exceptions should be made and the rates of copper used in controlling downy mildew be allowed to exceed 3 kg/ha. In such cases, it would be necessary to create a five-year ‘copper account’ (15 kg/ha over 5 years) for each farm, as kind of copper budget for all varieties *(Hoftorbilanz).*

Results

In the trial year 2018, once again 12 variants were set up, with the two copper-based agents (Funguran progress as approved product and CuCaps as test product) at different spray rates and with different mixing partners as synergists. Unfortunately, for the fourth year running, 2018 turned out not to be a normal year for downy mildew levels. Like 2015 and 2017, it was again a year with virtually no incidence of infection. However, what this trial year has chiefly shown is that neither the novel HopCaps (microencapsulated extract of hop) nor any other mixing partners cause clumping problems during application in combination with copper. The trials will be repeated in 2019 and 2020 at a new site on a more susceptible variety.

Developing methods of controlling the hop flea beetle *Psylliodes attenuatus* in organic hop production

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Hopfenökologie (IPZ 5e) *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Ecology) (IPZ 5e)*
Funded by:	Bayerisches Staatsministerium für Ernährung, Landwirtschaft und Forsten *(Bavarian State Ministry for Food, Agriculture and Forestry)* (BioRegio 2020 – Landesprogramm Ökologischer Landbau) *(BioRegio 2020 - Regional Programme for Ecological Agriculture)*
Project lead:	Dr. F. Weihrauch
Project staff:	Dr. F. Weihrauch, A. Baumgartner, M. Felsl, M. Mühlbauer
Collaboration:	Wageningen University & Research, NL; Julius-Kühn-Institut, Institut für Biologischen Pflanzenschutz *(Institute for Biological Plant Protection),* Darmstadt
Duration	01.03.2015 - 30.06.2018

Objective

The hop flea beetle (*Psylliodes attenuatus)* is steadily becoming a major concern for organic hop producers. 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 in mid- to late summer at the hop flowers and the gradually developing cones, reaching up as far as 5 to 6 metres on the trellises, causing significant yield losses in those areas where there is a greater degree of infestation. For the time being, there is no effective practice method of controlling the hop flea beetle in organic hop production, 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 suitable for use in organic agricultural systems, would therefore play a key role in integrated plant protection management.

Results

See the detailed report in 7.1 for the results for 2018 and for a headline summary of findings from the completed project.

The use of microencapsulated extracts of hop as a novel biological fungicide to combat downy mildew in hop production

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Hopfenökologie (IPZ 5e) *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Ecology) (IPZ 5e)*
Funded by:	Wissenschaftsförderung der Deutschen Brauwirtschaft e.V., Berlin (Wifö) *(Science Funding from the German Brewing Industry)*
Projeckt lead:	Dr. F. Weihrauch
Project staff:	Dr. F. Weihrauch, M. Obermaier, A. Baumgartner, M. Felsl
Collaboration:	Loibl Naturland organic farm, Schweinbach
	Lehrstuhl für Prozessmaschinen und Anlagentechnik (iPAT) *(Chair of Process Technology and Machinery (iPAT)),* Friedrich-Alexander-Universität Erlangen-Nürnberg
	Hallertauer Hopfenveredelungsgesellschaft m.b.H. (Hopsteiner), *(Hop Processing Society),* Mainburg
Scheduled to run:	01.07.2016 - 31.12.2019 (project extension)

Objective

In Germany, various efforts are underway to achieve a direct reduction in the quantities of pure copper applied per hectare every year as plant protection and to seek alternative active fungicide substances to replace it. In this context, the discovery was made at the Staatliches Weinbauinstitut (*State Viticulture Institute*) in Freiburg i. Br. that extract of hop works well *in vitro* in controlling the downy mildew *(Plasmopara viticola*) prevalent in grape vines. It is thought that the alpha acids and xanthohumol have an antimicrobial effect.
The purpose of the project is to develop a viable alternative to copper or to bring about a further reduction in its use in hop production. At the same time, the resulting plant protection agent must be not only effective and practicable to apply, it must also, above all, be affordable in practice. As a production method, spray congealing is a low-cost option, and, if suitable matrix substances and adjuvants are used, the cost of the end product can be kept down to normal market levels.

Methods

The current research project envisages developing through to the approval stage a prototype biological plant protection agent, based on microencapsulated extract of hop, to control downy mildew fungi in hop production. The desired outcome of the research work is the optimal formulation of the ingredients for the capsule prototypes and, in parallel, alongside the chemical optimization, the further development of microparticle production to ensure that manufacture of the hop capsules is economically viable and as efficient as possible. The prototypes which fulfil the aforementioned requirements for plant protection agents were tested for the second time outdoors in the trial yard at Schweinbach in 2018. In addition, the Hop Research Center at Hüll analysed the biological efficacy of these HopCaps partly outdoors again in 2018 ─ but sadly, for want of any incidence of infection, without result. The trials will be repeated in 2019 at a different site, and a spray recommendation suitable for implementation by organic hop farmers will be devised.

Further development of crop-specific strategies for ecological plant protection through dedicated networks – hops network

Sponsored by:	Bund Ökologische Lebensmittelwirtschaft (BÖLW e.V.) und Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Hopfenökologie (IPZ 5e) (*Organic Food Production Alliance (BÖLW e.V.) and Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Ecology (IPZ 5e)*)
Funded by:	Bundesanstalt für Landwirtschaft und Ernährung (BLE) über Bundesprogramm Ökologischer Landbau und andere Formen nachhaltiger Landwirtschaft (BÖLN-Projekt 2815OE095) (*Federal Agency for Agriculture and Food (BLE) through Federal Organic Farming Programme including other forms of sustainable agriculture) (BÖLN Project 2815OE095)*
Project lead:	Dr. F. Weihrauch
Project staff:	Dr. F. Weihrauch, M. Obermaier
Collaboration:	Bund Ökologische Lebensmittelwirtschaft (BÖLW e.V.) (*Organic Food Production Alliance (BÖLW)*)
Scheduled to run:	15.08.2017 - 14.08.2020

Approach and objective

The overall aim of the research project is to establish six crop cultivation networks (field crops, vegetables, hops, potatoes, fruit, and grapes) focused on plant health in organic farming, with coordinators for each section functioning as a central point of contact for the section. BÖLW is responsible for overall coordination; IPZ 5e at Hüll is responsible for coordination in the hops network.

It is the job of each coordinator to set up the crop network as a fixed group of working farms, to advise farms interested in converting, to collate issues relevant to plant health in the crop in question, to pick up and pass on information on innovation and any research needed, and to formulate plant health strategies for the respective crops. Within the organic hops network, communication takes place mainly via meetings of those involved 2 or 3 times a year, including a special workshop for all farms. Exchange of information between the crop networks and the overall coordinator is also by way of an annual workshop.

The most important events for the hops network in 2018 were the one-day hop production event during the Bioland Week at Kloster Plankstetten (06.02.2018), the summer excursion to Tettnang of the Arbeitskreis Ökohopfen *(Ecological Hops Study Group)* (24. - 25.07.2018), the network meeting with BÖLW and BLE in Kassel (09.10.2018) and, above all, the round table at Hüll on 17.10.2019 on the current issues to do with plant protection in organic hop production.

The main aim is to adhere to management strategies rather than relying on the introduction of phytomedicinal substances into the crop system. The expectations of the sponsors, BLE and BMEL, are centred around progress and innovation; i.e. ideally, as the overall outcome of the project, they would like to see the development of new management and cultivation systems and a joined-up work programme.

Developing a package of measures to promote biodiversity in hop production. What can be done?

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Hopfenökologie (IPZ 5e) *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Ecology (IPZ 5e))*
Funded by:	Erzeugergemeinschaft Hopfen HVG e.G. *(HVG Hop Producer Group)*
Project lead:	Dr. F. Weihrauch
Project staff:	Dr. F. Weihrauch, M. Obermaier
Collaboration:	TU München, Lehrstuhl für terrestrische Ökologie (Prof. W. Weisser) *(Munich Technical University, Chair of Terrestrial Ecology)*
Scheduled to run:	01.03.2018 - 31.12.2019

Objective and background:

Everyone is talking about biodiversity, and the Bavarian Government has declared that 2019 and 2020 are to be 'Biodiversity Years'. Already early in 2018, the Erzeugergemeinschaft Hopfen HVG *(HVG Hop Producer Group),* in conjunction with the LfL, started introducing measures to stop the decline and promote the diversity of species in hop cultivation. These measures include, for example: the evaluation of possible steps to promote biodiversity in and around hop yards, the drafting of a work concept, the formulating of individual issues and providing impulses for subsequent projects; making applications for approval of subsequent projects, e.g. with StMELF *(Bavarian State Ministry for Nutrition, Agriculture and Forestry),* and moderating the process of implementation in hop production practices.

Procedure

The first step is the building of a collaborative network within which as many as possible of the stakeholder federations, organizations and institutions work together to find a constructive approach and come up with solutions. To be included, besides the LfL and TUM, are BBV, AELF Pfaffenhofen (Fachzentrum Agrarökologie *Centre of Expertise for Agroecology*), UNB, LBV, IGN Niederlauterbach and all organizations in the Haus des Hopfens *(House of Hop).*

The raft of measures to be introduced includes, for example, not using marginal and unproductive land (not easily accessible), or problematical land (especially land directly adjacent to a watercourse or body of water); consciously giving more weight to small features that are already part of the landscape (e.g. field margins, climbing structures), thus enhancing their ecological importance; creating water's edge buffer strips, hedgerows, and strips or plots of wildflowers; repurposing 'there anyway' land (e.g. wayside borders, roadside verges, railway embankments, unused awkward-shaped pieces of land; establishing set-aside areas over several years; maintaining or creating stretches of bare ground (e.g. field-edge slopes). It is definitely not the object of the initiative in any way to compromise productivity or land used in production!

Establishing predator mites on undersown crops in commercial hop production

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, AG Hopfenökologie (IPZ 5e) *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding, WG Hop Ecology) (IPZ 5e)*
Funded by:	Bundesanstalt für Landwirtschaft und Ernährung (BLE) im Rahmen des Bundesprogramms Ökologischer Landbau und andere Formen nachhaltiger Landwirtschaft (BÖLN-Projekt 2815NA131) (*Federal Agency for Agriculture and Food (BLE) through Federal Organic Farming Programme including other forms of sustainable agriculture (BÖLN Project 2815OE095))* Gesellschaft für Hopfenforschung (GfH) e.V. *(Society of Hop Research)*
Project lead:	Dr. F. Weihrauch
Project staff:	M. Obermaier
Collaboration:	Commercial organic and integrated farms
Scheduled to run:	01.05.2018 - 30.04.2019

Objective

An attempt is to be made to provide overwintering shelter for predator mites by sowing suitable hardy ground cover in hop yard tractor alleys. In the spring, the predators can then move away from this refuge to settle again on the hop plants. This should be a functioning, sustainable, and economical way of establishing a permanent predator mite population on the hops which would deliver ecological plant protection against the two-spotted spider mite. It would also contribute an essential building block towards integrated plant protection.

Results

See 7.1 for further information in a detailed report.

1.2 Key Research Priorities

1.2.1 Research focus: hop farming/ production techniques

Using thermal imaging technology to optimize hop drying

Staff:	J. Münsterer
Scheduled to run:	2018 - 2019

Situation at the outset and objective

At the point in time when the hop releases most moisture during the first stage of drying, the drying rate depends chiefly on the air velocity. Even with the best settings for heat and air distribution, the drying process on the top floor can very quickly become uneven.

The reason for this is the inconsistent drying behaviour of the green hop on the top level, due to the uneven loading depth, the varying bulk density or the dwell time in the green hop silo before drying.

The objective is to use thermal imaging to monitor the drying process more easily, detect any unevenness more quickly, and thus react accordingly with the appropriate corrective measures.

Method

Thermal imaging cameras were permanently installed inside commercially operated kilns. It was then possible to use a monitor to control the evenness of the drying process across the entire drying surface on the basis of the surface temperature of the hop on the top floor.

Findings

The different colours of the thermal images pointed early on during the drying process to clusters of moisture or unevenly dried areas, so that mechanical steps could be taken to remedy the problem (e.g. manually raking through the hop) and quickly to restore uniformity of drying.

With automatic filling, any unevenness in drying can be quickly corrected by adjusting the settings, at the latest with the next filling operation. In this way, thermal imaging technology makes it possible to improve the evenness of the drying process and achieve better drying efficiency using very simple methods.

Measurements will continue in 2019 in other commercially operated kilns, in order to optimize drying in different kiln types.

Exploratory trial looking into N depot fertilization as an alternative way of fertilizing hop

Staff: J. Stampfl, S. Fuß, A. Schlagenhaufer

Scheduled to run: 2018 - 2019

Objective

Normally, the amount of N calculated as being required for hop during the growth period is split into at least three applications. An exploratory trial is to examine what impact subsurface depot fertilization has on yield and quality. This involves the entire nitrogen requirement being deposited in the ground beside the row of hops at the beginning of the growing season, as is customary with other field crops.

Methodology

The field trials took place using cultivars *Hallertauer Tradition* in a location with light soil and *Herkules* on a site with heavy soil. On the basis of N_{min} tests, the fertilizer requirement was calculated to be 150 kg N/ha for *Hallertauer Tradition* and 180 kg N/ha for *Herkules*. On 19 April 2018, the complete quantity was deposited using a fertilizer injector to inject thin streams of ammonium sulphate (21 % N / 24 % S) about 15-20 cm deep into the soil beside the rows of hops. The pure ammonium form and the concentration as a depot mean that the nitrogen should only gradually become available. The smaller the contact surface of the fertilizer with the soil, the more stable and less vulnerable to losses the depot. As a comparison, sub-plots were set up with the same fertilizer rates distributed according to usual farming practice in three applications.The different variants were replicated twice in each location. After a meticulous experimental harvest, cone yield, alpha acids content, residual plant mass, and nitrogen content were determined.

Findings

With respect to crop yield and alpha acids content there were no statistically significant differences between the systems. However, a tendency towards N deficit was visually identified in individual plants in the case of depot fertilization. It was plain to see that the conventionally fertilized sub-plots developed more biomass and the stand appeared much more homogeneous.The depot system could have advantages in drought years when nutrient availability from the subsurface depot is better than at the surface because of the soil humidity.

The experiment with depot fertilization highlighted the following problems: placement of the depot must be as close to the plant as possible if the nutrients are to be easily accessible. During distribution of the depot, some of the perennial roots were severed or injured by the injector equipment. Also, the vehicle needs to move at a very slow speed if the large quantity of fertilizer is to be applied in one operation. It is therefore not very likely that the technique will save time or mean less work in comparison with conventional fertilizing methods.

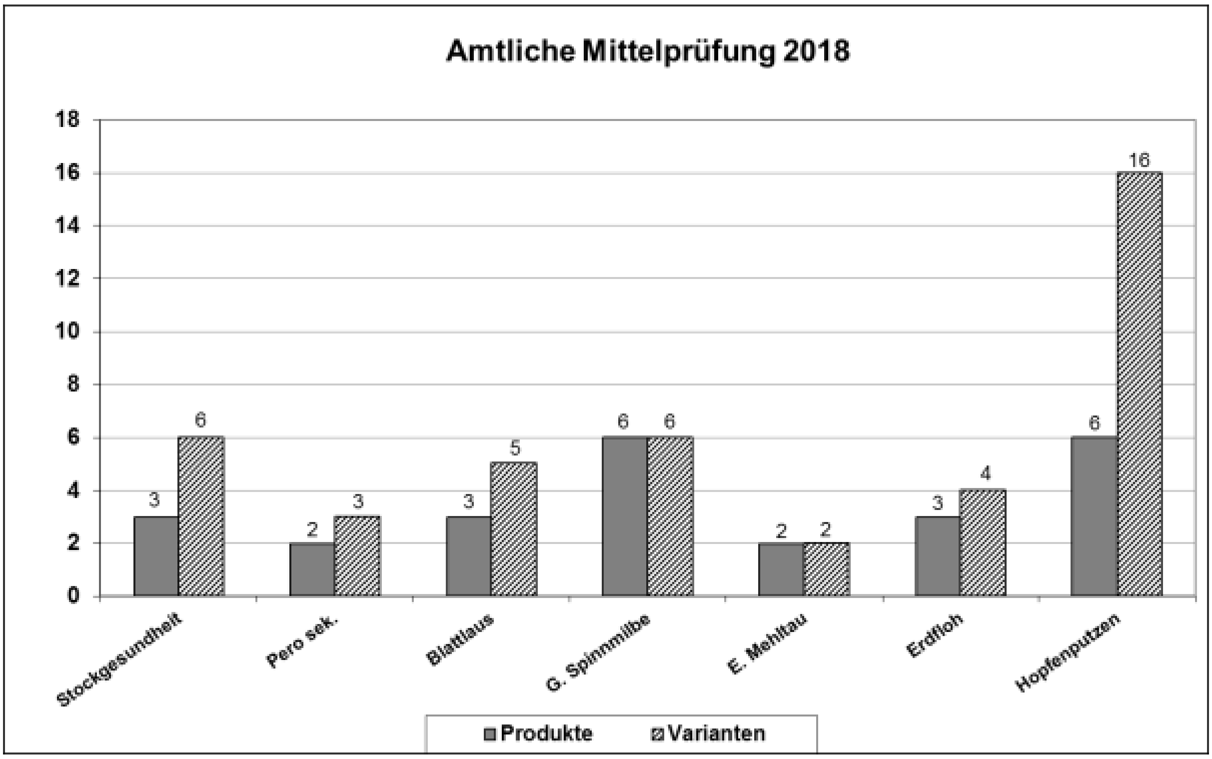
The exploratory trials will continue in 2019, with an attempt to deposit a depot directly beside the plants during primary tillage operations.

Fig. 1.11: Depositing the fertilizer depot beside the row of hops

1.2.2 Research focus: hop plant protection

Testing of plant protection agents 2018 for official certification/approval and consultancy documentation

Leads:	F. Weihrauch (acting lead till 30.06.2018) S. Euringer (from 01.07.2018)
Staff:	A. Baumgartner, M. Felsl, S. Laupheimer, G. Meyr, M. Mühlbauer, M. Obermaier, J. Weiher
Scheduled to run:	Ongoing



During testing for official certification of plant protection agents in 2018, a total of 25 products in 42 variants were tested.

Enzyme-linked Immunosorbent Assay (ELISA) to identify hop mosaic virus (HpMV) and apple mosaic virus (ApMV) infections on hop

Leads:	F. Weihrauch (till 30.06.2018 acting lead) S. Euringer (from 01.07.2018)
Staff:	M. Mühlbauer, M. Felsl
Collaboration:	Bayerische Landesanstalt für Landwirtschaft (LfL), Institut für Pflanzenschutz IPS 2c - Virologie (*Bavarian State Research Center for Agriculture, Institute for Plant Protection IPS 2c Virology)* Dr. Luitgardis Seigner and team
Scheduled to run:	Ongoing

Virus diseases are widespread in all hop-producing regions. The ELISA test has once again been set up at the hop research centre at Hüll so that infected plants can be identified and removed; and the necessary money has been invested to enable ELISA tests for hop mosaic virus (HpMV) and apple mosaic virus (ApMV) to be performed there. The first plants were successfully tested in June 2018. Altogether, 571 individual plants were screened in 2018.

We would like to thank Dr. Luitgardis Seigner and her team *(IPS 2c Virology)* and Ms Olga Ehrenstraßer for their support in helping to set up the ELISA tests at Hüll.

Spray tower testing of hop aphid resistance to active substances

Leads: F. Weihrauch (till 30.06.2018 acting lead)
S. Euringer (from 01.07.2018)

Staff: A. Baumgartner, M. Felsl, M. Mühlbauer

Scheduled to run: Ongoing

Every year, all hop varieties are infested by the hop aphid. Since some active substances have now been eliminated, it has become more difficult to find new strategies for preventing resistance. If an active agent or agents based on the same effect mechanism are used repeatedly, this will lead to one-sided universal selection of resistant individuals, and, as a result, the development of resistances is promoted, and satisfactory control is no longer possible. The manifestation of resistances to active substances in the hop aphid is monitored by means of resistance testing in the spray tower. The results from these lab tests may differ from control success in practice, it has therefore been decided not to publish the results. In 2018, four active substances were tested, each of them in seven different concentrations.

1.2.3 Research focus: hop quality and analytics

Performance of all analytical studies in support of the Working Groups in the Hops Department, in particular the hop breeding unit

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. Therefore, analytical testing of its constituent components is key in ensuring successful research into hop. WG IPZ 5d carries out all the analytical work necessary to resolve issues relating to trials run by the other groups. In hop breeding, in particular, selection of breeding lines is based on the data processed by the lab.

See also projects of Arbeitsgruppe IPZ 5c Züchtungsforschung Hopfen *(WG IPZ 5c Hop Breeding Research).*

Development and optimization of aroma analytics, using gas chromatography/ mass spectroscopy

Project lead: Dr. K. Kammhuber
Bearbeitung: S. Weihrauch, Dr. K. Kammhuber
Project staff: AG Züchtungsforschung Hopfen *(WG Hop Breeding Research)*, Wissenschaftszentrum Weihenstephan für Ernährung, Landnutzung und Umwelt (*TUM School of Life Sciences, Weihenstephan, Land Use and the Environment)*
Scheduled to run: April 2014 - open end

Since the spring of 2014, WG IPZ 5d has been in possession of a gas chromatography/mass spectrometry system (funded by the *Society of Hop Research*). To date, 143 substances have been identified. Some substances are important for differentiating between varieties, but are not aroma-active. The objectives of this project are to refine variety identification and determine the aroma-active compounds in order to provide help in breeding and developing new special flavor hops.

Development of an NIRS calibration system for a acids and water 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 developed an NIRS (near infrared spectroscopy) calibration for a acids content, based on HPLC (high performance liquid chromatography) data and conductometric values, as a fast and cheap method to replace the increasing number of wet chemical tests. The objective was to achieve repeatability and reproducibility that can easily be implemented in practice. The Hop Analytics Working Group (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 EBC 7.4 standard.

However, it was decided to discontinue collaboration in developing a joint NIRS calibration 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 HPLC calibration and determination of moisture content. NIRS is suitable 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 is improving, thanks to continuing expansion every year.

Since 2017, the lab has had new equipment and is at present developing a new calibration for it.

Development of analysis methods for hop polyphenols

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

Thanks mainly to their properties beneficial to health, polyphenols are proving to be of growing interest in the context of alternative applications for hop. Of course, they also play a part in sensory impressions. It is therefore important to have access to suitable methods of analysis. As yet, there are no official standardized models available; all the laboratories involved in poly-phenol analytics are currently using their own methods.

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

Analytics for Working Group IPZ 3d Medicinal and Aromatic Herbs

Project lead:	Dr. K. Kammhuber
Collaboration:	AG Heil- und Gewürzpflanzen, IPZ 3d *(WG Medicinal and Aromatic Herbs, IPZ 3d)*
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 IPZ 3d, starting in 2009. No analyses were required in 2018.

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2 Weather Conditions and Growth Development 2018 ─ impact on technical aspects of production and occurrence of pests and pathogens in the Hallertau region

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2.1 Weather Conditions and Growth Development in 2018

The hop-growing year 2018 went from winter straight into summer. Due to the cold snap in March, the first shoots were slow to appear, but then the vegetation burst out with a vengeance in April and May, as temperatures rose far above average and even as high as in summer proper. Although uncovering and pruning operations did not go ahead until late March/early April, training work commenced already around 20 April. In the warm weather, the plants developed faster than anticipated, and without the usually identifiable differences in growth development, which normally depend on pruning dates or whether sites are less or more exposed. The first stands had already reached trellis height by the beginning of June and early-maturing cultivars *Hallertauer Mittelfrüher* and *Northern Brewer* began flowering early, as did other far advanced stands.

Weather conditions in June were characterized by violent local thunderstorms, accompanied by heavy torrential downpours within a very short timespan, which caused substantial erosion damage in places. In the northern part of the Hallertau region, which received far less precipitation, and in areas with light soils, the hops showed signs of incipient drought stress as a result. Rainfall in July and August, although it varied considerably from one region to another, was, on the whole, below average, while temperatures were very high. The two factors combined meant uncomfortable conditions for the hops and resulted in reduced flower production and premature ripening, especially in non-irrigated locations or soils with low water storage capacity. First stands planted to cultivar *Hallertauer Mittelfrüher*, which had stopped growing after flowering early and produced no more flowers, had already to be harvested at the beginning of August. Harvest maturity in all varieties was reached approximately one week early on average, although this varied considerably from location to location, depending on the available water.

2.2 Diseases and Pest Infestation

Thanks to the rapid growth of the hops and the fast development of the juveniles, there were few issues with pests like wireworm, lovage weevil and hop flea beetle. There were only a limited number of reports of primary downy mildew infection from commercially operated farms. Zoosporangia counts in the spore traps also remained comparatively low throughout the season, so that only 4 spray warnings for downy mildew were deemed necessary to control secondary infection in the Hallertau region.

In contrast, powdery mildew caused far greater problems, with the first cases of infection in commercial production being reported as early as mid-May. Notwithstanding the numerous control measures carried out in response, the problem grew even worse in many yards towards the end of the season, particularly in dense *Herkules* stands or hops already suffering from drought stress. The situation became so bad that heavy losses in crop yields and reductions in quality were the result.

There was also an increase in the occurrence of the dreaded *Verticillium* wilt disease in 2018. As a result of a wave of infections in June, entire trained bines wilted and died back in July; a sad sight in many hop yards, and identifiable even from a distance.

The favourable conditions provided by the warm, dry spring, encouraged early and heavy infestation by the hop aphid and the two-spotted spider mite. In contrast to the experience of past years, the side effects of Actara did not prove sufficient to control the hop aphid and it became necessary to launch a targeted attack with one or two insecticide treatments.

It is common knowledge that hot and dry years are spider mite years. The hot, dry summer weather continued into September and, in spite of several control treatments, it was not possible to manage the spider mite nearly effectively enough in badly affected yards. The result was red staining of the cones and substantial losses in crop yields and quality.

2.3 Special Aspects 2018

The hop-growing year 2018 will be remembered for its dry and very hot summer and the unusually early harvest.

Regions with lower levels of thundery rain or sites with no irrigation and reduced water storage capacity registered heavy losses in crop yields and quality, but better locations with enough thundery downpours in June produced near average yields.

Alpha acids levels were unsatisfactory in almost all locations and were even below last year's low levels for the principal varieties. Altogether, the quantities of alpha acids produced were roughly 20% down on the figures for an average harvest.

In terms of appearance, the neutral quality assessment found that there was a high proportion of leaves and stalks. Some lots were even below the minimum quality requirement and had to be cleaned up. As far as infestation ratings go, the later harvested bittering hops fared badly. A good 20% of the lots were graded 4 and 5 (2017: 3%)

Expectations that the hot summer would mean less plant protection expenditure were disappointed. Although the dry weather meant that only very few fungicide applications were necessary to control downy mildew, which brought cost savings, the positive effect was more than cancelled out by the high costs of managing powdery mildew and the two-spotted spider mite. In spite of concentrated efforts to contain it, the sudden late outbreak of powdery mildew on *Herkules*, just prior to harvest, is something hop growers will not forget in a hurry.

Weather data 2018 (monthly means and totals), compared with 10*- and 50**-year mean values

Month		**Temperature in 2 m Höhe**			**Relat. air humidity**	**Precipitati-on**	**Days with precipitation**	**Sunshine**
		Mean (°C)	**Min.Ø (°C)**	**Max.Ø (°C)**	**(%)**	**(mm)**	**>0.2 mm**	**(hrs)**
January	2018	3.6	0.6	6.8	94.4	84.5	18.0	28.7
	10-yr	-0.6	-3.9	2.8	90.8	61.7	15.6	45.3
	50-yr	-2.4	-5.1	1.0	85.7	51.7	13.7	44.5
February	2018	-2.8	-6.5	0.7	87.9	28.4	11.0	85.8
	10-yr	-0.3	-4.1	3.9	86.3	38.2	11.6	69.6
	50-yr	-1.2	-5.1	2.9	82.8	48.4	12.8	68.7
March	2018	2.6	-1.4	7.1	86.1	46.0	18.0	123.4
	10-yr	4.4	-0.5	10.3	79.8	42.3	12.2	149.0
	50-yr	2.7	-2.3	8.2	78.8	43.5	11.3	134.4
April	2018	12.9	5.3	20.4	70.9	6.0	7.0	245.5
	10-yr	10.2	3.2	16.2	73.1	41.7	9.5	200.8
	50-yr	7.4	1.8	13.3	75.9	55.9	12.4	165.0
May	2018	16.6	10.7	22.8	73.0	72.8	12.0	243.2
	10-yr	13.6	7.8	19.6	75.3	105.3	15.9	206.9
	50-yr	11.9	5.7	17.8	75.1	86.1	14.0	207.4
June	2018	17.9	11.7	24.1	78.9	139.2	10.0	243.9
	10-yr	17.0	10.9	23.1	75.9	114.8	14.2	221.3
	50-yr	15.3	8.9	21.2	75.6	106.1	14.2	220.0
July	2018	19.2	12.2	26.8	78.2	67.2	8.0	284.4
	10-yr	18.9	12.3	25.8	75.6	102.3	12.7	247.9
	50-yr	16.9	10.6	23.1	76.3	108.4	13.9	240.3
August	2018	19.7	12.5	27.6	79.3	85.8	6.0	265.4
	10-yr	18.2	11.7	25.6	79.4	98.3	11.5	244.3
	50-yr	16.0	10.2	22.5	79.4	94.9	13.3	218.4
September	2018	15.0	9.1	22.5	86.4	52.5	13.0	211.9
	10-yr	13.8	8.3	20.5	84.7	60.4	10.7	170.0
	50-yr	12.8	7.4	19.4	81.5	65.9	11.4	174.5
Oktober	2018	10.2	4.6	17.7	88.5	43.8	7.0	154.8
	10-yr	8.8	4.3	14.4	89.1	54.1	11.0	113.4
	50-yr	7.5	2.8	13.0	84.8	60.0	10.4	112.9
November	2018	4.3	1.4	7.8	97.5	22.8	11.0	55.4
	10-yr	4.5	1.2	8.4	92.5	54.6	11.3	60.0
	50-yr	3.2	-0.2	6.4	87.5	58.8	12.6	42.8
December	2018	2.8	0.4	5.3	98.5	95.3	23.0	24.4
	10-yr	1.2	-1.9	4.4	92.5	63.9	15.9	39.7
	50-yr	-0.9	-4.4	1.6	88.1	49.1	13.3	34.3
Ø year	2018	10.2	5.1	15.8	85.0	744.3	144.0	1966.8
	10-yr	9.1	4.1	14.6	82.9	837.6	152.1	1768.0
	50-yr	7.4	2.5	12.5	81.0	828.8	153.3	1663.2

*10-year mean is based on data from the period 2009 to 2019

**50-year mean is based on data from the period 1927 to 1976

3 Statistical Data on Hop Production

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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	Number of farms	Hop acreage per farm in ha	Year	Number of farms	Hop acreage per farm in ha
1975	7 654	2.64	2005	1 611	10.66
1980	5 716	3.14	2010	1 435	12.81
1985	5 044	3.89	2015	1 172	15.23
1990	4 183	5.35	2016	1 154	16.12
1995	3 122	7.01	2017	1 132	17.26
2000	2 197	8.47	2018	1 121	17.97

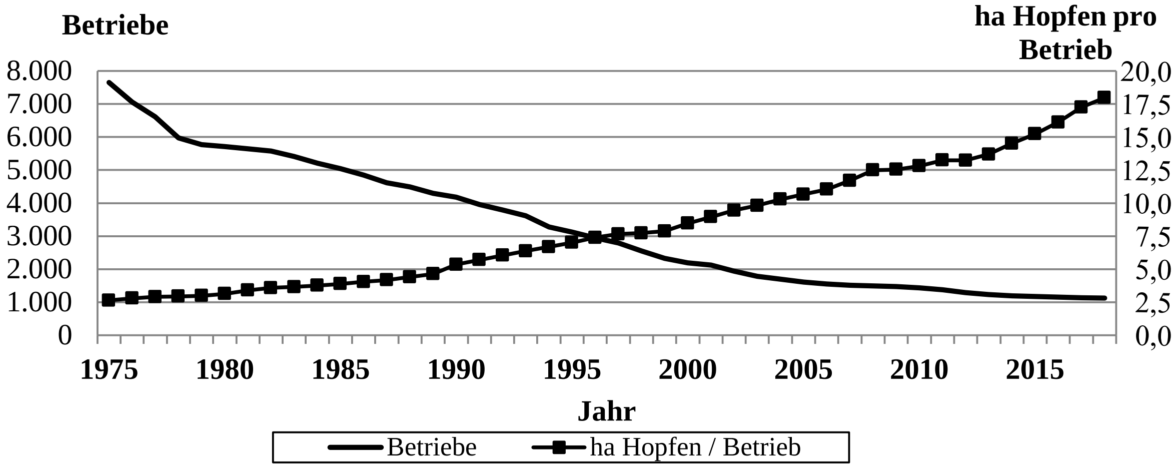


Fig. 3.1: Number of hop farms and their hop acreages in Germany

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				Hopfenbaubetriebe				Hop acreage per farm in ha	
	in ha		Increase + / decrease - 2017 to 2016				Increase + / decrease - 2017 to 2016			
	2017	2018	ha	%	2017	2018	farms	%	2017	2018
Hallertau	16 310	16 780	469	2.9	912	903	- 9	- 1.0	17.88	18.58
Spalt	391	404	13	3.2	55	55	± 0	± 0	7.11	7.34
Tettnang	1 353	1 397	43	3.2	133	132	- 1	- 0.8	10.18	10.58
Baden, Bitburg and Rheinpfalz	22	22	0	± 0	2	2	± 0	± 0	11.00	11.00
Elbe-Saale	1 466	1 541	75	5.1	30	29	- 1	- 3.3	48.86	53.13
Germany	**19 543**	**20 144**	**601**	**3.1**	**1 132**	**1 121**	**- 11**	**- 1.0**	**17.26**	**17.97**

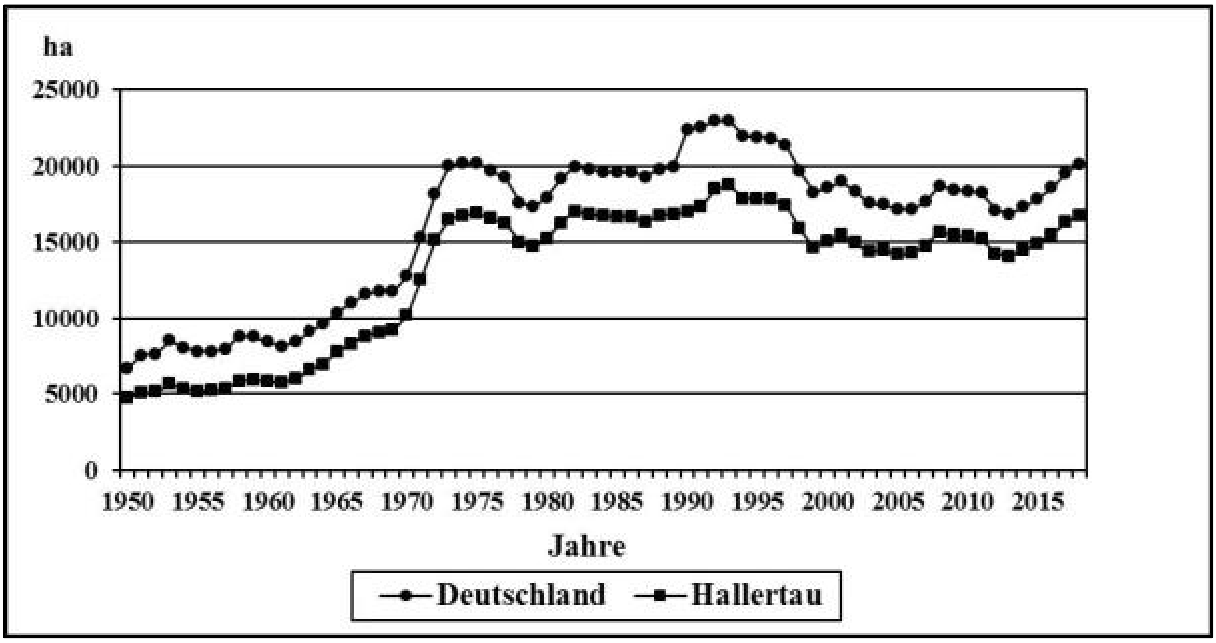


Fig. 3.2: Hop-growing acreage in Germany and in the Hallertau region

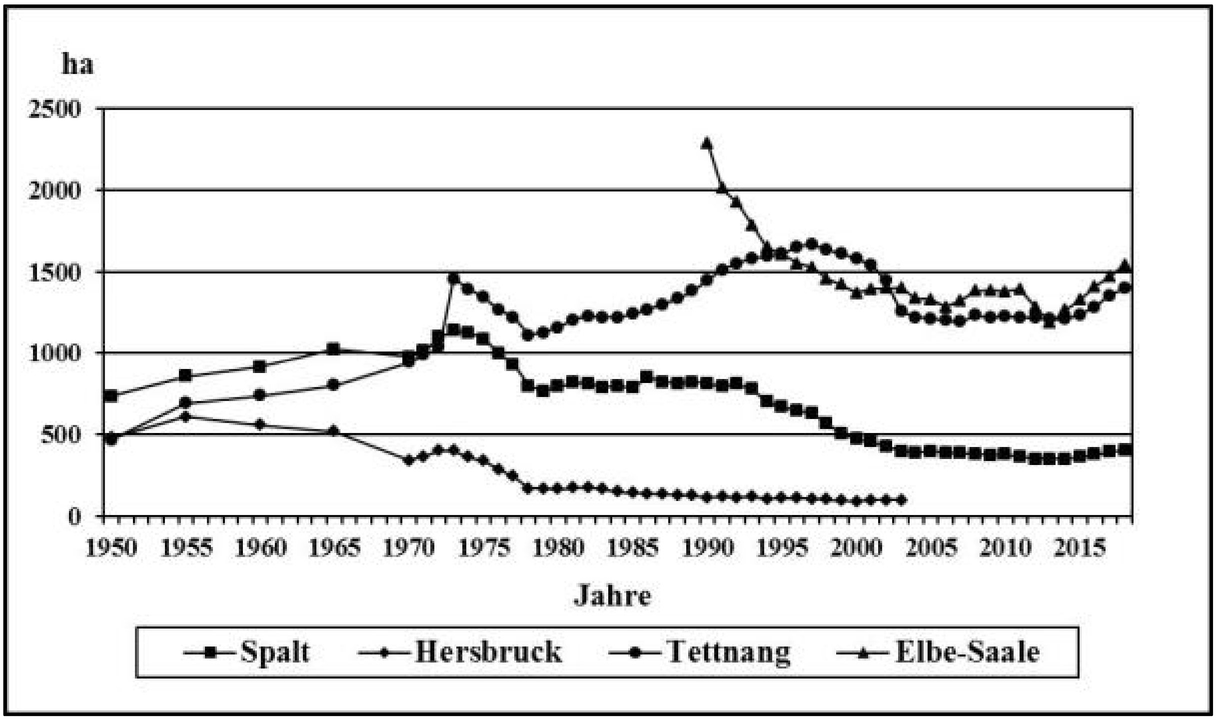


Fig. 3.3: Hop-growing acreage in the Spalt, Hersbruck, Tettnang and Elbe-Saale regions

Hersbruck has been part of the Hallertau since 2004.

3.1.2 Hop varieties in 2018

The acreage under hop in Germany increased considerably by 601 hectares in 2018, and now stands at 20 144 ha.

The percentage of traditional noble **aroma varieties** again declined in 2018 (- 0,9 %), falling to below 50% for the first time, although, at 122 ha, the acreage absolute had risen again for the first time in 2 years. In terms of variety, the acreage planted to *Hallertauer Mittelfrüher* and *Northern Brewer* declined; all other acreages under traditional noble aroma varieties remained the same or increased in size.

The acreage devoted to growing **bittering hops** once more grew significantly, this time by 507 hectares, and now accounts for a share of 44,6 %. Again, the acreage growing all the older hop varieties was on the decline. In contrast, the acreage planted to *Herkules* (+512 ha) and *Polaris* (+ 51 ha) increased again. This means that *Herkules* is far and away the most widely grown variety of hop in Germany (6 309 ha), claiming almost one-third of Germany's total acreage under hop.

Market saturation in the greatly expanded **flavor hops** segment meant that, for the first time, its share of the acreage shrank. Although the acreages producing cultivar *Amarillo* for the American craft beer market and the new Hüll flavor hop *Ariana* were able to increase in size, the area devoted to growing other flavor hops either remained unchanged, or even fell victim to the first land clearances. The total acreage of 1 194 hectares in this segment was in decline for the first time, and now accounts for only 5.9 %. Further clearances will be necessary in order to consolidate the market.

Tab. 3.3:Aroma varieties by hectare in the German hop-growing regions in 2018

Aroma Varieties

Hop-growing region	Total hop acreage	HAL	SPA	TET	HEB	PER	SSE	HTR	SIR	OPL	SGD	SAZ	NBR	other	Aroma varieties	
															ha	%
Hallertau	**16 780**	503	0		918	2 681	468	2 580	435	139	63	7	156	11	**7 962**	**47.4**
Spalt	**404**	35	120		5	26	94	32	19	1	1			5	**338.27**	**83.8**
Tettnang	**1 397**	148		750	0	58	11	55	41	1	17				**1 081**	**77.4**
Baden, Bitburg and Rheinpfalz	**22**	1				8		4							**14**	**60.8**
Elbe-Saale	**1 541**					230	4	40	20			149	137		**580**	**37.7**
Germany	**20 144**	**687**	**120**	**750**	**924**	**3 003**	**578**	**2 712**	**515**	**141**	**82**	**156**	**293**	**15**	**9 974**	**49.5**
Variety (in %)		3.4	0.6	3.7	4.6	14.9	2.9	13.5	2.6	0.7	0.4	0.8	1.5	0.1		

Variety changes in Germany

2017 ha	19 543	723	121	747	916	2 966	532	2 704	473	141	80	137	300	14	**9 852**	**50.4**
2018 ha	20 144	687	120	750	924	3 003	578	2 712	515	141	82	156	293	15	**9 974**	**49.5**
Change (in ha)	601	-35	-1	3	8	37	45	8	42	1	2	19	-7	1	**122**	**-0.9**

Tab. 3.4:Bittering and high alpha varieties by hectare in the German hop-growing regions in 2018

Bittering and high alpha varieties

Hop-growing region	BGO	NUG	TRG	HMG	HTU	HMR	HKS	PLA	other	Bittering hops	
										ha	%
Hallertau	17	116		1 364	244	11	5 897	131	27	**7 808**	**46.5**
Spalt				3		3	37		1	**44**	**11.0**
Tettnang					0		235	9	3	**248**	**17.8**
Baden, Bitburg and Rheinpfalz			0	3			5			**8**	**34.7**
Elbe-Saale		12		622	14		136	84	1	**867**	**56.3**
Germany	**17**	**128**	**0**	**1 992**	**258**	**14**	**6 309**	**225**	**33**	**8 975**	**44.6**
Variety (in %)	0.1	0.6	0.0	9.9	1.3	0.1	31.3	1.1	0.2		

Variety changes in Germany

2017 (in ha)	16	131	0	2 011	284	17	5 797	174	39	**8 468**	**43.3**
2018 (in ha)	17	128	0	1 992	258	14	6 309	225	33	**8 975**	**44.6**
Change (in ha)	1	-3	0	-19	-26	-3	512	51	-6	**507**	**1.3**

Tab. 3.5:Flavor hops by hectare in the German hop growing regions in 2018

Flavor varieties

Hop growing region	VG1	CAL	ANA	CAS	HBC	HMN	MBA	MON	COM	Flavor varietes	
										ha	%
Hallertau	258	57	59	68	142	111	281	27	8	**1 011**	**6.0**
Spalt		1	4	5	3	4	3			**21**	**5.2**
Tettnang	8	9	5	4	13	13	12	4	0	**68**	**4.9**
Baden, Bitburg and Rheinpfalz				1						**1**	**4.5**
Elbe-Saale	34	5		8	11	12	24			**93**	**6.1**
Germany	**300**	**72**	**68**	**86**	**168**	**140**	**321**	**31**	**8**	**1 194**	**5.9**
Variety (in %)	1.5	0.4	0.3	0.4	0.8	0.7	1.6	0.2	0.0		

Variety changes in Germany

2017 (in ha)	280	73	61	86	170	157	356	31	8	**1 223**	**6.3**
2018 (in ha)	300	72	68	86	168	140	321	31	8	**1 194**	**5.9**
Veränderung (in ha)	20	-1	7	0	-2	-17	-35	-1	0	**-29**	**-0.4**

3.2 Crop Yields in 2018

The 2018 hop harvest in Germany produced 41 794 270 kg (= 835 884 cwt.). Due to the hot and dry summer, this was only slightly up on last year's crop volume (41 556 250 kg or 831 125 cwt.), in spite of the fact that there was a notable increase in acreage (601 ha).

In relation to the total acreage, the average yield of 2 075 kg/ha is less than the per hectare yield of the previous year (2 126 kg/ha) and is thus a below average yield.

The 2018 alpha acids levels were also below average, in fact, even below the low levels of the previous year in the principal varieties. The substantial deficit can be attributed to high alpha cultivar *Herkules* (14,6 % alpha) and *Hallertauer Magnum* (11.6 % alpha), in particular, and the principal aroma cultivars *Perle* (5.5 % alpha) and *Hallertauer Tradition* (5.0 % alpha), which together account for almost 70 % of the total acreage under hop in Germany. In total, the quantity of alpha acids produced in Germany in 2018 is estimated to be approximately 4 000 t, around 800 t, or 20 %, less than the yield that would usually be produced by the present acreage in a normal year.

Tab. 3.6: Crop volumes and per hectare yields for hop in Germany

	2013	2014	2015	2016	2017	2018
Yield kg/ha or (cwt./ha)	1 635 kg (32.7 cwt.) (hail damage)	2 224 kg (44.5 cwt.)	1 587 kg (31.7 cwt.)	2 299 kg (46.0 cwt.)	2 126 kg (42.5 cwt.)	2 075 kg (41.5 cwt.)
Acreage in ha	16 849	17 308	17 855	18 598	19 543	20 144
Total volume in kg or cwt.	27 554 140 kg = 551 083 cwt.	38 499 770 kg = 769 995 cwt.	28 336 520 kg = 566 730 cwt.	42 766 090 kg = 855 322 cwt.	41 556 250 kg = 831 125 cwt.	41 794 270 kg = 835 884 cwt.

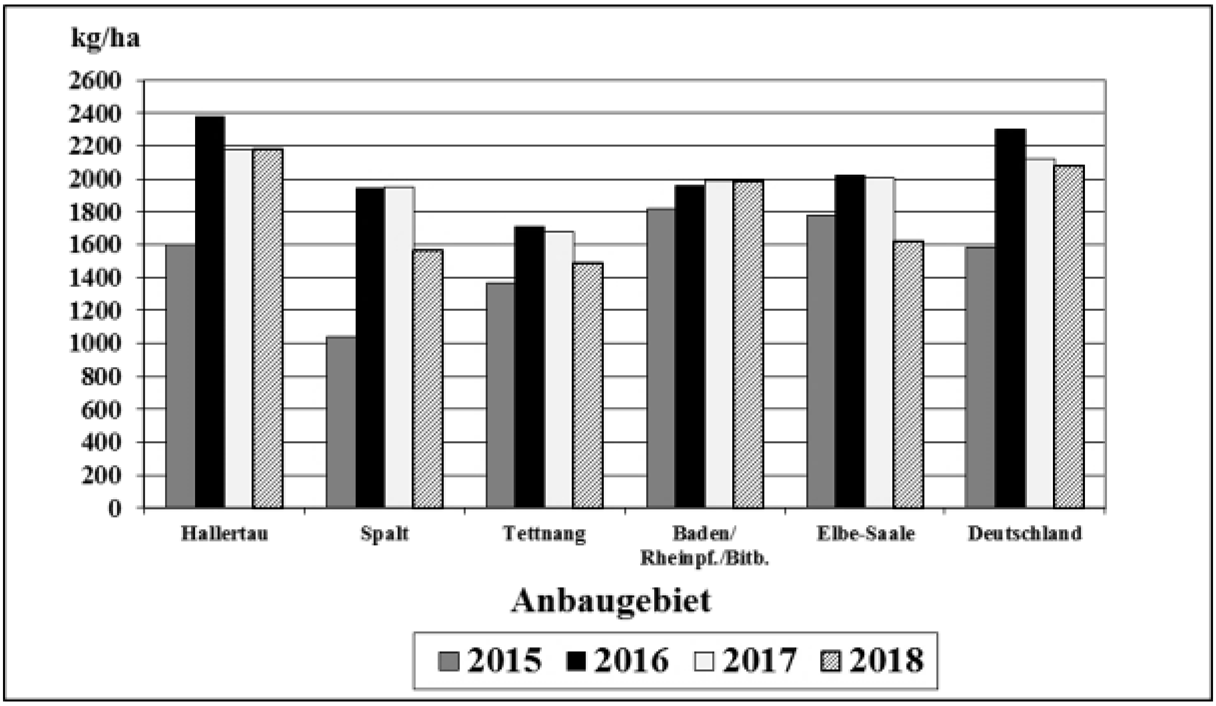


Fig. 3.4: Average yields for the individual hop-growing regions in kg/ha

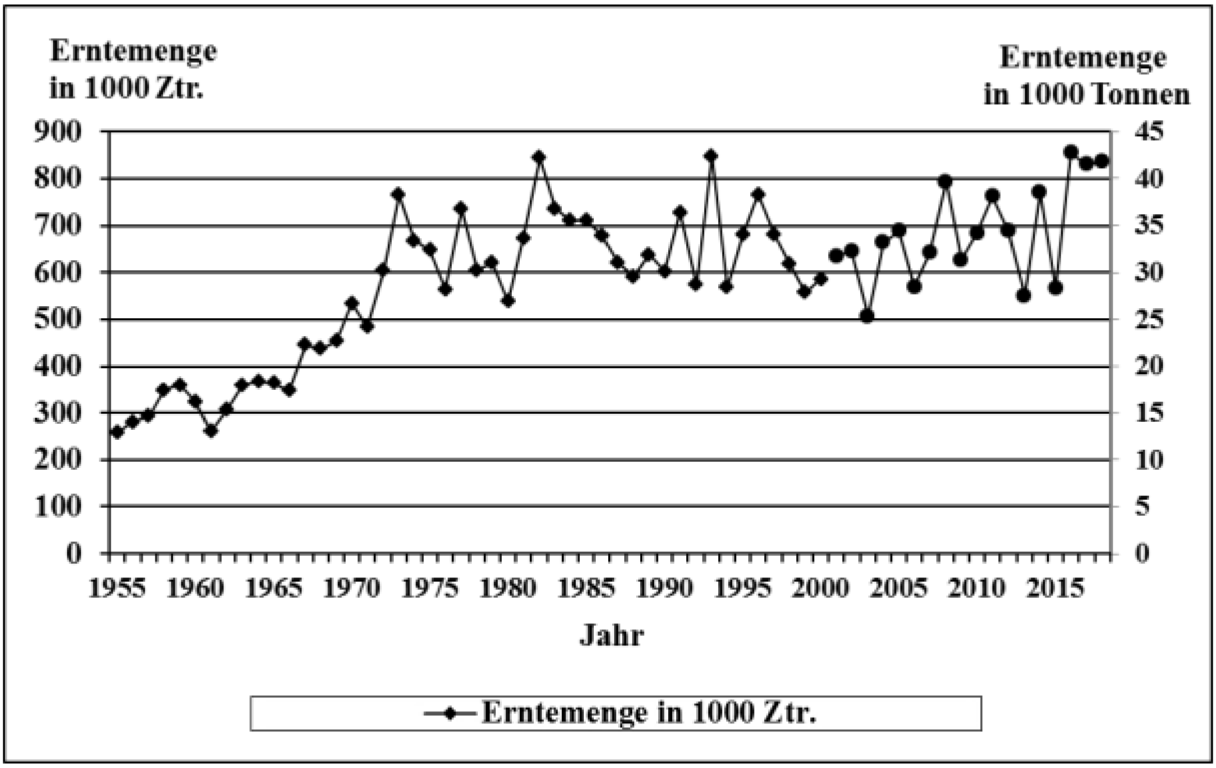


Fig. 3.5: Crop volumes in Germany

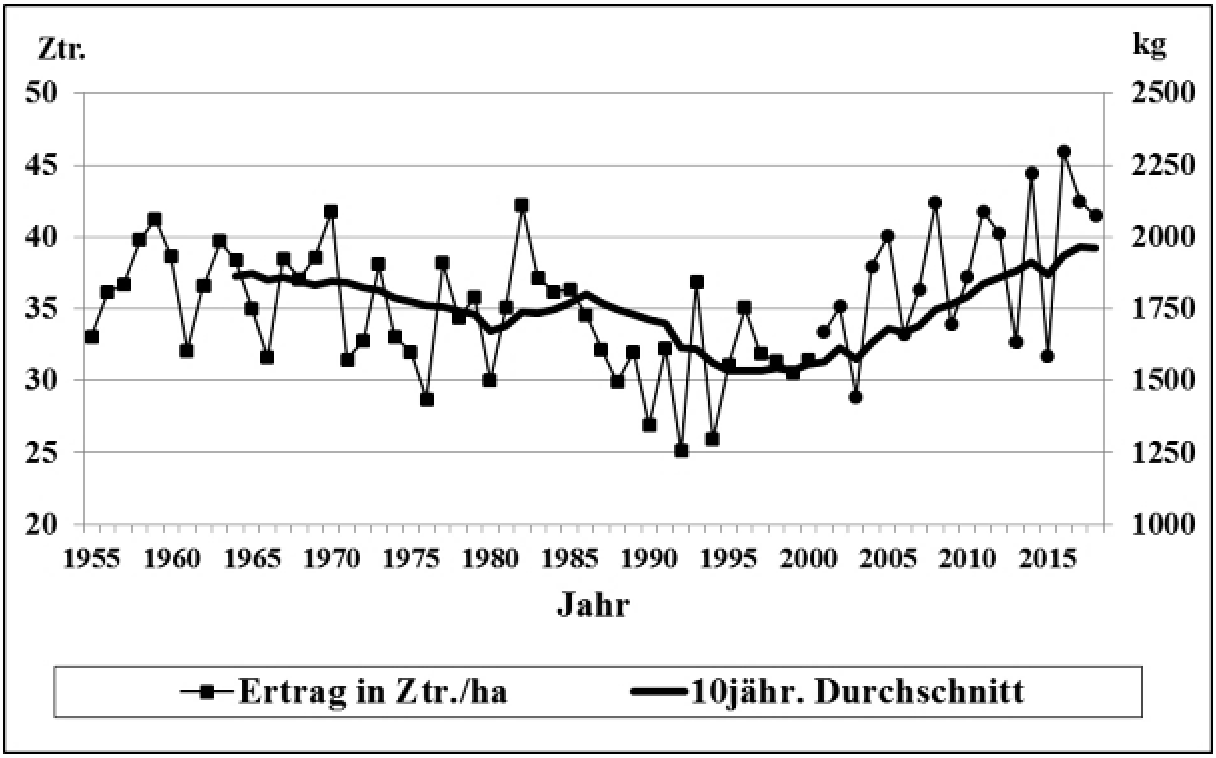


Fig. 3.6: Average yield (cwt. or kg/ha) in Germany

Tab. 3.7: Per hectare yields in the German hop-growing regions

Hop-growing region	Yields in kg/ha total acreage								
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Hallertau	1 893	2 151	2 090	1 638	2 293	1 601	2 383	2 179	2 178
Spalt	1 625	1 759	1 383	1 428	1 980	1 038	1 942	1 949	1 564
Tettnang	1 315	1 460	1 323	1 184	1 673	1 370	1 712	1 677	1 486
Bad. Rheinpf./ Bitburg	1 839	2 202	2 353	1 953	2 421	1 815	1 957	1 990	1 985
Elbe-Saale	1 931	2 071	1 983	2 116	2 030	1 777	2 020	2 005	1 615
Æ Yield/ ha **Germany**	**1 862 kg**	**2 091 kg**	**2 013 kg**	**1 635 kg**	**2 224 kg**	**1 587 kg**	**2 299 kg**	**2 126 kg**	**2 075 kg**
Total crop Germany (t or cwr.)	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	42 766 t 855 322	41 556 t 831 125	41 794 t 835 884
Acreage (ha) Germany	18 386	18 228	17 124	16 849	17 308	17 855	18 598	19 543	20 144

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

Region/variety	2009	2010	2011	2012	2013	2014	2015	2016	2017	**2018**	**Ø 5 years**	**Ø 10 years**
Hallertau Hallertauer	4.2	3.8	5.0	4.6	3.3	4.0	2.7	4.3	3.5	**3.6**	**3.6**	**3.9**
Hallertau Hersbrucker	3.4	3.5	4.5	3.0	1.9	2.1	2.3	2.8	2.3	**2.0**	**2.3**	**2.8**
Hallertau Hall. Saphir	4.5	4.5	5.3	4.4	2.6	3.9	2.5	4.0	3.0	**3.3**	**3.3**	**3.8**
Hallertau Opal	9.0	8.6	9.7	9.0	5.7	7.3	5.9	7.8	7.2	**6.4**	**6.9**	**7.7**
Hallertau Smaragd	6.4	7.4	8.0	6.0	4.3	4.7	5.5	6.2	4.5	**3.0**	**4.8**	**5.6**
Hallertau Perle	9.2	7.5	9.6	8.1	5.4	8.0	4.5	8.2	6.9	**5.5**	**6.6**	**7.3**
Hallertau Spalter Select	5.7	5.7	6.4	5.1	3.3	4.7	3,2	5.2	4.6	**3.5**	**4.2**	**4.7**
Hallertau Hall. Tradition	6.8	6.5	7.1	6.7	5.0	5.8	4.7	6.4	5.7	**5.0**	**5.5**	**6.0**
Hallertau Mand. Bavaria				8.8	7.4	7.3	7.0	8.7	7.3	**7.5**	**7.6**	
Hallertau Hall. Blanc				9.6	7.8	9.0	7,8	9.7	9.0	**8.8**	**8.9**	
Hallertau Huell Melon				7.3	5.3	5.4	5.8	6.8	6.2	**5.8**	**6,0**	
Hallertau North. Brewer	10.4	9.7	10.9	9.9	6.6	9.7	5.4	10.5	7.8	**7.4**	**8.2**	**8.8**
Hallertau Polaris				20.0	18.6	19.5	17.7	21.3	19.6	**18.4**	**19.3**	
Hallertau Hall. Magnum	14.6	13.3	14.9	14.3	12.6	13.0	12.6	14.3	12.6	**11.6**	**12.8**	**13.4**
Hallertau Nugget	12.8	11.5	13.0	12.2	9.3	9.9	9.2	12.9	10.8	**10.1**	**10.6**	**11.2**
Hallertau Hall. Taurus	17.1	16.3	17.4	17.0	15.9	17.4	12.9	17.6	15.9	**13.6**	**15.5**	**16.1**
Hallertau Herkules	17.3	16.1	17.2	17.1	16.5	17.5	15.1	17.3	15.5	**14.6**	**16.0**	**16.4**
Tettnang Tettnanger	4.2	4.0	5.1	4.3	2.6	4.1	2.1	3.8	3.6	**3.0**	**3.3**	**3.7**
Tettnang Hallertauer	4.5	4.2	5.1	4.7	3.3	4.6	2.9	4.4	4.3	**3.8**	**4.0**	**4.2**
Spalt Spalter	4.4	3.7	4.8	4.1	2.8	3.4	2.2	4.3	3.2	**3.5**	**3.3**	**3.6**
Spalt Spalter Select	5.7	5.6	6.4	4.6	3.3	4.5	2.5	5.5	5.2	**3.2**	**4.2**	**4.7**
Elbe-S. Hall. Magnum	13.7	13.1	13.7	14.1	12.6	11.6	10.4	13.7	12.6	**9.3**	**11.5**	**12.5**

Source: Hop Analytics Working Group (AHA)

4 Hop Breeding Research

RDin Dr. Elisabeth Seigner, Dipl.-Biol.

At the Hüll Hop Research Center modern, top-performing varieties are being developed, which meet the demands of the hops and brewing industry. The work pursues three goals:

- to develop traditional noble aroma varieties with delicate aroma profiles typical of hop,
- since 2006, to breed special aroma varieties with broad-based brewing potential, which can impart the appropriate unique fruity/floral flavour profiles and hoppy/spicy nuances to the beer during brewing using either the dry or the wet hopping method, as required,
- to create robust, high alpha varieties with high yield potential.

For years now, biotechnology and genome analysis techniques have been employed alongside classical breeding procedures.

4.1 Crosses in 2018

A total of 95 crosses were performed in 2018.

4.2 The New Breeds from Hüll Withstand the Extremes of 2018 - and deliver evidence of their climate tolerance and brewing versatility

Leads:	A. Lutz, Dr. E. Seigner
Staff:	A. Lutz, J. Kneidl, Dr. E. Seigner, team IPZ 5c
Collaboration:	Dr. K. Kammhuber, team IPZ 5d
	Beratungsgremium der GfH *(Soc.of Hop Research Advisory Comm.)*
	Forschungsbrauerei *(Research Brewery)* Weihenstephan, Technische Universität München-Weihenstephan, Lehrstuhl für Getränke- und Brau technologie *(Chair of Brewing and Beverage Technology)* Prof. Becker, Dr. Tippmann (till Sept. 2018), Ch. Neugrodda (from Oct. 2018)
	Versuchsbrauerei *(Experimental Brewery)* Bitburger-Braugruppe, Dr. S. Hanke
	National and international brewing partners
	Partners from the hop-trading and hop-processing sectors
	Association of German Hop Growers
	Hop growers

Since 2012, the Hop Research Center at Hüll has made six new breeding lines available to the hops and brewing industry. Five special aroma varieties, with unique fruity and hoppy/spicy aroma profiles, were instrumental in helping German hop growers to gain access to the craft beer market. *Polaris* is a new high alpha cultivar on the market; its very high alpha acids content and particularly good plant health mean that it can be recommended for cultivation in hop production areas where high alpha cultivar *Herkules* has problems with crown rot.

And the new varieties from Hüll can do much more. In these new breeds, special emphasis has been placed on enhanced resistance to the most prevalent pests and diseases in hop growing, so that, thanks to their broad spectrum resistances and tolerances, they require smaller amounts of plant protection products and yet still produce healthy cones of the best quality for brewing.

Furthermore, systematic work continues on developing new varieties that can manage with decidedly less fertilizer and still produce consistently high yields. For decades now, greatly reduced amounts of nitrogen have been used in the breeding yard, enabling the selection of breeding lines with optimized nitrogen use efficiency. Primarily, this practice plays a decisive role in helping to protect groundwater in the hop-producing regions, but it also has an impact on the issues surrounding the wilt disease caused by the *Verticillium* fungus, since the disease can be alleviated, at least in its milder form, through deployment of less nitrogen. An overview of the new cultivars from Hüll:

Mandarina Bavaria

Abstammung:	**Cascade x Hüller Mann**
Agron. Merkmale:	**robust, Stress- und Trockentoleranz**
Krankheitsresistenz:	**breit**
Lagerstabilität:	**gut**
Ertrag:	**2.300 kg/ha**
Gesamt-Ölgehalt:	**1,5 – 2,5 ml/100 g**
Alphasäuren:	**7,0 – 10,0 %**

Aroma im Bier: vielfältig, hopfig, Mandarine, Grapefruit

Hopfenaroma: hopfig, würzig, fruchtig, Mandarine, Grapefruit

Hallertau Blanc

Abstammung:	**Cascade x Hüller Mann**
Agron. Merkmale:	**robust, Stress- und Trockentoleranz**
Krankheitsresistenz:	**breit**
Lagerstabilität:	**sehr gut**
Ertrag:	**2.300 kg/ha**
Gesamt-Ölgehalt:	**1,3 – 2,1 ml/100 g**
Alphasäuren:	**8,0 – 11,0 %**

Aroma im Bier: grüne Früchte, Mango, Stachelbeere

Hopfenaroma: hopfig, würzig-krautig, Stachelbeere, Weißwein

Huell Melon

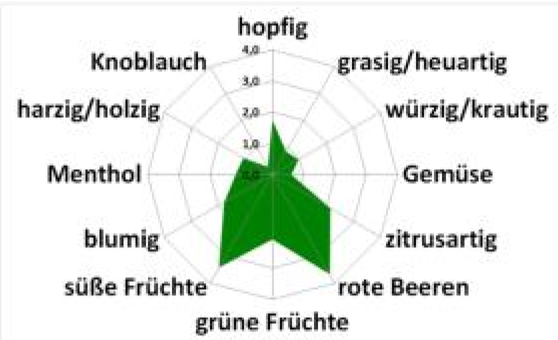
Abstammung: Cascade x Hüller Mann
Agron. Merkmale: robust, Stress- und Trockentoleranz
Krankheitsresistenz: breit
Lagerstabilität: gut
Ertrag: 2.000 kg/ha
Gesamt-Ölgehalt: 1,5 – 2,4 ml/100 g
Alphasäuren: 5,0 – 8,0 %

Aroma im Bier:
hopfig,
süße Aromanoten,
Honigmelone,
Aprikose,
Erdbeere

Hopfenaroma:
hopfig,
fruchtig, süß,
Honigmelone,
Aprikose,
Erdbeere

Callista

Abstammung: Hall. Tradition x Hüller Mann
Agron. Merkmale: robust, Stress- und Trockentoleranz
Krankheitsresistenz: breit
Lagerstabilität: mittel
Ertrag: 2.200 kg/ha
Gesamt-Ölgehalt: 1,4 – 2,0 ml/100 g
Alphasäuren: 2,0 – 4,0 %



Aroma im Bier:
vielfältig,
hopfig,
Maracuja,
Grapefruit,
Pfirsich

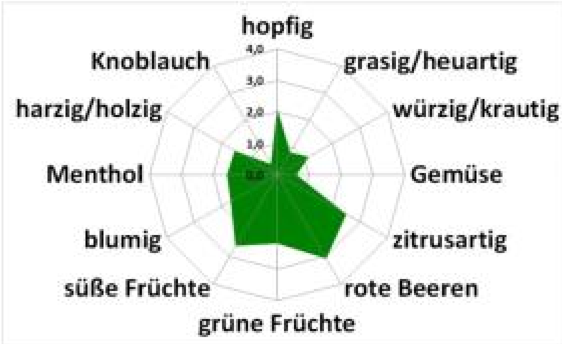
Hopfenaroma:
hopfig,
Aprikose,
Maracuja,
Himbeere,
Brombeere,
Grapefruit

Ariana

Abstammung: Herkules x Hüller Mann
Agron. Merkmale: robust, Stress- und Trockentoleranz
Krankheitsresistenz: sehr gut
Lagerstabilität: sehr gut
Ertrag: 2.300 kg/ha
Gesamt-Ölgehalt: 1,5 – 2,3 ml/100 g
Alphasäuren: 9,0 – 11,0 %

Aroma im Bier:
hopfig,
fruchtig,
Cassis,
Zitrus

Hopfenaroma:
hopfig, mild,
Schw. Johannis-
beere,
Pfirsich,
Zitrus,
harzig



Polaris

Abstammung: Hüller Zuchtmaterial
Agron. Merkmale: robust, Stress- und Trockentoleranz
Krankheitsresistenz: mittel
Lagerstabilität: sehr gut
Ertrag: 2.300 kg/ha
Gesamt-Ölgehalt: 3,0 – 4,4 ml/100 g
Alphasäuren: 18,0 – 23,0 %

Aroma im Bier:
hopfig, würzig,
Minze,
Zitrus

Hopfenaroma:
hopfig, würzig,
Zitrus,
Minze

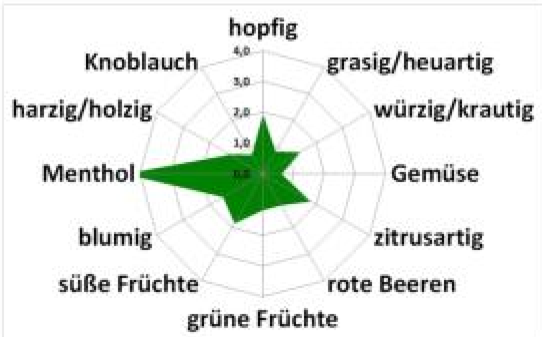


Fig. 4.1: The cultivars from Hüll – an overview

Climate tolerance

2018 was a year of extreme conditions, bringing with it very high temperatures that were well above the 10-year mean values (Fig. 4.2); throughout the main growing season (April - August), there was also a drastic precipitation deficit of over 100 mm compared with the 10-year mean (376 mm as against 481 mm). Against this backdrop, the new varieties from Hüll had the opportunity to deliver proof of the advances in breeding that have been made.

Drastic yield reductions were recorded for landrace *Hallertauer Mittelfrüher* and the older cultivars from Hüll, such as *Perle* and *Hallertauer Magnum*, due to the higher temperatures already making themselves felt in April. A comparison of the 'average' crop yields in 2017 with the kg alpha per hectare yields in the extreme conditions of 2018 clearly shows (*Tab. 4.1*) that growers had to deal, on average, with a reduction of 33 % in *Hallertauer Mittelfrüher*, minus 23 % in *Perle* and minus 38 % in *Hallertauer Magnum*. In contrast, the new Hüll varieties, selected in the light of the climate changes already becoming apparent in the 1990s, demonstrated a far greater tolerance to stress and drought. This applies especially to new cultivars *Mandarina Bavaria* and *Hallertau Blanc*, for which there are robust multiannual yield results available. They withstood the adverse growing conditions and went on to deliver the very same alpha acids yields as in 2017 (minus 1 und 0 %), in spite of the weather extremes. The results for alpha acids yields in *Herkules* and *Polaris*, which are respectively only 8% and 6% down on the 2017 yields, bear this out, too. Clear evidence of the advances in breeding in the high alpha range is thus provided by these two successors to *Hallertauer Magnum* (minus 38 %). Against that, *Huell Melon*, with its 35 % reduction in alpha acids yield, earns only a middle ranking position in terms of climate tolerance.

Even a comparison of yield data (in kg alpha acids per hectare) for 2018 with the above-average crop yields of 2016, clearly points up the improved stability of the new Hüll varieties in the face of climate fluctuations. While the kg alpha acids per hectare yields of *Hallertauer Magnum*, *Perle* and *Hallertauer Mittelfrüher* were reduced by about 40 to 60 %, the deficit in *Mandarina Bavaria* and *Hallertau Blanc* was limited to under 20 % (minus 19%, minus 18 %, respectively). The new aroma cultivars *Callista* and *Ariana* were not released for cultivation by the GfH until 2016, so there are not yet any robust yield results available for the period 2016 to 2018. There are, however, signs that the results here will be similarly positive.

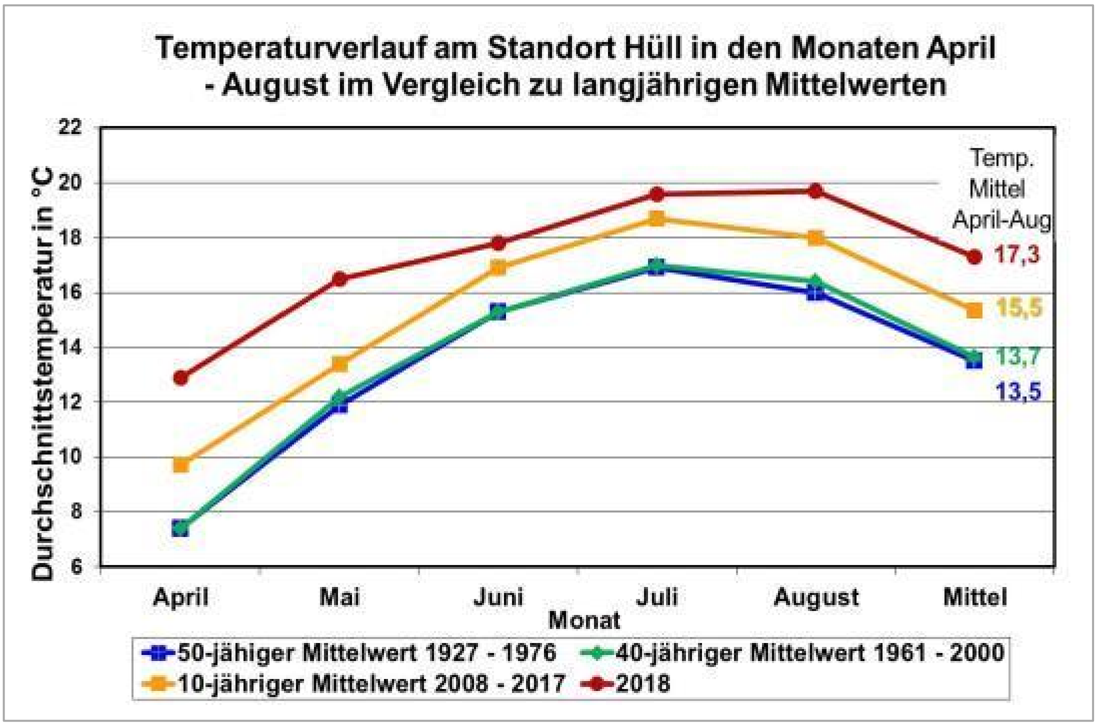


Fig. 4.2: Temperature development at the Hüll site April - August 2018, compared with mean values over many years

Multiple uses of the new Hüll aroma varieties in the brewing industry

As a consequence of the limited availability of traditional noble aroma varieties, master brewers have been using the new varieties in the wet hopping process, and with convincing results; up to now they had only been used in dry hopping. The standardized brewing trials commissioned by the GfH *(Society of Hop Research)* at the Brewing Faculty of TUM Weihenstephan, delivered confirmation that the excellent wet-hopping attributes of the breeding varieties from Hüll also make them suitable for brewing classical lagers. The corresponding analysis data and the results from tasting trials conducted by a panel of experienced tasters provide corroboration. The 'single hopped' lagers made with the new Hüll aroma varieties, where the hops are added at the beginning of the boil and in the whirlpool, were characterized by a traditional hoppy flavour and a mild and pleasant bitterness. In addition, the lagers were trial-tasted by visitors from the industry at the BrauBeviale 2018, who were able to appreciate the harmony of the flavour with its distinctly hoppy nuances. They pronounced the beers brewed with the new Hüll aroma hops to be highly drinkable.

Already in 2015, *Callista* and *Ariana* had delivered proof of their excellent desirable brewing attributes in comprehensive standardized brewing trials employing both wet and dry hopping processes. (Hanke et al., 2015; Hanke et al., 2016)

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., Schüll, F., Seigner, E., Lutz, A. (2016): Development of a Tasting Scheme and a New Systematic Evaluation Program for new German Breeding Lines by example of the New German varieties Callista and Ariana. BrewingScience 69, 94-102.

Tab. 4.1: Overview of crop yields of the principal varieties grown in the Hallertau region
Yield/ha based on weighing data from Hopfenring e.V. and Association of German Hop Growers, average alpha acids content (conductometric values according to ECB 7.4) from (AHA) Hop Analytics Working Group; values adjusted for proportion of young hop plants;
in italics and blue: 5-year mean

Sorte	Fläche Hallertau	**Alpha in %**			**Alpha in %**	**Alpha**		**Schwankung in %**		**Ertrag in kg/ha**				**kg Alpha/ha**				**minus kg Alpha/ha**	
	2018 in ha	**2016**	**2017**	**2018**	**Ø 10 J. 2008-2017**	**Min**	**Max**	**minus**	**plus**	**Ø 10 J.**	**2016**	**2017**	**2018**	**Ø 10 J.**	**2016**	**2017**	**2018**	**2018 zu 2016**	**2018 zu 2017**
Hallertauer Mfr.	503	4,3	3,5	3,6	4,0	2,7	5,0	-33	25	1440	1860	1405	910	58	80	49	33	**-59**	**-33**
Perle	2681	8,2	6,9	5,5	7,6	4,5	9,6	-41	26	1965	2345	1965	1900	149	192	136	105	**-46**	**-23**
Hall. Tradition	2581	6,4	5,7	5,0	6,2	4,7	7,5	-24	21	1980	2325	1940	2025	123	149	111	101	**-32**	**-8**
Spalter Select	468	5,2	4,6	3,5	4,9	3,3	6,4	-33	31	2080	2285	2110	1990	102	119	97	70	**-41**	**-28**
Saphir	435	4,0	3,0	3,3	4,0	2,5	5,3	-38	33	2100	2290	2040	2035	84	92	61	67	**-27**	**10**
Mandarina Bavaria	281	8,7	7,3	7,5	*7,5*	*7,0*	*8,8*	*-7*	*17*	-	2790	2710	2610	-	243	198	196	**-19**	**-1**
Hallertau Blanc	142	9,7	9,0	8,8	*8,7*	*7,8*	*9,7*	*-10*	*11*	-	2820	2500	2560	-	274	225	225	**-18**	**0**
Huell Melon	111	6,8	6,2	5,8	*5,9*	*5,3*	*7,3*	*-10*	*24*	-	2520	2500	1920	-	171	155	111	**-35**	**-28**
Northern Brewer	162	10,5	7,8	7,4	8,2	5,4	10,9	-34	33	1700	2200	1540	1320	139	231	120	98	**-58**	**-19**
Hall. Magnum	1364	14,3	12,6	11,6	13,8	12,6	15,7	-9	14	2110	2140	2300	1555	291	306	290	180	**-41**	**-38**
Hall. Taurus	244	17,6	15,9	13,6	16,5	12,9	17,9	-22	8	2020	2225	2025	2040	333	392	322	277	**-29**	**-14**
Herkules	5897	17,3	15,5	14,6	16,7	15,1	17,5	-10	5	3035	3240	2995	2940	507	561	464	429	**-23**	**-8**
Polaris	131	21,3	19,6	18,4	*19,3*	*17,7*	*21,3*	*-8*	*10*	-	2360	2150	2160	-	503	421	397	**-21**	**-6**

4.3 Crossbreeding with Tettnanger Landrace

Objective

The aim of this breeding programme is to improve significantly the yield potential and fungal resistance of Tettnanger landrace, while retaining the aroma profile as close to the original as possible. The hop needs to be adapted to suit climatic conditions, in order to deal with the early flowering problem linked to higher temperatures. Moreover, a modern variety is expected to make more efficient use of nutrients, a crucial factor in implementing the new fertilizer ordinance.

Method

This objective cannot, however, be achieved solely through selective breeding within the naturally occurring variability of Tettnanger landrace. Therefore, attempts must be made to obtain the desired result through crossbreeding for traits of interest with preselected male aroma lines which deliver broad-spectrum disease resistance and, on account of their relatedness, good agronomic performance.

Chemical analysis of the cone compounds

Chemical analysis of the cones from all tests is carried out at Hüll by Dr. Kammhuber and his IPZ 5d team. Aroma quality is assessed through organoleptic examination.

Testing for virus and *Verticillium*, pathogen elimination

In order to make sure that the plants are virus-free before propagation for the female advanced selections, leaves from each hop under scrutiny are tested for hop viruses by IPZ 5b, with support from the LfL Virus Diagnostics group (IPS 2c), using the DASELISA (Double Antibody Sandwich Enzyme Linked Immunosorbent Assay) technique. Screening is aimed at detecting the hop mosaic virus and the apple mosaic virus, both of which have a negative impact on quality and crop volumes (Seigner et al. 2014).

The Verticillium-free status of a hop plant is scrutinized by the genome analysis team at the breeding department in Freising, using highly sensitive Real-time-PCR. (Maurer et al., 2013; Seigner et al., 2017).

If the starting material is infected with a virus or *Verticillium*, meristem tissue culture, a biotechnology technique, is used to eliminate the pathogens in an arduous and time-consuming process which takes several months. To make sure the elimination process has been successful, the micro-plants generated *in vitro* are again examined for virus and *Verticillium* contamination, using the detection techniques described above.

Results

Seedling assessment

Since 2010, 29 specifically created crosses have been performed; over 1 400 female seedlings have been preselected for their resistance and vigour, planted out in the breeding yard at Hüll and tested over a period of three years. Thanks to the application of only minimal amounts of plant protection products and reduced quantities of nitrogen during the growing trials (seedling assessment and female advanced selections) in our breeding yards, selection has, for many years now, been concentrated on the most robust, resistant hops with the most efficient nutrient uptake.

As part of the seedling assessment, cones from a total of 24 Tettnanger progenies were harvested for the first time in 2018. Seven promising candidates were chosen. Following verification of their virus- and *Verticillium*-free status, five seedlings have been earmarked for propagation and subsequent planting out in the new female advanced selections. Two candidates infected with *Verticillium* are being cured by means of meristem tissue culture and will be available for the female advanced selections in 2020.

Female advanced selections

So far, a total of 11 promising candidates have been chosen for the female advanced selections, on the basis of their good agronomic traits, resistances/tolerances and pleasing components.

In the 2015 season, the first two breeding lines from the Tettnanger breeding programme underwent growing trials ─ six plants from each line, each replicated twice ─ in two locations, first in the Hallertau and, from 2016, at the Straß experimental station in Tettnang. In 2016, there followed seven further lines which will have the chance to prove their performance potential during a 4-year trial period, in different soils and in different weather conditions. As a result, judgements as to vigour, yield, disease resistances, compounds, and aroma will be far more reliable. Two new lines reached this crucial growing phase of the trials in the 2017 season.

Outlook

The female advanced selections are followed by on-farm field trials. Then, a breeding line must pass further tests in commercial farm plots under real-world conditions (field trials in rows, and large-scale field trials). At the earliest, this trial phase for the new breeding lines from the crossbreeding programme will go ahead with effect from 2019/2020, at the earliest.

4.4 Development of Healthy, High-yielding Hops with High Alpha Acids Content, Especially Suited to Cultivation in the Elbe-Saale Region

Objective

The goal of this research project is to breed and test new robust, high-yielding hop breeding lines, notable for their alpha acids content and their broad-spectrum resistance/tolerance to fungi and pests, in particular to the pathogens causing crown rot. Furthermore, a modern hop variety is expected to deliver maximum yields as a result of optimized nutrient use efficiency, in spite of receiving reduced levels of nitrogen. Added to that, a better capacity to cope with climate changes should be able to address the issue of early flowering brought on by the higher temperatures (in *Hallertauer Magnum*, for example) in order to prevent yield losses.

Eventually, competitive new varieties are to be released, with a view to securing the area's long-term ability to compete as a hop-producing region in world markets.

In pursuit of this goal, new high alpha breeding lines are to be developed, while already selected lines from the current Hüll high alpha breeding programme are being tested by a grower in the Elbe-Saale region to establish their suitability for cultivation there.

Implementation and methods

- **Crosses**

The LfL provides breeding lines and varieties for this crossbreeding programme from its own breeding material, selected for the desired traits. The crosses, the nursery work, and preselection for resistance/tolerance to powdery mildew/downy mildew are performed in the LfL greenhouses at Hüll. The subsequent 3-year seedling assessment, involving individual plants, and the female advance selections, also take place at LfL sites. In this context, the use of plant protection products and fertilizer is systematically reduced, and hops are selected for their robustness, resilience, and optimized nutrient uptake.

All further selection stages will be go ahead simultaneously in the Hallertau and the Elbe-Saale region.

Chemical analysis of the crop samples from the Hüll breeding programme is performed at Hüll by Dr Kammhuber and his team IPZ 5d.

In order to be sure of the virus-free status of the plants for the female advanced selections, leaves from each hop in question are tested for hop viruses by IPZ 5b, with support from the LfL Virus Diagnostics group (IPS 2c), using the DASELISA (Double Antibody Sandwich Enzyme Linked Immunosorbent Assay) technique. Testing is aimed at detecting the hop mosaic virus and the apple mosaic virus, both of which have a negative impact on quality and crop volumes (Seigner et al. 2014).

The *Verticillium*-free status of a hop plant is scrutinized by the genome analysis team at the breeding department in Freising, using highly sensitive Real-time-PCR. (Maurer et al., 2013; Seigner et al., 2017).

If the starting material is infected with a virus or *Verticillium,* meristem tissue culture, a biotechnology technique, is used to eliminate the pathogens. In the last few years, it has been possible to make further improvements to this technique, chiefly by considerably speeding up regeneration of the microplants through the use of a RITA® fluid culture stage during the tissue culture procedure (Seigner et al., 2017).

- **Row planting trial growing Hüll high alpha breeding lines in the Elbe-Saale region**

New, highly promising breeding lines from the current LfL breeding programmes are being tested in real-world conditions in the Elbe-Saale region in order to ascertain which breeding lines are suitable for cultivation in the local conditions and will be able to deliver the required performance traits and resistances to diseases there. Hüll high alpha lines have been undergoing testing since 2014 on the Berthold farm in Monstab, Thuringia, growing in conditions typical of the area. Also, testing of the lines on the farm of the Querfurt Agrargenossenschaft *(agricultural cooperative)* in Saxony-Anhalt and at the Hopfengut *(hops estate)* Lautitz in Saxony began in 2018.

Results

- **Crosses**

Thirty-three crosses were performed in 2018 with the objectives described above in mind. As of May 2018, there were altogether 2 329 seedlings from 40 crosses with the goal ‘high alpha’ in the vegetation hall after pre-screening for resistance.

Promising candidates are currently undergoing either the 3-year seedling assessment in the breeding yard at Hüll or the 4-year female advanced selections at Hüll and/or Stadelhof.

- Row planting trial in the Elbe-Saale region

Furthermore, it has been possible to gather more information on the row planting trial in progress since 2014 on a hop farm in the Elbe-Saale region. At present, three Hüll high alpha breeding lines are being trialled at the Berthold farm for comparison with cultivars *Hallertauer Magnum*, *Herkules*, *Polaris* and *Ariana*. Only high alpha lines noted for their good plant health in the breeding yard at Hüll were chosen. ***(Fehler! Verweisquelle konnte nicht gefunden werden.)***.

A proper comparison involving yields from the two lines 2010/80/728 and 2011/71/19, which were not planted until the end of June 2015, was not possible during the 2016 season because there were still gaps in the stands in the spring of 2016, with 20 plants having to be replaced. For this reason, the plots were still heterogeneous at harvest. Although breeding line 2010/80/728 did very well in 2017, at 3 400 kg/ha, with an alpha acids content of 18.5 %, breeding line 2011/71/19 appeared to be thriving better from spring onward in 2018. Neither breeding line has so far exhibited any plant health problems. High alpha breeding line 2010/75/764 planted in 2014 produced highly promising yields and alpha acids results in the year of planting, 2014, but the results at harvest in the two subsequent years were disappointing. The appearance of the stand was no longer so homogeneous, and alpha acids levels were unstable. In 2018, the stand became so heterogeneous that no harvesting was done.

The new aroma cultivar *Ariana*, with its broad-spectrum disease resistances and tolerances, which was first registered in 2016, is also being trialled at this site in the Elbe-Saale region, to assess its resistance to the crown rot pathogens prevalent in the area. If the findings are positive, *Ariana* will serve as a comprehensive source of resistance characteristics for this breeding programme.

Typical of the weather during the 2018 season were high temperatures and a serious lack of rainfall. At the Monstab site, only 330 mm of rain fell in 2018. During the growth period from April to September, rainfall measured only 158 mm. Irrigation would be possible, but the available wells are not nearly productive enough to make up the deficit. From the end of May to the beginning of September, 100 mm of water was supplied through irrigation.

Outlook

In 2019, one or two more promising breeding lines from the current Hüll breeding programme are to be planted out at the Monstab site. The first findings for the promising new breeding lines from the crossbreeding programme are not expected until after the 3-year assessment of the seedling generation S2017 in the Hüll breeding yard, i.e. in 2020/2021 at the earliest. Before any reliable observations can be made concerning the breeding lines involved in the row planting trials, each of the breeding lines will have to undergo these growing trials over a period of five years. Since the spring of 2018, two more farms have been participating in the row planting trials, so that promising high alpha breeding lines are now being tested in real-world on-farm conditions in all three federal states.

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Tab. 4.2: Results of row planting trial of Hüll high alpha lines (row with 102 plants per breeding line) with an Elbe-Saale grower, using Hallertauer Magnum, Herkules and Polaris as reference varieties; [1] a acids content in weight % air dry, according to EBC 7.4

Properties	Hallertauer Magnum	Herkules	Polaris	Ariana	Breeding line 2010/75/764	Breeding line 2010/80/728	Breeding line 2011/71/19
Year planted	1998	2001	2012	2016	March 2014	June 2015	June 2015
Aroma assessment	pleasant	pleasant	pleasant, special aroma	pleasant, fruity, special aroma	pleasant	medium	pleasant
Alpha acids (%)[1]	**12.4** (10.6 – 14.5)	**13.9** (13.5 – 14.5)	**16.4** (13.7 – 18.2)	**8.5** (8.2 – 9.7)	**12.8** (11.5 - 13.7)	**17.9** (16.3 - 19.0)	**15.9** (15.0 - 17.2)
Yield (kg/ha)							
harvest 2014	2 210	3 230	2 850		2 615*		
harvest 2015	1 640	1 640	1 900		3 030		
harvest 2016	2 830	2 500	2 435	1 651 (Jungh.)	3 010	2 210	2 230
harvest 2017	2 925	1 950	2 785	4 488	2 750	3 375	2 930
harvest 2018	2 419	no longer grown due to crown rot	2 256	3 092	no harvesting due to crown rot	2 097	2 395
kg α-/ha	**304** (174 – 410)	**325** (221 – 453)	**401** (309 – 507)	**324** (272 – 376)	**372** (348 – 392)	**469** (341 – 637)	**405** (358 – 466)
Plant health	very good	poor	very good	very good	medium	good	good
Agronomic assessment		yield potential reduced due to crown rot	robust, medium to poor twining ability	weighty, robust, good, broad resistances	top-heavy, weighty, a acids highly variable	full resistance to PM, low number of cones	good resistance to PM, good stature, high yield potential

4.5 Research into and Work on the Problem of *Verticillium* on Hop ─ molecular detection direct from the hop bine via Real-time PCR

Managing *Verticillium* wilt disease in the German hop-growing regions is a long-term undertaking. The research conducted and the guidance provided by the LfL and the implementation by hop growers of preventive plant cultivation measures play a crucial role in the concerted efforts to control *Verticillium* in hop growing.

Objective

Apart from the implementation of further phytosanitary and horticultural measures, (see *Green Pamphlet*) the use of *Verticillium*-free planting material plays a decisive part in preventing the further spread of the *Verticillium* wilt fungus in the hop-growing area. Since 2013, a highly sensitive PCR-based technique has been used to detect *Verticillium* in hop planting material, to make sure that only hops free of the wilt fungus undergo the LfL tests, and are then passed on to propagation facilities under contract to the *Society of Hop Research* (GfH) and subsequently to hop growers.

Method

Molecular detection direct from the hop bine via Real-time PCR (Polymerase Chain Reaction) as per Maurer, Radišek, Berg and Seefelder (2013).

A section of the inner core, containing water-conducting vascular tissue, and, therefore, potentially also *Verticillium* spores or mycelium, is excised from the hop bine under scrutiny. The bine section is shredded in a homogenizer and used to isolate the DNA; hop DNA as well as DNA from possible fungal contamination in the vascular tissue are also isolated.

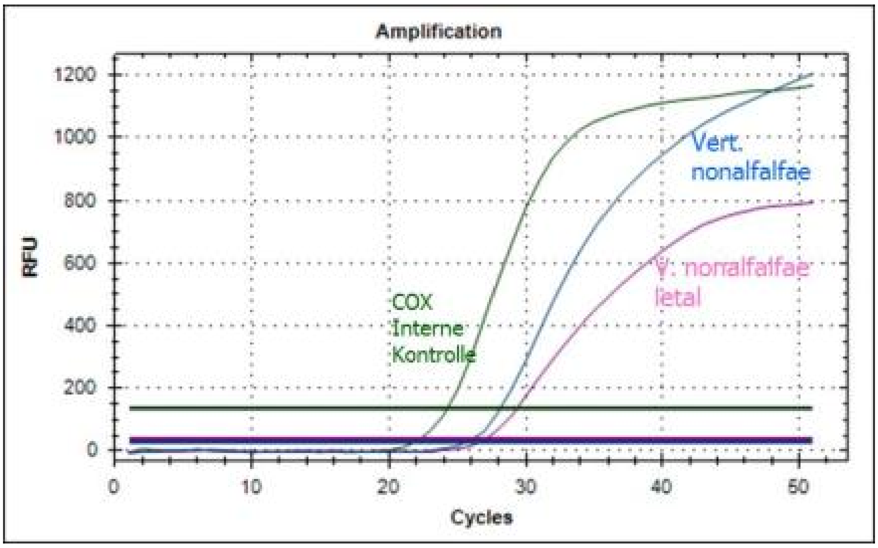

Fig. 4.3: In the multiplex Real-time PCR, the sharp gradient of the blue curve (amplification of sequences specific to V. nonalfalfae with emission of the fluorescent dye FAM coupled to the probe) shows that the hop bine under scrutiny is infected with V. nonalfalfae (primer pair do not differentiate between mild and lethal strains). At the same time, infection with a lethal strain of wilt fungus V. nonalfalfae is detected in this hop sample (steep rise of the fluorescence signal Cy5= red curve). The sharp gradient of the green curve (HEX) reflects evidence of the hop-specific COX gene and confirms that the detection reaction is functioning correctly. Amplification curves of the controls and further samples were masked in the diagram, so as not to confuse the picture.

With Real-time PCR using primers and probe specific to *Verticillium nonalfalfae*, the fungal infestation is ultimately flagged up by an increase in fluorescence between amplification cycles 18 and 35 (Fig. 4.3 blue curve). With this method, simultaneous detection of lethal strains of *Verticillium nonalfalfae* is also possible (primer pair and probe from Seefelder and Oberhollenzer, unpublished; Fig. 4.3***Fehler! Verweisquelle konnte nicht gefunden werden.***, red curve). Moreover, with this multiplex Real-time-based method, the presence of hop-specific DNA (as an internal control = green curve in *Fig. 4.3* for COX = cytochromoxidase as per Weller et al., modified in 2000) confirms that the PCR is functioning correctly, so that 'false negative' results can be ruled out.

Results

- **Hop analyses**

Hop bines, roots/root cuttings, leaves, cones, shoot tips and *in vitro* plants were screened for *Verticillium* by Real-time-PCR, with the following aims:

- to examine breeding material from Hüll for *Verticillium nonalfalfae* and to differentiate between infection with mild or lethal strains of *V. nonalfalfae*
- to examine the mother plants from a GfH propagation facility for *Verticillium* infestation, to ensure that root cutting material passed on to growers is wilt-free
- molecular verification of wilt symptoms in the breeding yard at Hüll, in the two wilt screening yards and in commercial plots, in collaboration with S. Euringer, IPZ 5b
- to examine regenerated meristem-derived plants after 'hoped for' elimination of *Verticillium* through meristem culture in combination with heat treatment
- studies of patterns of *Verticillium* infection on hops grown outside in the open

- **Optimizing the method**

With the purpose of improving reliability and validity of Real-time PCR results, various parameters were examined: concentration of the primers and probes, temperature optimization, comparison of results from singleplex, duplex, and triplex detection and testing of the COX system (modified as per Weller et al., 2000) as internal control

- **Assistance with aubergine tests**

In the context of studies carried out by IPZ 5b using aubergines as indicator plants to identify *Verticillium*-contaminated soils, IPZ 5c (as collaborative partners) examined wilt-free aubergines and aubergines showing wilt symptoms using Real-time-PCR, thus verifying the assessments.

- **Providing *Verticillium* inoculation material**

Two mild and two lethal *Verticillium* reference strains from the glycerine-stored strain collection were revitalized in a complete medium and propagated. The virulence properties of the strains used were again verified by Real-time PCR, before the fungal strains were transferred to fluid culture and propagated as infection material for artificial inoculation tests.

Outlook

Work on optimizing Real-time PCR is ongoing. A constant check is kept on whether the primers used in the PCR reaction for detecting *Verticillium nonalfalfae* still cover all the mild and virulent species occurring in the Hallertau region.

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4.6 Meristem Tissue Culture to Obtain Healthy Planting Material

Lead:	Dr. E. Seigner, A. Lutz
Staff:	B. Haugg
Collaboration:	P. Hager, R. Enders, IPZ 5c
	Dr. L. Seigner, IPS 2c, and Virus Diagnostics Team

Objective

Not only *Verticillium* but also viruses on hop can cause devastating yield losses and harm to quality, but these diseases cannot be kept down by means of plant protection agents. For this reason, a method of control known as meristem culture, which employs biotechnology techniques, has now taken on greater importance. Based on the assumption that the meristem is not connected to the functioning vascular system, and also on the premise that even viruses or fungal structures inadvertently introduced by ourselves have been rendered inactive after heat treatment, it should be possible successfully to regenerate pathogen-free hop plants from heat-treated meristems.

Method

For the purpose of producing *Verticillium*- and virus-free hop plants, the uppermost tip of a shoot (= meristem), is excised following heat treatment and cultured in a tissue culture medium. Thanks to special nutrients in the tissue culture medium, leaf structures emerge from the meristem after about 3 weeks, which then go on to develop into a complete plant.

To make sure that the meristem-derived hops are virus-free, the leaves are examined for the various viruses typical on hop. This is done by Working Group IPS 2c, using the DASELISA (Double Antibody Sandwich Enzyme Linked Immunosorbent Assay) technique or by RT-PCR (Reverse Transkriptase Polymerase Chain Reaction).

In order to verify successful elimination of the *Verticillium* fungus via the meristem stage, the *in vitro* generated micro-plants are examined for *Verticillium* using Real-time-PCR and specific TaqMan probes and primers. (Seigner et al., 2017).

Results

Using the tissue culture technique *(Fig. 4.4)*, which has been optimized in the last few years, six breeding lines previously infected with *Verticillium* were ‘cured’ in 2018. It is remarkable that, thanks to continuing improvements to the individual steps in the culture procedure, all breeding lines can now be rendered *Verticillium*- and virus-free and returned to Hüll as *in vitro* hops within one year (March to February). The regeneration process, which used to be heavily dependent on genotype, was completed successfully for all genotypes ‘treated’ so far. However, there are still a small number of the micro-plants that do not take well to tissue culture and need a slightly longer regeneration period. In mid-February, the culture-derived micro-plants at Hüll are transferred to soil; after acclimatizing in the greenhouse, they are then planted out in May. In this way, it was possible, after pathogen elimination, to speed up the transfer of promising aroma-range breeding material from the Tettnanger (see **Fehler! Verweisquelle konnte nicht gefunden werden.**) and the high alpha (see Fig. 4.4) crossbreeding programmes to wilt-free locations for growing trials, even though the material had initially been infected with *Verticillium*.

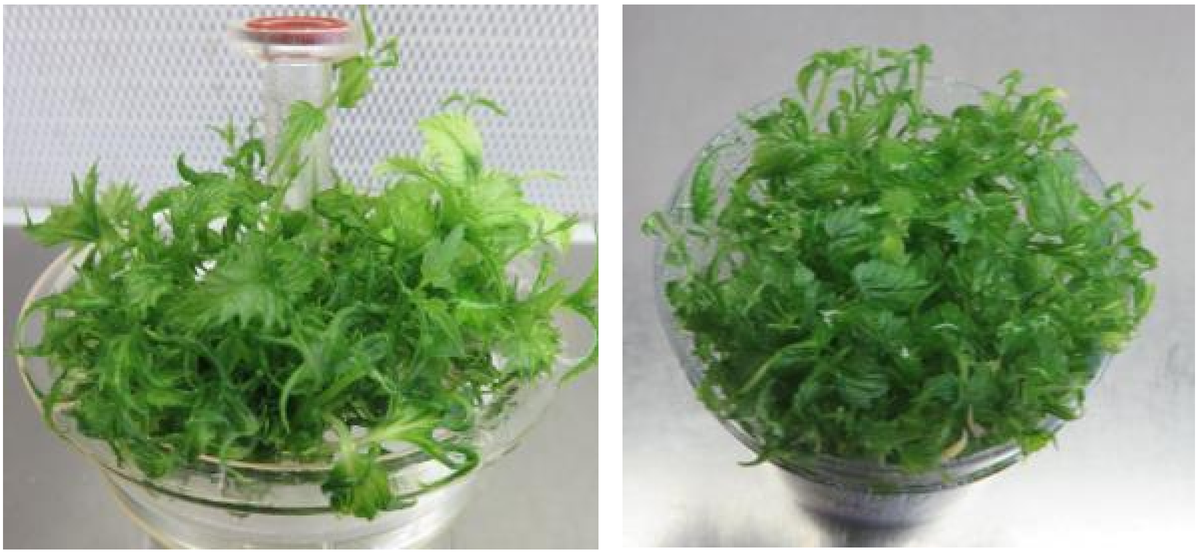

Fig. 4.4: Regeneration of micro-plants derived from meristems after 6-week culture in RITA®-fluid culture system (left), and after a further 6 weeks in a solid medium. At this stage the plantlets are cloned to produce enough test material for Verticillium and virus testing.

Outlook

Work on further optimizing meristem regeneration continues, where the current focus is on improving the effectiveness of pathogen removal. The elimination of viroids now presents a new challenge, and novel strategies are being pursued.

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4.7 Establishing a Detached Leaf Assay to Assess the Level of Tolerance of Hops to Downy Mildew (*Pseudoperonospora humuli*)

Leads: Dr. E. Seigner, A. Lutz

Staff: B. Forster

When hops become infected with the downy mildew fungus (*Pseudoperonospora humuli*) hop growers are repeatedly confronted with enormous problems. Admittedly, downy mildew infections were not a problem in 2018, thanks to the extreme drought conditions. However, we continue to work on devising effective solutions to support hop growers in their struggle to manage this fungal disease. Alongside the downy mildew warning service, which has been in place for two decades now, breeding research has been contributing significantly towards managing the problem. The focus is on developing hops with markedly improved tolerance to the fungus. Every year, thousands of new seedlings undergo spraying with a fungal spore suspension in the greenhouse; this is then followed by an assessment of their reaction to the fungus. During this mass screening process, it is not possible to establish the level of tolerance in the individual hops with any precision.

Objective

To enable fact-based judgements to be made regarding the tolerance of individual seedlings or varieties, a standardized testing system using detached leaves (detached leaf assay) is to be established in the laboratory, by means of which tolerance or susceptibility to downy mildew can be accurately and reliably assessed. Only tolerance to so-called secondary infection is examined in this context, i.e. how susceptible or resistant the hop is to the zoosporangia of the fungus, which land on the leaves from the outside. When humidity is very high, the zoospores are released from the sporangia, penetrate the interior of the leaves through the leaf stomata and develop into a fungal mycelium. The leaves of susceptible hops then exhibit the typical symptoms of fungal infection ─ a sporulating fungal mycelium.

Method

The undersides of the hop leaves are sprayed with the downy mildew sporangia suspension. Five to fourteen days after inoculation, the reaction of the leaves is visually assessed, in part using a biocular eyepiece (no visible symptoms, chloroses, necroses, sporulation).

The leaves are rated on a scale from 0 to 5, focusing on sporulation: 0 (highly tolerant) = no symptoms; 1 (tolerant) = 1-10%; 2 (moderately tolerant) = 11-30%; 3 (susceptible) = 31-60%; 4 (highly susceptible) = 61-80%; 5 (susceptible in the extreme) = 81-100% of the leaf's surface is affected.

Results

Work on establishing and optimizing a leaf assay has been in progress for some years now. First findings in this context were collated in 2013 in a Bachelor's degree thesis (Jawad-Fleischer, 2014). After further improvements in reproducibility, in maintaining the vitality of the zoospores, and with respect to the temperature regime of the leaf assay, it became possible, depending on tolerance to downy mildew, reliably to produce chloroses, necroses and, in the case of susceptible hops, sporulation, on the leaves being tested. Cultivation of the test plants has also been optimized. At the moment, there is, however, some difficulty in keeping a supply of fresh spores for inoculation over a period of several months. For this reason, first experiments were conducted using frozen inoculation material, based on the findings of Mitchell et al. (2010), and these will continue in 2019.

Within only a few days of inoculation, chlorotic marks appear on the leaves of the more susceptible or less tolerant hops, accompanied by distinct sporulation on the undersides. Heavy sporulation at an early stage is an indication of high vulnerability to the fungus. At an advanced stage, dark brown necrosis spots become visible. How each leaf reacts varies according to its age. Young leaves at the growing stage exhibit more marked symptoms than older leaves.

In the case of tolerant hops, sporulation is completely suppressed, or smallish necrosis spots appear on the leaves (hypersensitive reaction of the host cells) as a defensive reaction, especially at an early stage in the infection.

With very few exceptions, field monitoring of the hitherto examined varieties and breeding lines has confirmed the tolerance assessments from the leaf assays.

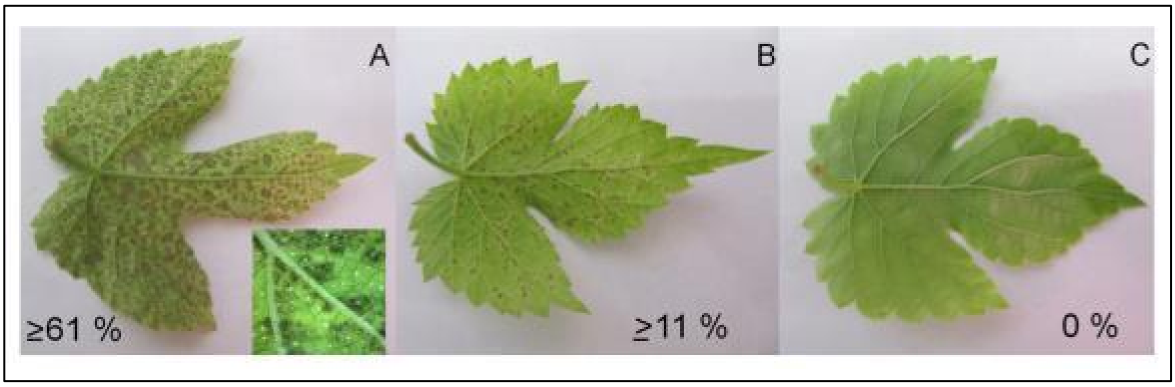

Fig. 4.5: Different reactions of hop leaves 6 days after inoculation with Peronospora: susceptible (A), moderately tolerant (B) and highly tolerant (C) to the fungus; % of infected leaf surface = sporulation; additionally, in photo A, a close-up of the infection showing black spore areas

Outlook

The leaf assay has a crucial advantage; it is free of any influence exerted by weather conditions or location, and this means that any judgements as to the tolerance to disease in a hop variety or breeding line are made under standardized conditions. At the end of the day, in terms of translating the results of the detached leaf assay into practice and thus including it the breeding process, the decisive factor will be whether the tolerance/susceptibility of a hop to secondary downy mildew infections determined by leaf assay in the laboratory can be correlated with the tolerance/susceptibility assessments in the field.

More varieties and breeding lines will be examined using the detached leaf assay in the coming season.

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5 Hop Farming, Technical Aspects of Production

LD Johann Portner, Dipl.-Ing. agr.

5.1 N_{min} Audit in 2018

The use of nitrogen fertilizer in compliance with DSN (N_{min}) is now an established part of fertilization management on commercially run hop farms. The new fertilizer ordinance stipulates a minimum of 3 audits for farms signing up to the exemption option involving the re-cycling of bine residues or for businesses with hop-growing acreages in 'Red Areas'.

In 2018, three-quarters of the hop farms in the Bavarian hop-growing regions Hallertau and Spalt took part in the DSN audit and 4 010 hop yards (2017: 3 067 samples) were tested for N_{min} content. The significant increase in the number of N_{min} audits is down to the requirements of the new fertilizer ordinance, which stipulate that all hop farms putting their bine residues back on the areas planted to hop by 15 October must conduct at least 3 N_{min} audits in the spring. The N_{min} value must then be taken into account in determining N requirement and calculating how much fertilizer is needed on the tested plots. For the remaining hop-growing acreage, growers can use the final average values for each region issued by the state advisory service, when deciding on N requirement if no N_{min} audit result is available

Tab. 5.1: Number of samples taken, provisional and final 2018 N_{min} values for rural districts and growing regions

Rural district/ growing region	Number of samples taken	Provisional N_{min} value (status 29.03.2018)	**Final N_{min} value**
Eichstätt (incl. Kinding)	287	49	**59**
Freising	349	49	**52**
Hersbruck	90	(49)	**48**
Kelheim	1 606	48	**50**
Landshut	238	70	**68**
Pfaffenhofen (and Neuburg-Schrobenhausen)	1 333	46	**48**
Spalt	107	53	**53**
Bavaria	**4 010**	**49**	**51**

The graph below is a compilation showing the history of the number of samples taken for the purposes of the N_{min} audit. In 2018, the average N_{min} content of 51 kg N/ha in the Bavarian hop yards amounted to only half the level of the previous year (102 kg N_{min}/ha), a historical low. This is probably a result of the wet autumn, greater N displacements and higher leaching losses, in addition to ground frost and a cold spring, accompanied by low release of nitrogen.

Now that the new fertilizer ordinance necessitates a determination of individual nitrogen fertilizer requirements for all stands, it is no longer possible for an average fertilizer recommendation for nitrogen to be calculated and issued.

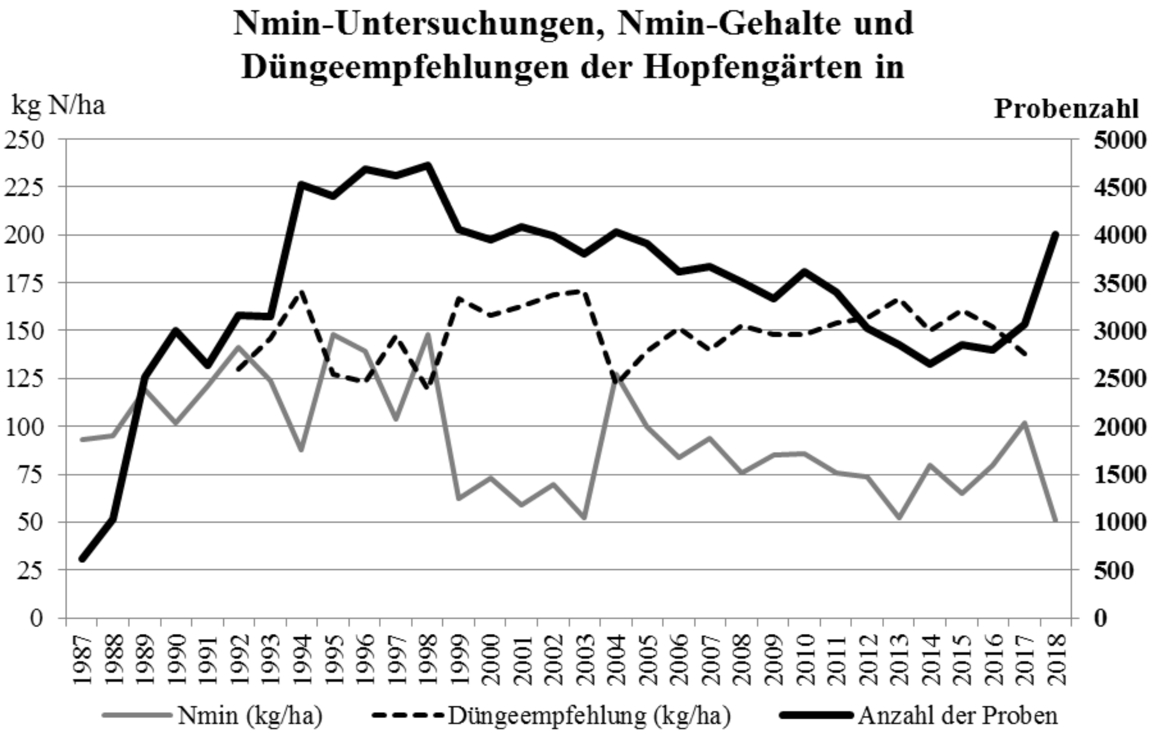

Fig. 5.1: N_{min} audits, N_{min} levels and fertilizer application rate recommendations (up to 2017) in Bavarian hop yards over the years

5.2 Model Project: Demonstration Farms ─ Integrated Plant Protection, Sub-project Hop Farming in Bavaria (ID 5108)

Project lead:	J. Portner
Project staff:	R. Obster
Collaboration:	Julius Kühn-Institut (JKI) Zentralstelle der Länder für EDV-gestützte Entscheidungshilfen und Programme im Pflanzenschutz (ZEPP) *(Central Institution for Decision Support Systems in Crop Protection/ Crop production)*
	5 Demonstration farms (growing hops) in der Hallertau region
Funded by:	Bundesministerium für Ernährung und Landwirtschaft (BMEL) über die Bundesanstalt für Landwirtschaft und Ernährung (BLE)
Scheduled to run:	01.03.2014 – 30.04.2019

Objective

As part of the national plan of action to promote the sustainable use of plant protection pro-ducts, the scope of the nationwide model project *Demonstration Farms - Integrated Plant Protection,* in train since 2011, was expanded to include hop production, and, in 2014, a sub-project entitled *Hop Farming in Bavaria* was set up in the Hallertau region.
The aim of the project, scheduled to run for five years, was to minimize deployment of plant protective chemicals on hop through regular crop inspections and detailed recommend-ations. At the same time, the fundamentals of integrated plant protection (IPS) needed to be adhered to and non-chemical plant protection measures given preference – inasfar as these are available and their use is practicable. The idea was for the demonstration farms to act nationwide as torchbearers within the framework of the project by passing on to hop growers, advisors and the general public all the information on the latest measures and insights relevant to IPS.

Methodology and action taken

At each of five conventionally operated hop farms in the Hallertau region (locations: Geibenstetten, Buch, Einthal, Dietrichsdorf and Mießling), the project supervisor closely monitored three demonstration plots, each an average of around 2 hectares in size, on the lookout for signs of harmful organisms. The cultivars chosen were HA, HE, HM, HS, HT, PE and SR. Each plot underwent a weekly assessment during the growing season to ascertain the precise extent of disease and pest infestation. If necessary, the incidence of infestation or infection in plot sub-sections was examined separately. The project supervisor based her recommendations regarding counter measures on damage thresholds, information from warning services, and forecasting models. If non-chemical treatments were available as a possible alternative to chemical agents, these were the preferred choice. The assessment data gathered, the time requirement, and the protective measures undertaken were recorded on a special app and in online programs and then sent on to the JKI for evaluation.

A special website has been set up in order to keep the public informed and to share the knowledge gained with professional colleagues; in addition, information is also shared via publications, talks and lectures, trade conferences and field day events.

Results and findings

- **Strictly necessary levels and non-chemical plant protection**

The model project’s objective of reducing to the **minimum necessary to be effective** the use of chemical plant protection agents in hop production at the demo farms**,** through regular crop inspections and detailed recommendations, has been successfully put into practice. At the same time, the fundamentals of integrated plant protection were complied with; any necessary control measures were carried out in line with damage thresholds and warning service advice, and the adoption of **non-chemical plant protection measures** given preference, inasfar as these were available and workable. However, the number of non-chemical options was only very limited, the reason being that there are hardly any tried and tested chemical-free methods available and there are problems with technical feasibility or economic viability. The model project also revealed that hop growers already employ many preventive measures to control pests and diseases as a matter of course, for example, hop pruning (management of both powdery and downy mildew), hilling (me-chanical weed control) and leaf stripping (to prevent disease and pest infestation in the lower section of the hop plant and on the hilled row).

Tab. 5.2 : Preventive and non-chemical plant protection measures in hop production

Indications	**Non-chemical measures**
Downy mildew	Pruning Phosphorous acid to fortify the plants Removal of stunted shoots or 'spikes'
Powdery mildew	Pruning Elemental sulphur Reducing the number of trained shoots per trained bine (in suitable varieties)
Botrytis	Reducing the number of trained shoots per trained bine (in suitable varieties)
Verticillium nonalfalfae	Cutting off the bines in infected plots at a low level and removing them from the hop yard (burning) Growing neutral catch crops No spreading of fresh bine residues in the hop yards
Hop flea beetle (1st generation)	Stone meal
Rosy rustic moth	Removing affected shoots by hand Controlling couch grass Mechanical removal of grass weeds on field margins
Two-spotted spider mite	Leaf stripping (defoliating by hand) Mechanical weed control on field margins Predator mites (A coating of glue → damage to hops in 2015) (Spraying whey powder)
Damage caused by game	Sheep fat-based repellent (Trico) Plant fortifier with repellent effect (BioEnergy) Protective fencing Acoustic and sensory deterrent (Wildschreck KR01) A protective covering to prevent damage by game
Weed control	Tillage operations Nutrient salts Controlling couch grass by hand Nylon cord Flaming Organic acids
Leaf stripping	Defoliating by hand Nutrient salts Leaf suction machine Organic acids

- **Timescale for precise monitoring of pests and diseases**

The time required for the precise monitoring and assessment of pests and diseases on the hop-growing demonstration plots was approximately 10 hours per plot throughout the whole season. With 12 monitoring days on average, the required time amounts to roughly 50 minutes per plot and monitoring day. For apple and wine production, the total time required per season is the same, although the time required for each plot per monitoring-day is a lot less ─ around 30 minutes. The reason for this is that in hop growing the harmful organisms need to be monitored mainly at the top of the hop plant, so that, when trellis height is reached, a second person is needed at the tractor controls to operate the lifting platform.

- **Treatment index**

The JKI (Julius Kühn Institute) have worked out a treatment index (BI) for all demonstration farms and all years as an indicator of the intensity of use of plant protection products. The number of plant protection products used in relation to the permissible spray rate and the plot size is termed the treatment index. Reduced spray rates and treatments of sub-plots have been taken into account and lower the treatment index compared with treatment using the full permissible spray rate on the total area.

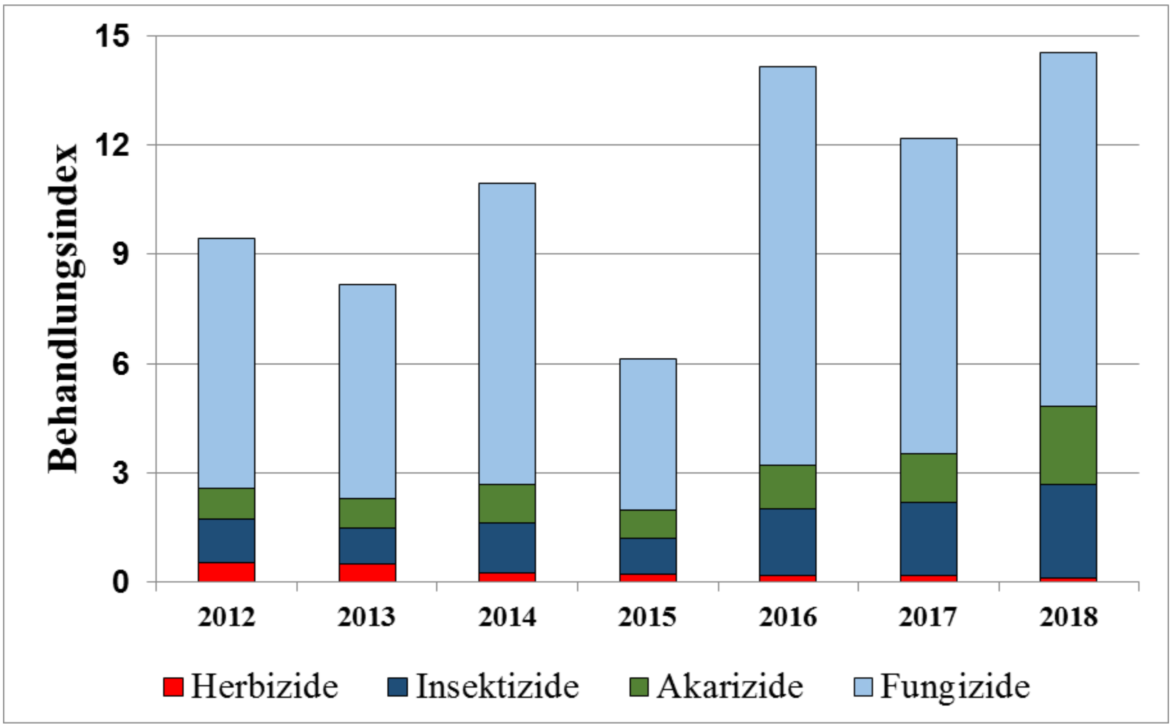

Fig. 5.2: Intensity of treatments on IPS demonstration farms in hop production

Fig. 5.2 shows the considerable fluctuation in the treatment index from one project year to the next. For instance, the treatment index more than doubled from 2015 to 2016, reflecting how pest and disease pressure can vary greatly from year to year in hop growing; in 2015 there were only 3 alerts for treatment to deal with secondary infection of downy mildew, while in 2016 there were 8. Moreover, in 2016, the occurrence of powdery mildew, two-spotted spider mites and hop aphids was more prevalent than in the year before, and growers had to carry out more control treatments. Thus, the treatment index for hop is a reflection of infection and infestation levels and evidence of how the demonstration farms geared their control activities to suit the actual situation in each case, and then limited their deployment of plant protection products to a necessary minimum.

A comparison and evaluation of the different treatment indexes for the various vertical crops participating in the project, i.e. in apple orchards, vineyards, and hop yards, shows that the treatment index for hop is substantially lower than that for the other crops. This is in spite of the fact that hops are the tallest type of crop, require the highest water rates, and have the largest leaf surface area to be protected ─ yet more evidence that IPS practices are already being taken very seriously in hop cultivation.

A further comparison of the treatment index of the demonstration farms and that of the reference farms should deliver information as to whether the intensity of plant protection use can be lowered further by means of extensive monitoring operations and the best possible advisory assistance. The reference farms are representative of ‘average’ Hallertau hop growers implementing integrated plant protection principles. The following chart shows that there is hardly any difference between the treatment indexes of the two groups being compared, insofar as the small number of data sets (individual plots) on which they are based allow a statistically sound comparison. This is yet more evidence that integrated plant protection is being widely practised in hop growing, and plant protection treatments to control pests and diseases are adjusted to suit the current situation as it varies from year to year.

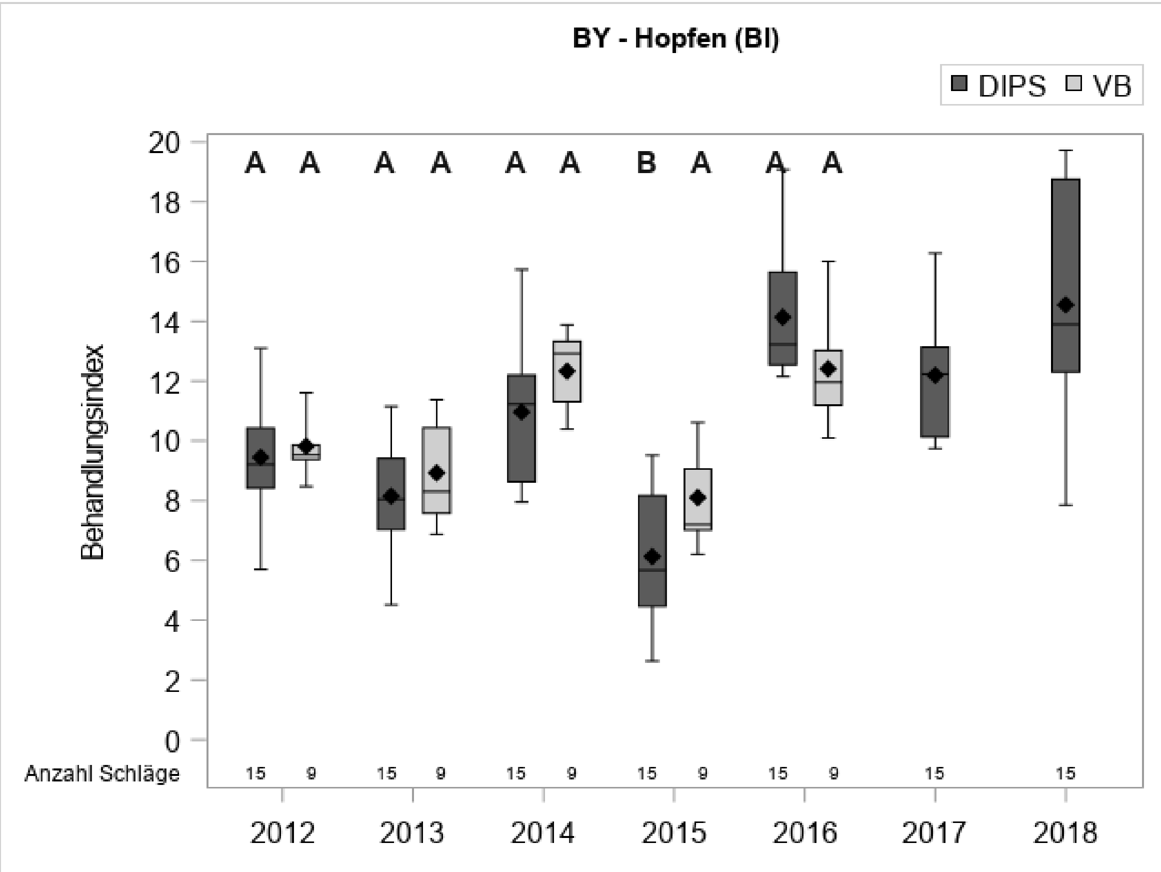

Fig. 5.3: Treatment intensity on demonstration farms (DIPS) and reference farms (VB) in hop production (treatment index of VB for 2017 and 2018 not yet available)

Activities and highlights

The following briefly outlined activities and highlights, which took place during the 5-year timespan of the demonstration project, attest to its impact beyond the boundaries of the local region:

- **Annual working meetings of the demonstration farms**

Every year at the start of the growing season, the demo farms and the project participants got together at the House of Hop for a working meeting, in order to exchange information and plan and discuss various activities for the upcoming hop year. The focus of the meetings was on the implementation of chemical-free protection measures, and the organization and thematic orientation of the field day events.

- **TV feature on the Bavarian Television programme *Unser Land***

In Bavaria, the nationwide model project *Demonstration Farms ─ Integrated Plant Protection* was concerned solely with hop growing. This came to the notice of Bavarian Television in 2014, the first year of the project; a special feature lasting several minutes was filmed for the programme *Unser Land* and broadcast in September 2014.

- **Trade conferences on plant protection in 2015 and 2016**

Traditionally, on the day after the hops tour with the press at the start of harvest, a plant protection symposium is held, attended by the top representatives of the regulatory bodies, the plant protection industry, the hops organizations, and the LfL *(State Research Center for Agriculture),* at which problems to do with plant protection are discussed and potential solutions debated. In 2015 and 2016, the conference was hosted by a demonstration farm, so that it was possible to present the model project to an audience of specialists in this field.

- **Minister Brunner's visit to a demonstration farm in 2017**

During his regular round of farm visits, Staatsminister Brunner called in on a demonstration farm in the spring of 2017, where he learnt about integrated plant protection in hop farming. He was particularly interested in the sensor-controlled plant protection equipment for treating rows of hops. It switches off between the individual plants, thus reducing by more than 50 % the quantity of plant protection product required, as compared with non-stop treatment.

Fig. 5.4: Demonstration of sensor-controlled plant protection equipment treating rows of hops

- **On-farm demo days and field day events**

In the interests of public relations and the presentation of integrated plant protection principles in hop growing, the demonstration farms took turns every year to host an on-farm demo day or a field day event. A particular aspect of plant protection was always highlighted, and the large numbers of visitors and hop growers were shown, for example, chemical-free protection measures as opposed to chemical treatments, or innovative technologies were demonstrated in groups. The highly successful field day events, with their substantial visitor numbers of 100 – 250, were particular highpoints of the model project.

Tab. 5.3: On-farm demo days and field day events at the demonstration farms

Date	Demonstration farm	Topics	Visitor numbers
18.06.2015	Mehrl, Einthal	Leaf stripping	250
23.07.2015	Obster, Buch	Two-spotted spider mite control	200
27.05.2016	Kronthaler, Dietrichsdorf	Sensor-controlled plant protection technology, incorporation of cover crop, erosion control	150
23.05.2017	Moser, Geibenstetten	Filling and cleaning of plant protection equipment, nozzle technology and user protection	100
04.07.2018	Weingart, Mießling	Leaf stripping	250

Conclusion

The model project *Demonstration Farms ─ Integrated Plant Protection* proved to be a successful means of raising the level of awareness about integrated plant protection and plant protection issues in hop cultivation. Non-chemical measures, in particular, as far as these are available and practicable, were presented and taken note of. However, their use is limited and, in many cases, they are no replacement for chemical plant protection. Even so, the project has shown that, if attention is paid to damage thresholds and warning service alerts, chemical plant protection can be reduced to the minimum necessary for it to be effective, and practitioners can tailor treatments to suit the actual levels of infection and infestation each year. The large numbers of attendees and the high level of take-up of the on-farm demo and field day events confirm that hop growers have a keen interest in these issues. This suggests that the field day events should be continued after completion of the model project.

5.3 Development of Optimal Air Distribution Systems when Redesigning a Special Belt Dryer to Dry Hops (ID 6055)

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft Institut für Pflanzenbau und Pflanzenzüchtung (IPZ 5a) *(Bavarian State Research Center for Agriculture, Institute for Crop Science and Plant Breeding (IPZ 5a))*
Funded by:	Erzeugergemeinschaft HVG *(HVG Hop Producer Group)*
Project lead:	J. Portner
Project staff:	J. Münsterer
Collaboration:	HTCO GmbH, Freiburg, J. Satzl, Fa. Fuß C. Euringer
Duration:	2014 - 2018

Situation at the outset and objective

Owing to the continuing expansion of the acreage under hop, drying capacity on many hop farms can no longer keep pace with the quantities of hop being harvested. This means that it is imperative for those drying capacities to be augmented. It is thanks to new findings from trials focused on optimizing belt drying and the insights gained in practice that hop drying in a belt dryer now, for some farming businesses, offers an interesting economical alternative to kiln drying.

In the last few years, instead of building a new kiln, many a farmer has opted to purchase a second-hand belt dryer. However, the number of used belt dryers on the market is limited, so this means that in future there will be an increased demand for new belt dryers that are specially designed for drying hops.

The decisive factor in determining the evenness of the drying process is the way in which the air is distributed. A further air-flow simulation, as described in the Annual Report 2017, was to be used to optimize the air distribution systems common hitherto or to develop novel systems. The idea is to adjust the air inlets so that the inflowing drying air is directed as evenly as possible onto the belts transporting the hop.

Method

First, air-flow specialists HTCO from Freiburg used CCM+ software to simulate and depict the air-flow behaviour in a commonly operated type of belt dryer. This was done with the aid of the plans, sketches and CAD data that were available. In the simulation, the drying air in the conventional type of dryer is merely forced in between the dryer belts through side-wall inlet openings; a method where higher air velocities often lead to the formation of 'holes' and an uneven drying process across the width of the drying belt. On the basis of these findings on air flow and temperature distribution, a number of different air distribution systems were tested and, if necessary, redesigned.

Eventually, two differing systems, promising to be the most viable solutions, were selected to undergo closer examination in an air-flow simulation. In one variant, the air had to be distributed via built-in cassette modules, similar to the technique often used in belt dryers for drying spices, for example, where the air streams in from the side and is redirected to flow in the direction of travel of the belt. The second variant was an air distribution system developed and put forward by Mr Josef Satzl, specialist in engineering design with the Fuß company.

In the latter variant, the drying air coming from the lateral inlet openings is distributed over the belts through rows of tapered perforated plates. In the simulation, the cassette modules and the rows of perforated plates were additionally tried out with closed and air-permeable covers.

It is envisaged that the air distribution systems should be installed between the drying belts at each drying level.

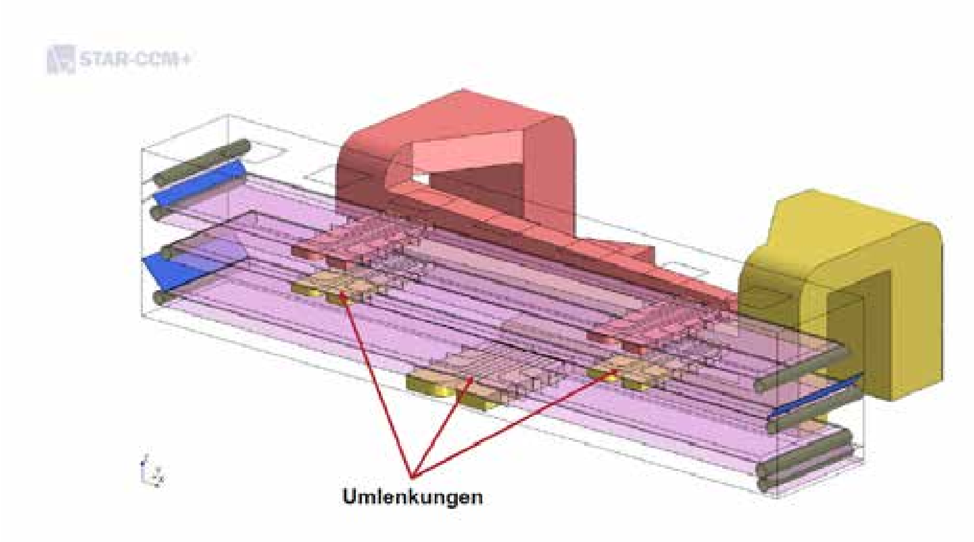

Fig. 5.5: Air distribution through cassette modules

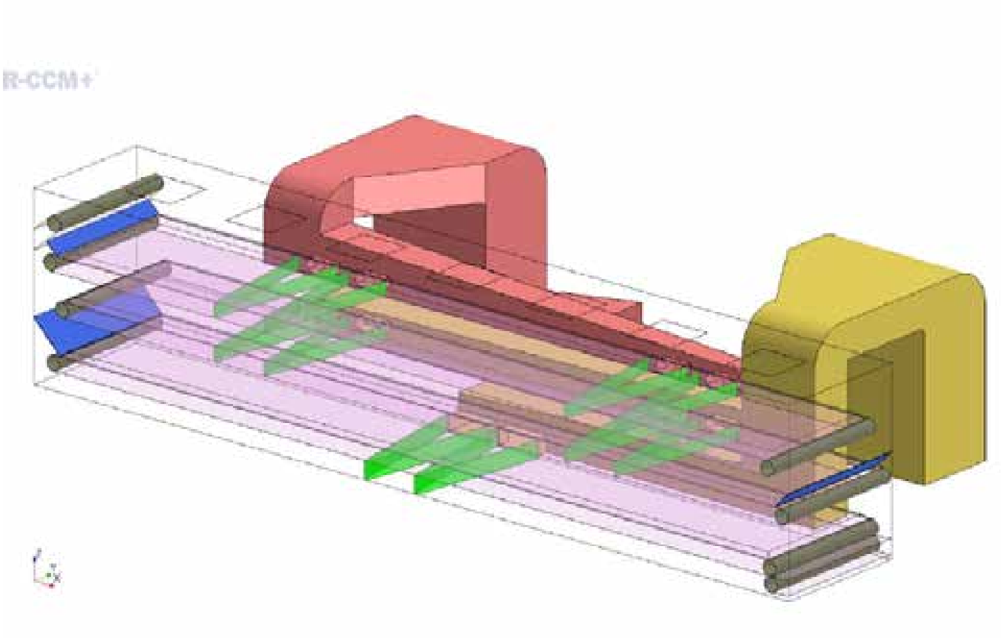

Fig. 5.6: Air distribution through rows of perforated plates

Findings

The vertical air speeds of the drying air flowing in and out through the hops on all drying belts were calculated in the simulation for different air velocities and flow resistances in the hops, and illustrated in diagrams. *Figs. 5.7* to *5.9* show flow velocities and the uniformity of the air velocities over the hops on the top drying belt, in different variants.

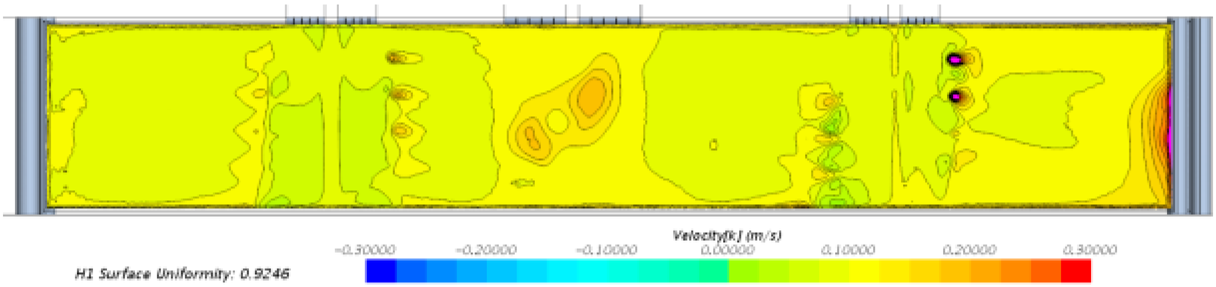

Fig. 5.7: Cassette module with closed cover

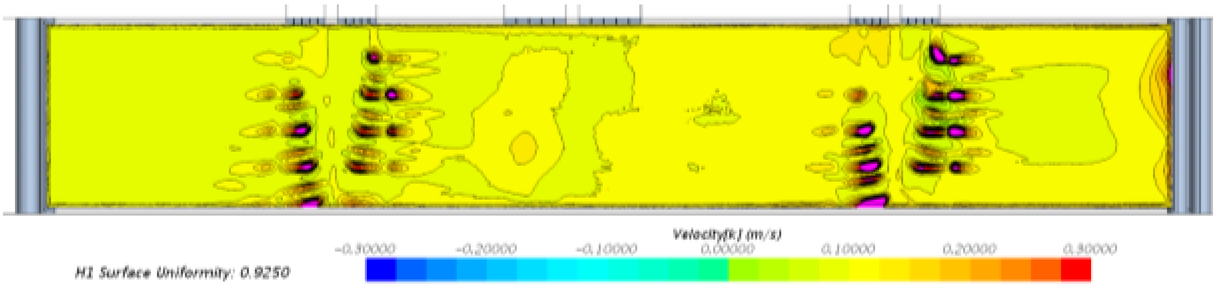

Fig. 5.8: Cassette module covered with perforated plates

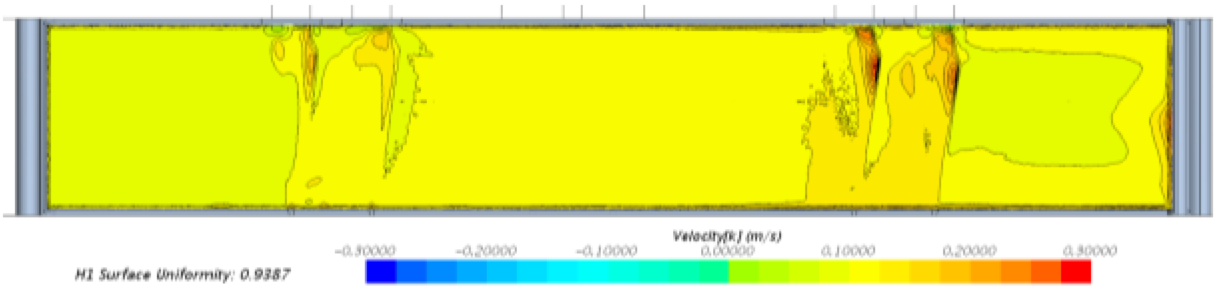

Fig. 5.9: Rows of tapered perforated plates

Fig. 5.8 clearly shows that covering the cassette module with perforated plates greatly increases the vertical air speeds directly above the redirection points, and this makes velocity distribution, on the whole, more uneven than when the module is completely covered. Calculations from the simulation showed that the air distribution system in which the drying air flows in from the side to be distributed through rows of tapered perforated plates produced the most uniform inflow.

According to physicist Dr Axel Müller, a specialist in the field, it is anticipated that both simulated air distribution systems – cassette module with air flow redirected in the direction the belt travels, and the system using rows of tapered perforated plates – will deliver uniform air distribution. The decision as to which system to choose depends on how easy implementation of their design proves to be. The good results produced so far by the air distribution system employing cassette modules in belt dryers have been confirmed by the simulation. It is not possible to say whether air distribution via rows of tapered perforated plates *(*Fig. 5.9*)* would be an improvement/an alternative until they have actually been fitted and operated in a belt dryer.

5.4 Improving Drying Operations in Commercially Operated Hop Kilns through Uniform Air and Temperature Distribution

Project staff: J. Münsterer

Duration: 2016 – 2018

Situation at the outset and objective

Due to differences in factors like cone size, cone shape, lupulin content, strig size, and strig shape, there are big differences in the drying behaviour of different hop varieties. If such considerations are taken into account, it is possible to continue optimizing drying operations by adjusting the drying parameters accordingly. In order to do this, it is important to ensure that both temperature and air velocity of the inflowing drying air are uniform across the entire drying surface beneath all floor levels, otherwise an uneven drying process will very quickly result.

Data loggers can be used to record temperature and relative humidity of the drying air during the drying process. The differences in these parameters can then be used to assess the stages of the drying operation and point to the causes of any unevenness in drying.

Method

Twelve data loggers each were installed in a number of commercially operated kilns. With the help of defined installation times, it then became possible to record the changes in temperature and relative humidity of the drying air as it passed through the individual kiln levels (tiers). Four data loggers were located in the plenum chamber above the air distribution system. The others were mounted in the left-hand and right-hand halves of the kiln, in each case beneath the individual levels. This arrangement meant that it was possible to record the condition of the drying air on the movable floor, the middle floor, and the top floor and to establish how uniform the drying process was.

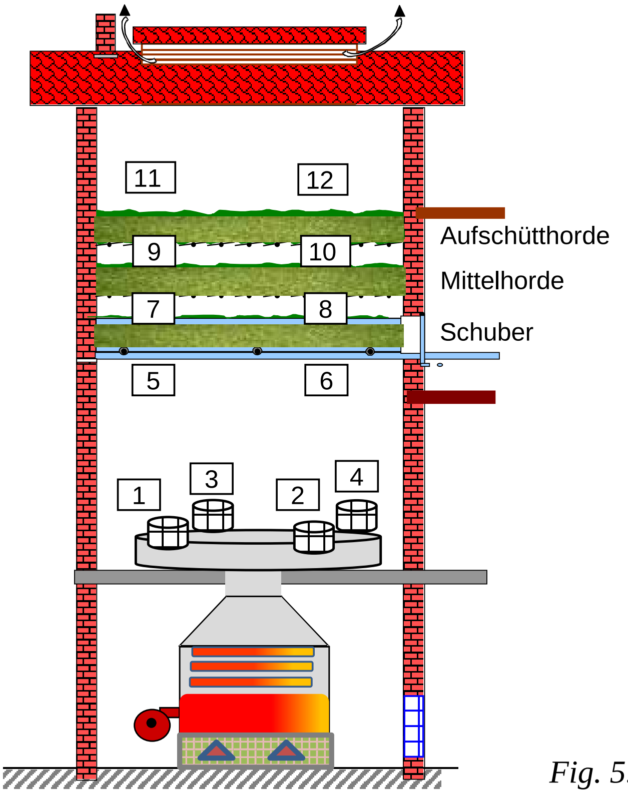

Fig. 5.10: Position of the 12 data loggers installed in commercially operated kilns

Findings

In the plenum chamber in some hop kilns, differences of up to 10°C were found in the drying air coming from the air and heat distributors, but in others, the temperature difference was less than 2°C. **Fehler! Verweisquelle konnte nicht gefunden werden.** and Fig. 5.12 show the drying temperatures recorded by the data loggers in two different commercially operated hop kilns, with even and uneven heat and air distribution. The diagram shows how the drying temperatures change on each level in the same period between 13°° and 17°° hours between loading and off-loading, in the left-hand and right-hand halves of the kiln.

In the kiln with uniform heat and air distribution (Fig. 5.11*)*, there are hardly any temperature differences discernible in the drying air flowing from the air heater. Since the air flowing onto the hops here had almost the same drying temperature within each level, the drying process was uniform over the entire drying surface. It is also clear that drying temperatures on the movable bottom floor, the middle floor and the top floor varied only within a certain temperature range, on the top floor never exceeding 60°C.

In the case of the kiln where drying temperatures were already uneven in the plenum chamber (Fig. 5.12), there was an unevenness in the drying process between the left-hand and right-hand halves of the kiln. It is also clear that, because of unevenness in the hops on the middle floor and on the top floor especially, drying took place in temperatures that were too high and within a range that was too wide.

In order to achieve a uniform drying process and optimal drying rates, it is essential to make sure that temperature and air distribution in the kiln are even and a specific temperature range is maintained inside the different drying stages (floors).

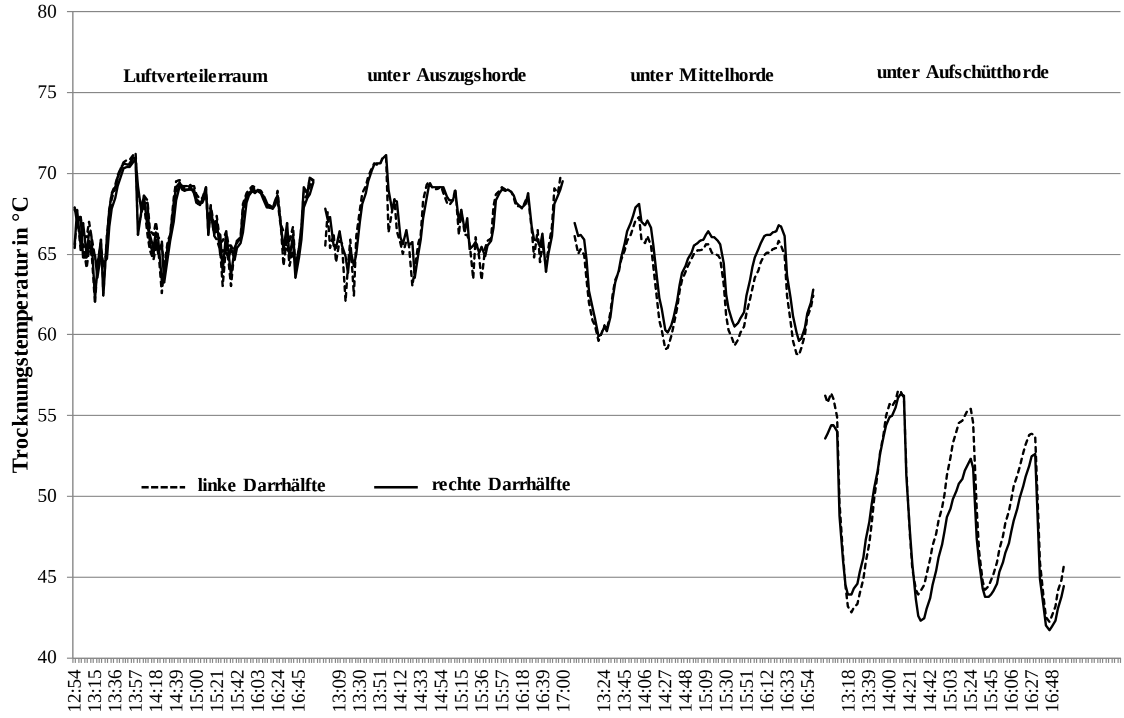

Fig. 5.11: Drying temperatures, air flowing onto the different drying levels when heat and air are distributed evenly

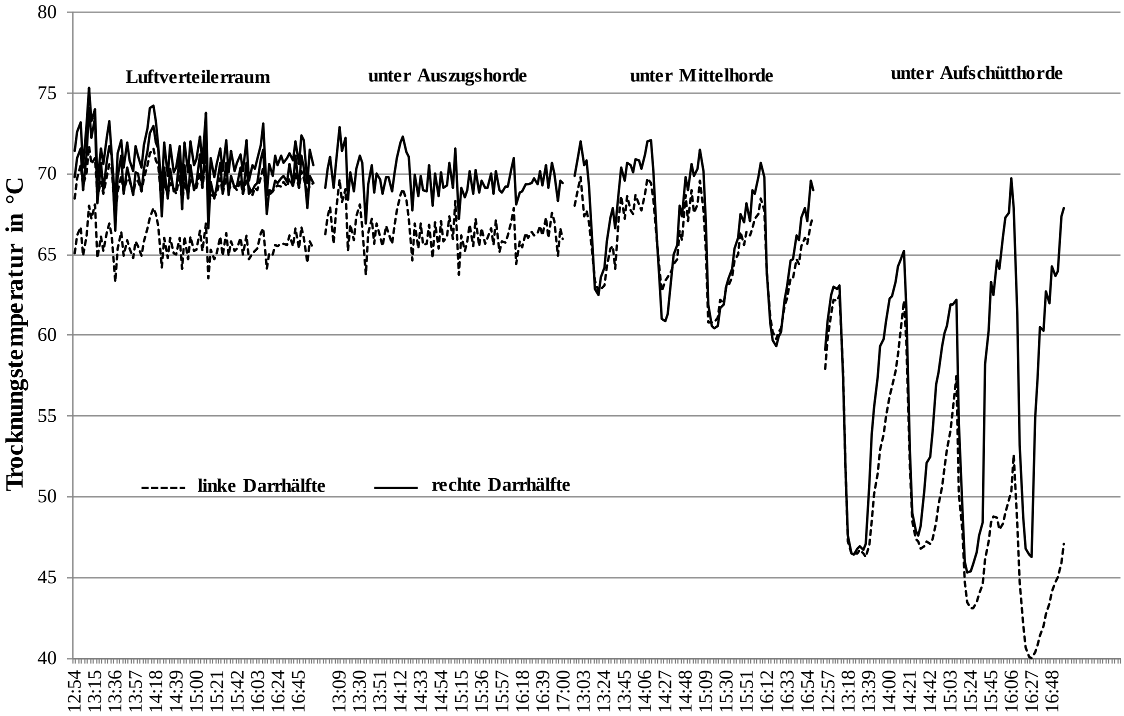

Fig. 5.12: Drying temperatures, air flowing onto the different drying levels when heat and air are distributed unevenly

5.5 Plant-available Nitrogen from Bine Residues, as Demonstrated in a Pot Culture Experiment with Perennial Ryegrass

Staff: J. Stampfl, S. Gschlößl (thesis for Bachelor's degree)

Collaboration: Dr. S. von Tucher, Lehrstuhl für Pflanzenernährung, Wissenschaftszentrum Weihenstephan, TU München *(Chair of Plant Nutrition, Science Center Weihenstephan, TU Munich)*

Dr. T. Ebertseder, Fakultät Nachhaltige Agrar- und Energiesysteme *(Faculty of Sustainable Agriculture and Energy Systems)* Hochschule Weihenstephan-Triesdorf

Duration: September 2017 - March 2018

Objective

Every year, hop harvesting in a stationary machine produces 230 000 tonnes of bine residues. At present, about 80 % of this material is spread in the autumn in the hop yards or on arable land before a deadline on 15 October. This means that 80-100 kg N/ha (total N), depending on variety and crop yield levels, is returned to the terrain. The question is: when will the nitrogen contained in the bine residues be mineralized and will the fact of the material being spread in the autumn increase the risk of export into other ecosystems. In order to investigate how the nitrogen in the crop residues is transformed, a comprehensive pot culture experiment using perennial ryegrass was set up as the subject of a thesis for a Bachelor's degree at Munich Technical University.

Methodology

The pot experiment took place in a greenhouse at the Dürnast testing station of Munich Technical University. To gain insight into the mineralization behaviour of the nitrogen contained in the bine residues, a comparison was made between fresh residues and 3-week old residues with a control, 3 mineral fertilizer variants, and 3 other organic substrates (liquid biogas fermentation residues, solid biogas fermentation residues, and oil radish). The bine residues were loaded into an agricultural storage clamp and divided into 3 layers (outside, middle, inside) because, regardless of its position in the clamp, the material had reached different stages in the rotting process. The 11 variants were arranged in pots of perennial ryegrass, in 4 replications, to establish how much nitrogen is released by looking at the development of biomass in the ryegrass. In addition, the fertilizers were put into unplanted pots, in 2 replications, so that N mineralization could be determined by means of N_{min} tests.

On the basis of the Nt content (total N) in the fresh mass of the various substrates, 1.2 g N was applied to each pot via the organic fertilizers. With respect to the total amount of N, this equates to the variant which received the highest level of mineral fertilizer (1.2). The two other variants fertilized with mineral fertilizer were given 0.6 g N and 0.3 g N. The control variant received no nitrogen at all. (Fig. 5.13 and Fig. 5.14).

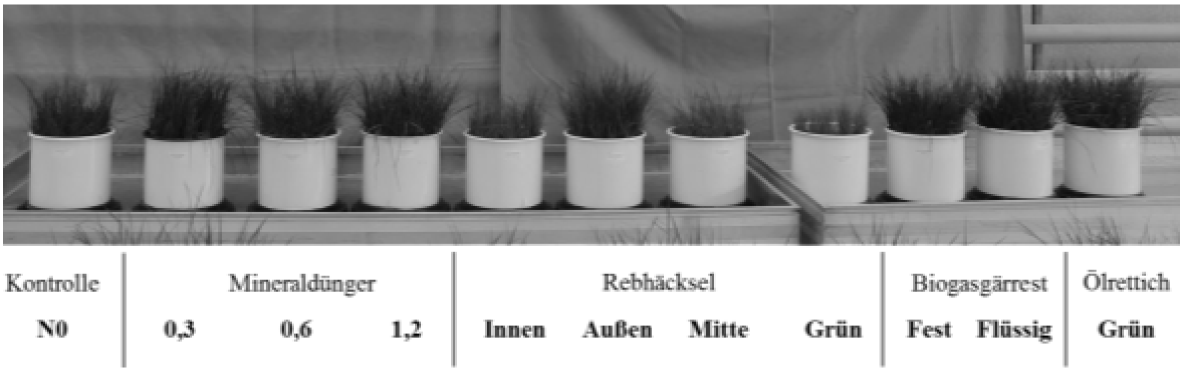

Fig. 5.13: Growth 5 weeks after sowing and before the first cut

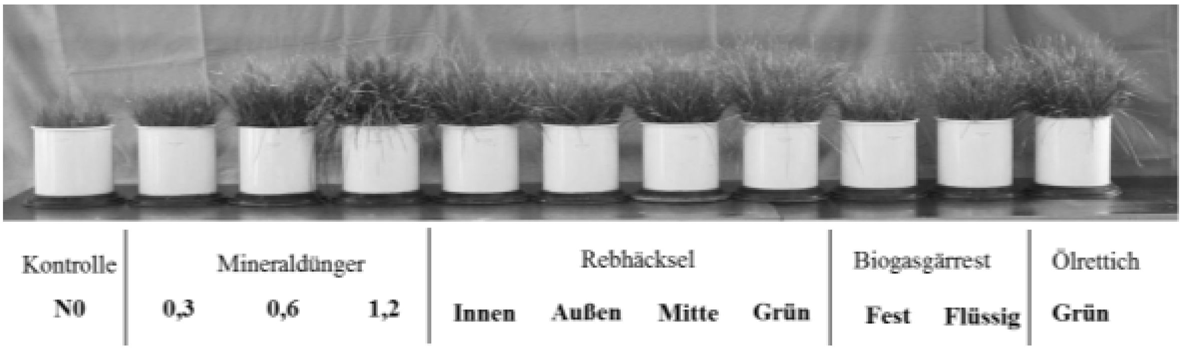

Fig. 5.14: Growth 15 weeks after sowing and before the third cut

The new growth in the planted variants was cut at 5, 10, 15, 24 and 31 weeks after sowing so that an assessment could be made of biomass development and nitrogen uptake. The following parameters were then determined:

- dry matter yield in g/pot
- N content in % of the dry matter
- N uptake in mg/pot
- net N uptake in mg/pot
- net N utilization in % of the amount of fertilizer

Pictures were taken of all variants and replications before each cutting date.

The soil in the pots not planted with ryegrass was tested for N_{min} content at slightly shorter intervals.

Results

Fertilizing effect: Pots planted with perennial ryegrass

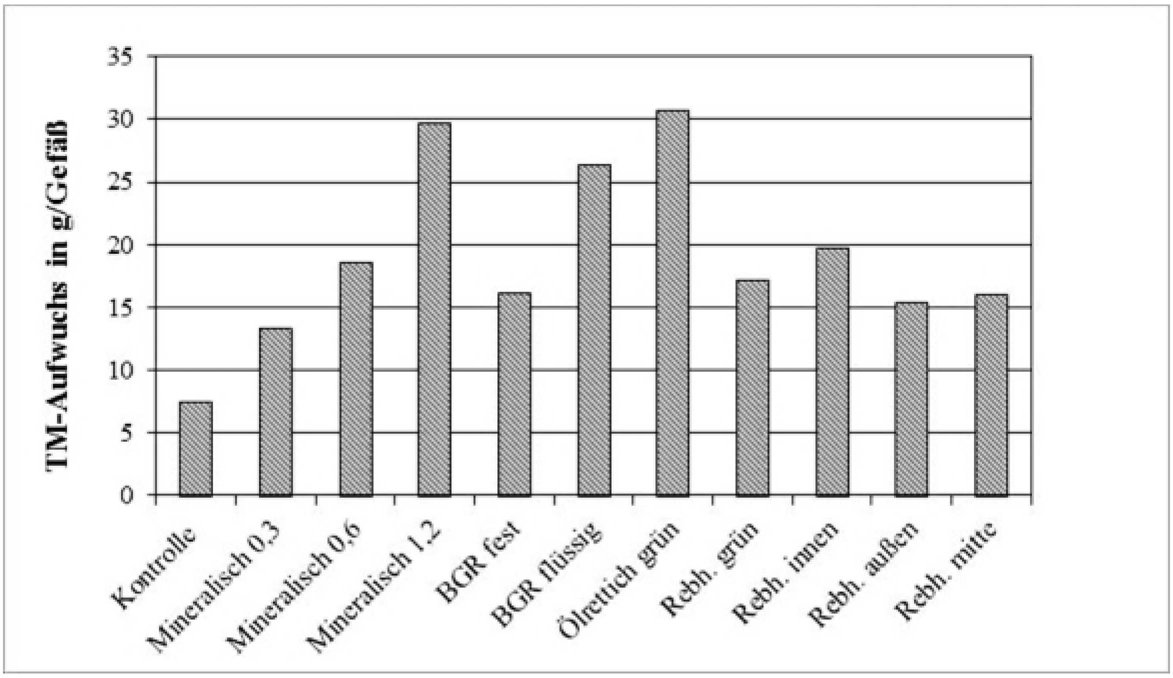

Fig. 5.15: Dry matter development in g/pot

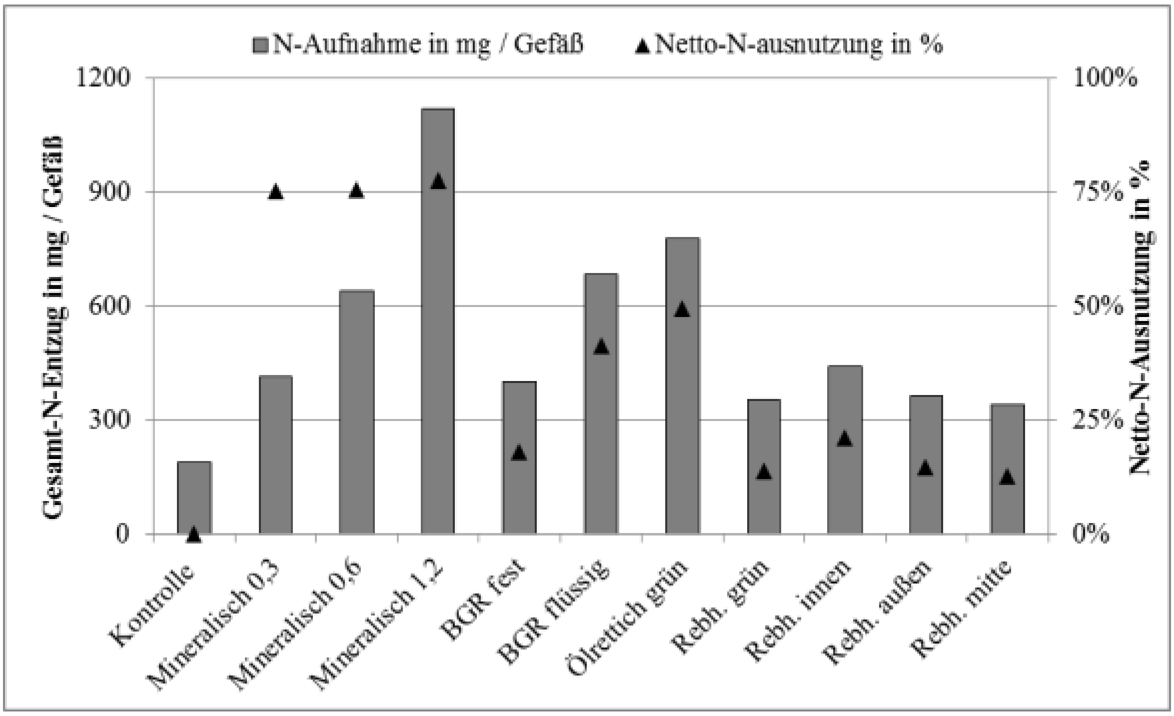

Fig. 5.16: Total N extraction in mg/pot and net N utilization in %

As Fig. 5.15 shows, the mineral fertilizer (1.2 g N), the oil radish, and the liquid biogas fermentation residues produce the highest dry matter yields with the greatest N uptake. Compared with the mineral fertilizer (1.2 g N), the variants with bine residues delivered only half as much dry matter yield and managed only about a third of the nitrogen uptake.(Fig. 5.16**Fehler! Verweisquelle konnte nicht gefunden werden.**).

This means that the best bine residue variant arrives at a net N utilization of 21%, as against 78% in the mineral fertilizer variant with the same amount of nitrogen in the pot. It can be concluded that the bine residues have only a slight effect as a nitrogen fertilizer in the first 31 weeks after application. Comparisons amongst the bine residue variants show that the conventionally heaped material from the inside layer of the clamp had the best fertilizing effect.

Nitrogen release: Pots without perennial ryegrass

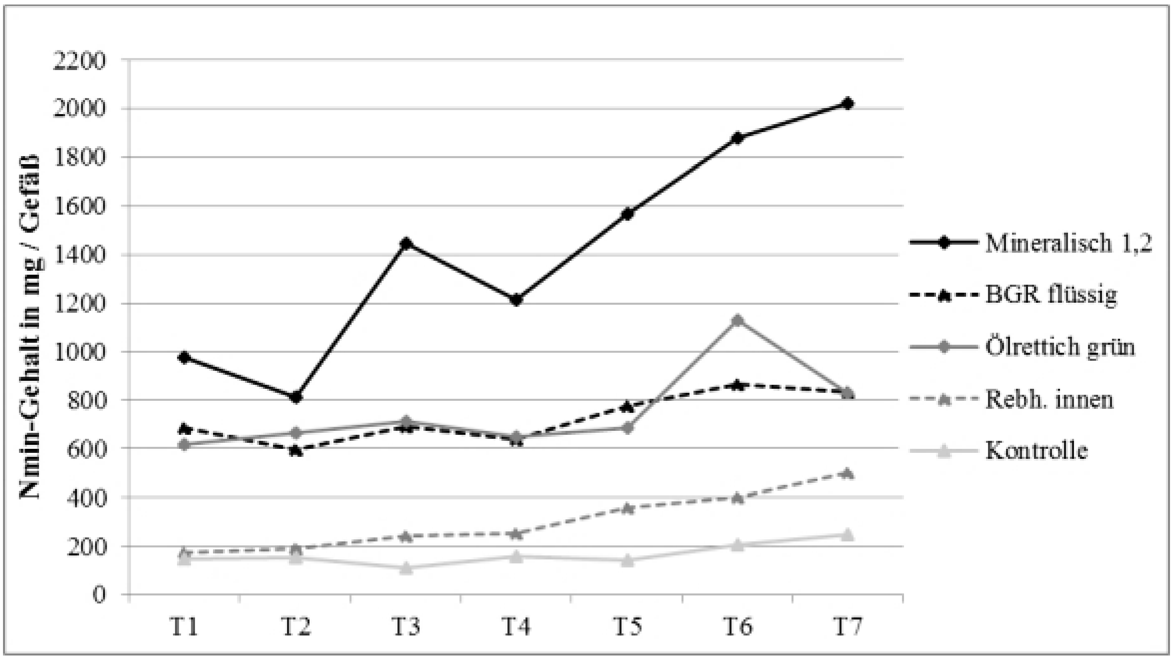

Fig. 5.17: Line graphs plotting N_{min} content of 5 variants

The variants with high nitrogen utilization had far higher N_{min} contents and a much greater release of nitrogen in the ground (Fig. 5.17). Both field crops and catch crops in hop require very little nitrogen fertilizer in the autumn. Mineralized nitrogen can hardly be utilized by the plant stock. Thus, organic fertilizers with fast N release are accompanied by an increased risk of nitrate leaching.

When bine residues were spread, only a very small portion of the nitrogen they contained was mineralized. The line graphs showing N extraction and development of N_{min} content make it clear that the mineralization behaviour and N fertilizing effect of hop bine residues cannot compare to that of biogas fermentation residues or rapidly transformable organic substrates (e.g. oil radish).

Outlook

The experiments took place in the greenhouse where growing conditions ─ regular watering and higher temperatures ─ were very different from the conditions normally prevailing in the autumn period, after bine residues are usually spread on the ground. Further outdoor field trials under real-world conditions to look into the transformation behaviour of the nitrogen contained in bine residues should now follow.

The findings with respect to the behaviour of bine residues in the soil in comparison with other organic or mineral fertilizers provide a good body of knowledge on which to base further field trials to be conducted over a number of years.

5.6 Methods of Assessing Plant N Status in Hop

Staff: J. Stampfl, A. Schlagenhaufer (thesis for Bachelor's degree)

Collaboration: Dr. S. von Tucher, Lehrstuhl für Pflanzenernährung, Wissenschaftszentrum Weihenstephan, TU München *(Chair for Plant Nutrition, Science Center Weihenstephan, Munich Technical University)*

Duration: May 2017 - September 2018

Objective

A needs-based fertilization management system, adjusted to suit developing weather conditions, is both beneficial for the environment and a boon in economical and ecological terms for the farmer. The use of too much nitrogen fertilizer not only causes yield losses, it is also responsible for a heightened susceptibility to disease in the hop plant. In view of the current issues in connection with *Verticillium* wilt disease in Central European hop-growing areas, which are aggravated by the application of too much nitrogen, it is imperative that N fertilization is tailored to specific plant needs. In order to ensure that the hop plant is best supplied, and consideration is given to environmental aspects, different models and measuring methods have so far been developed across the globe, which make is possible to adjust fertilization management during the growing season to suit weather constraints, crop development, and production techniques. The most important question is whether these methods can feasibly be translated into practices. As has been proven in the case of grain, the use of such tools to optimize fertilization management would be a sensible idea.

In the context of this thesis for a Bachelor's degree, SPAD readings were taken, the nitrate content of juice extracted from leaf stems, and the nitrogen content of leaf lamina were measured, to see whether these were suitable methods of assessing N status in hop. To this purpose, samples were taken from six test plots, which were part of a nitrogen enrichment trial with six different levels of fertilizer.

Methodology

Measuring was done on four trial plots located on commercially operated farms, made available by the Landesanstalt für Landwirtschaft *(Bavarian State Research Center for Agriculture*) for a broad-based project aimed at examining nutrient use efficiency and fertigation in hop. The plots are all centrally located in the Hallertau region between Wolnzach and Geisenfeld. The hop yards growing cultivars *Perle* and *Herkules* have soil not very different from the locally prevalent soil type.

The amount of chlorophyll present in the leaves was measured on site using a SPAD meter, Type SPAD 502 Plus Chlorophyll Meter. In addition, the nitrate content of each leaf stem was analysed by rapid reflectometric testing, following a nitrite reduction test and staining (Fig. 5.19). The nitrogen content (in % of the dry matter) of the lamina of the leaves was also determined via the Dumas combustion method, in order to provide a stable frame of reference.

On each sampling date, a mixed sample consisting of 15 leaves was collected from each plot, so that 15 leaves per plot were examined for chlorophyll content using the SPAD meter; then a sample was taken from the stem of each leaf to test for nitrate, followed by a sample from the lamina of each leaf to test for nitrogen content. The measurements were taken at intervals of 1-2 weeks in the period mid-June to shortly before harvest.

It was absolutely crucial that the right leaves should be chosen for the samples. Above all, leaf health and the position in the crop were the criteria. To make sure of an objective representation of the crop, only leaves from a height of 1.50 m to 2.00 m were sampled.

Exclusively leaves from hop plants with the usual two trained bines, and, at the same time, only leaves from one shoot of the 2 principal trained bines were selected, to ensure that the leaf samples were all the same age. The leaves chosen were, without exception, healthy and undamaged; this was to avoid erroneous SPAD meter readings caused by any other leaf discolorations not indicative of the amounts of nitrogen or chlorophyll present in the leaves. For the chlorophyll measurements, not only was the position of the leaf within the crop crucial, also the point on the leaf where the measurement was made was significant. The measuring point was selected in such a way that only the middle lobe of the five-lobed leaf was measured. This was done beside, rather than on, the leaf vein running down the centre of the lobe (Fig. 5.18), to avoid provoking incorrect measurements due to the lighter colour of the vein. The SPAD meter determines chlorophyll content from the light transmission behaviour of the leaves in the red and blue wavelength ranges.

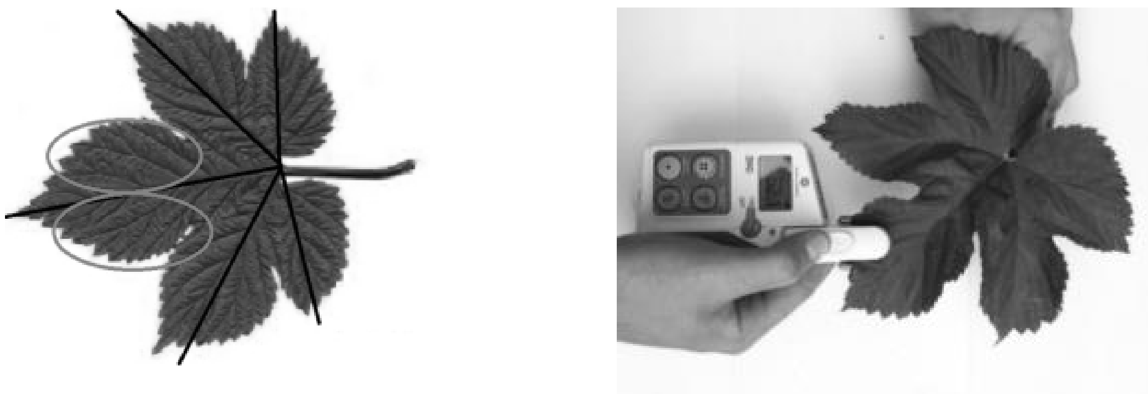

Fig. 5.18: Location on the leaf where the SPAD reading was taken

Fig. 5.19: Section of the leaf stem, determination of nitrate content

Findings

To evaluate the measuring results, first, line graphs were drawn, showing the three measuring methods and all sampling dates and variants, followed by an analysis to establish whether there were any statistically significant differences between the different fertilization variants on the individual dates. Then, a linear regression model was used to examine any correlation of the SPAD readings and nitrate content of the leaf-stem juice with the actually measured nitrogen contents of the lamina.

<u>Differences between the variants:</u>

Depending on location and natural nitrogen delivery, it was possible to discern some statistically significant differences. Statistically significant differences between the variants were not normally found in locations where the variants receiving smaller amounts of fertilizer did not lack nitrogen thanks to very high natural nitrogen delivery. In locations with low natural nitrogen delivery, the two rapid testing methods measured differences in the supply of nitrogen to the plants (Fig. 5.20 and Fig. 5.21). When the two methods are compared, the line graphs are seen to be very different. This is because the nitrogen taken up by the plant can be identified as nitrate in the extracted juice much sooner than through the SPAD readings. *Figures 5.20* and *5.21* show that the SPAD readings and the nitrate content in the extracted juice were always higher in the case of more heavily fertilized variants. Unfortunately, it was not always possible to find a significant difference between the variants, due to the fact that, at times, sampling could only be done in two replications.

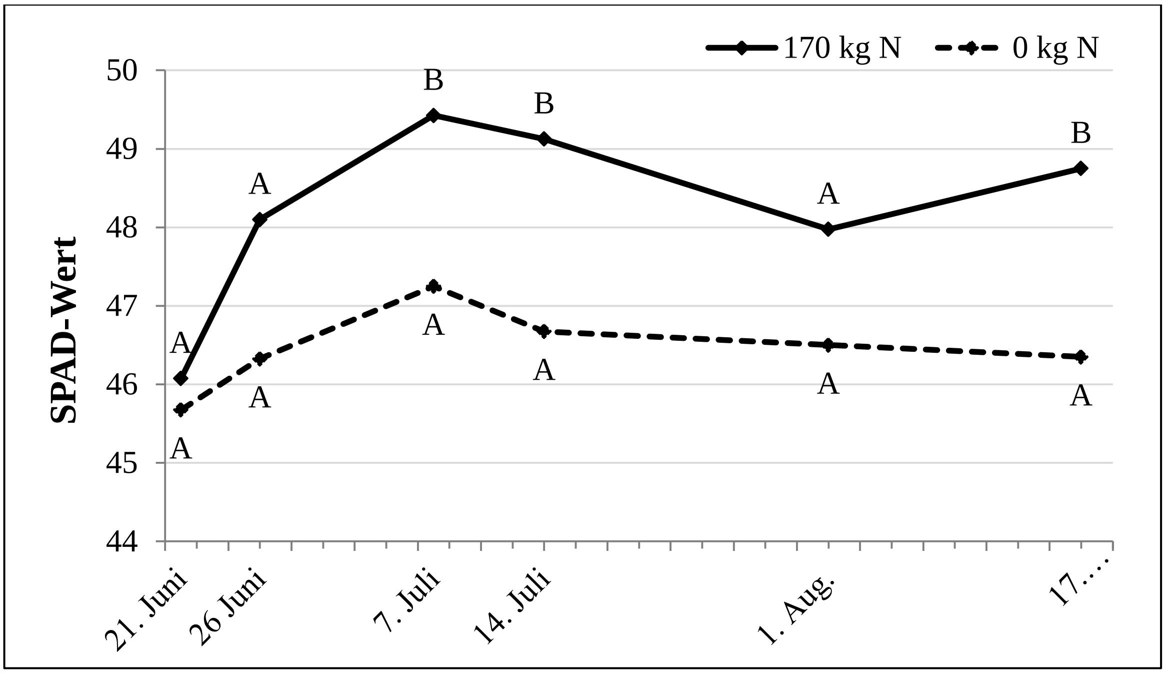

Fig. 5.20: SPAD value of hop leaves, shown as the year progressed, after different N fertilizer treatments. Cultivar: Perle. Different capital letters indicate statistically significant differences in the values within a single measuring date.

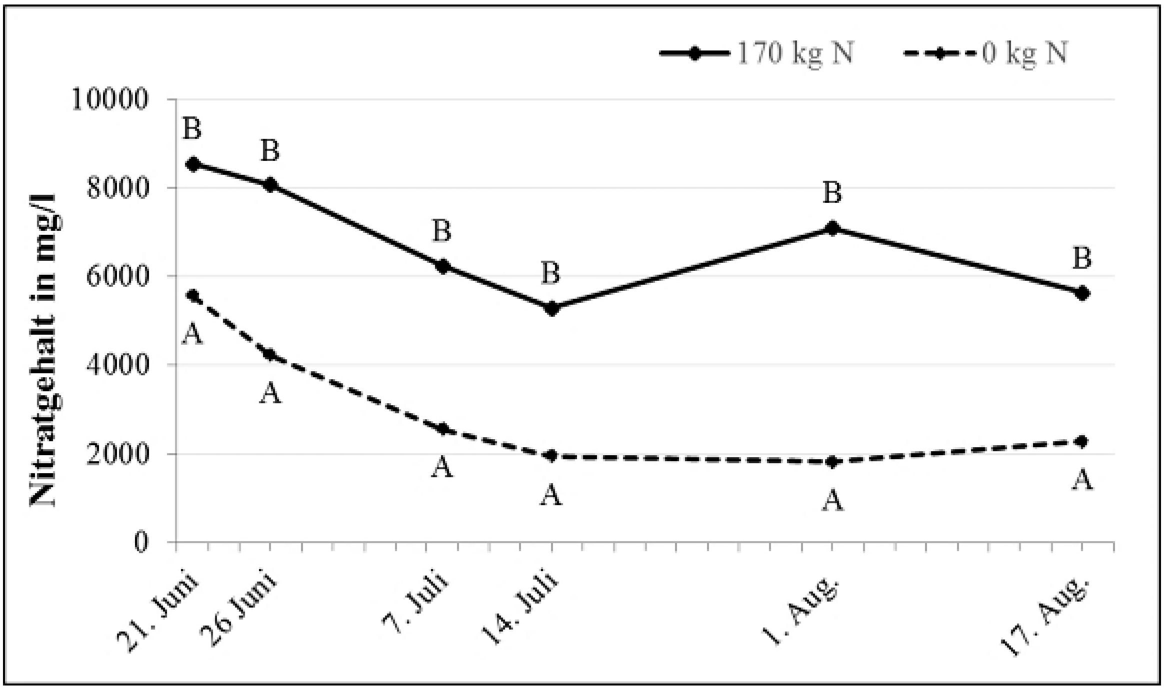

Fig. 5.21: Nitrate content in juice extracted from hop leaf stems, shown as the year progressed, after different N fertilizer treatments. Cultivar: Perle. Different capital letters indicate statistically significant differences in the values within a single measuring date

Fig. 5.22 shows total N content actually measured in the lamina. As in other crops, a definite dilution effect during the growing season is noticeable here, because the development of biomass during the summer months is much greater than the rate of nitrogen uptake.

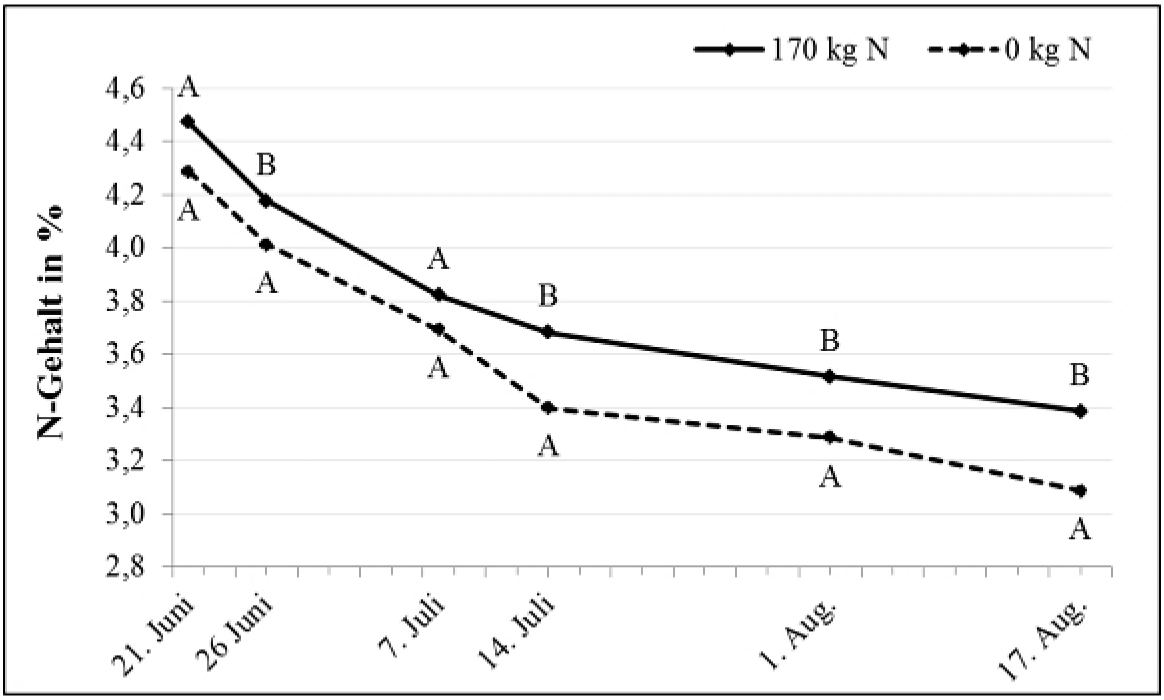

Fig. 5.22: N content of the lamina of hop leaves, shown as the year progressed, after different N fertilizer treatments. Different capital letters indicate statistically significant differences in the values within a single measuring date.

Correlation of the rapid testing methods with total N content of the leaf lamina:

For the purpose of verifying the accuracy of the two rapid tests, the relation of SPAD values and nitrate content to total N content levels was checked with the aid of a linear regression model.

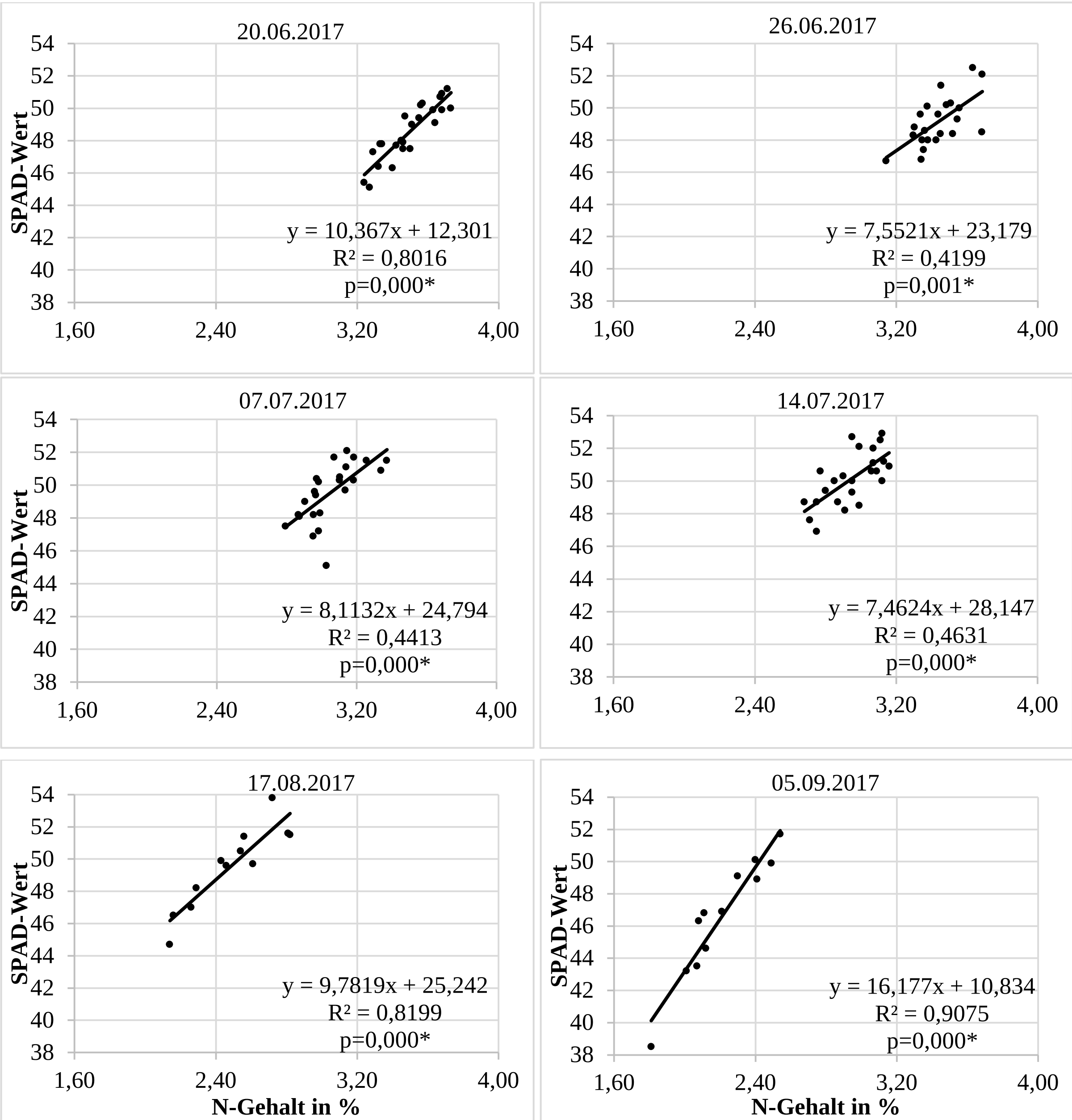

Fig. 5.23: Relationship between total N content and the SPAD value of lamina of hop leaves, Cultivar: Herkules, 6 dates

A close relation between SPAD value and N content of the lamina was found, as shown in Fig. 5.23. The coefficients of determination of up to $R^2 = 0.91$ meant that the correlation between SPAD and N content was statistically significant. This is in contrast to the relationship between nitrate content of the extracted juice and N content, where no significant correlations were found.

Conclusion

SPAD:

The great advantage of the SPAD meter is that it is simple to use and it can collect data in a quick and cheap way that is also easy on the crop. But because of the heterogeneous nature of the individual hop plants within the crop and the fact that choosing the leaf samples is not a precision activity, sampling must be viewed more critically here than in the case of grain crops, where the crop is more homogeneous. Other factors such as hop variety, weather conditions or growth development also play a role. Nevertheless, it was possible to obtain good results from the different fertilization variants, using different varieties and locations. In nearly all tests, the variants without fertilizer produced the lowest SPAD values, while the variants with the nitrogen rates recommended by the DSN produced the highest values, although there were significant differences on farms 1 and 2 on the individual dates. Not only the number of nitrogen applications but also the differences attributed to the timing of application could be identified with the SPAD values. Generally speaking, differences from one cultivar to another were also noted. In both tests, cultivar *Herkules* produced much higher SPAD values than cultivar *Perle*. Thus it can be said that there is not one single optimal value for hop; there is only an optimal range of SPAD values for each cultivar at each stage in its development, within which supply to the hop is ideal.

Nitrate in the leaf-stem juice:

Measuring the nitrate content of leaf stems is described as a rapid testing method, yet it turns out to be rather more time-consuming and more problematical than the SPAD test. The work requires the completion of many individual steps before the actual values are determined, with the result that there is plenty of room for error. Choosing the right leaf and coping with the measuring imprecision of the pipettes and the reflectometer proved to be far more difficult to repeat accurately than determining SPAD value or N content. Furthermore, in comparison with the SPAD test, it was not possible to establish any significant relation to the leaf N content levels, so that it is difficult to draw any reliable conclusion about N status in the hop.

Outlook

For the future, it can be said in the wake of these experiments that SPAD meter measuring in hop appears to be more appropriate than measuring nitrate content in leaf-stem juice. This study lays the groundwork for collecting further data in the future, potentially for a calibration of the SPAD meter for different hop varieties and their different stages of development.

5.7 LfL Projects as Part of the Production and Quality Campaign

As part of an agricultural production and quality drive in Bavaria during the period 2014 to 2018, the Bayerische Landesanstalt für Landwirtschaft (*Bavarian State Research Center for Agriculture*) once more arranged for representative data on yields and quality of selected agricultural crops to be collected, recorded and analysed. 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 resumé of the results for 2018.

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

Dry matter and alpha acids monitoring

In the period 07.08. - 25.09.2018 –spaced out across the Hallertau region – a trained bine each from 4 aroma varieties and 2 bittering varieties, taken each time from 10 different commercially run hop yards, was harvested at weekly intervals and then dried separately. This was done on 5 (for aroma varieties) and 7 (for bittering varieties) different dates. By determining the extent of moisture loss, and analysing the dry matter content and alpha acids levels in an accredited laboratory, it was possible, the following day, to establish the dry matter content of the green hop and the alpha acids concentration at 10% moisture 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. Farmers were thus able to refer to the data when they needed information as to the optimum harvest maturity of the most important hop varieties.

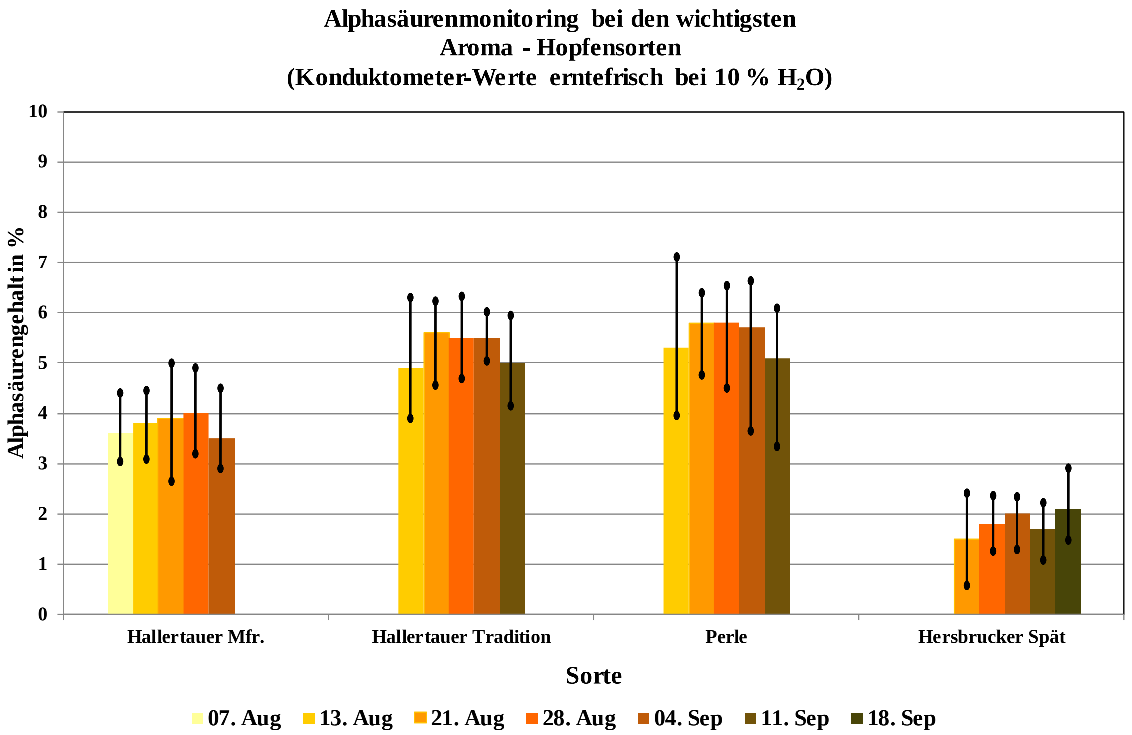

Fig. 5.24: Alpha acids monitoring in the major aroma varieties in 2018

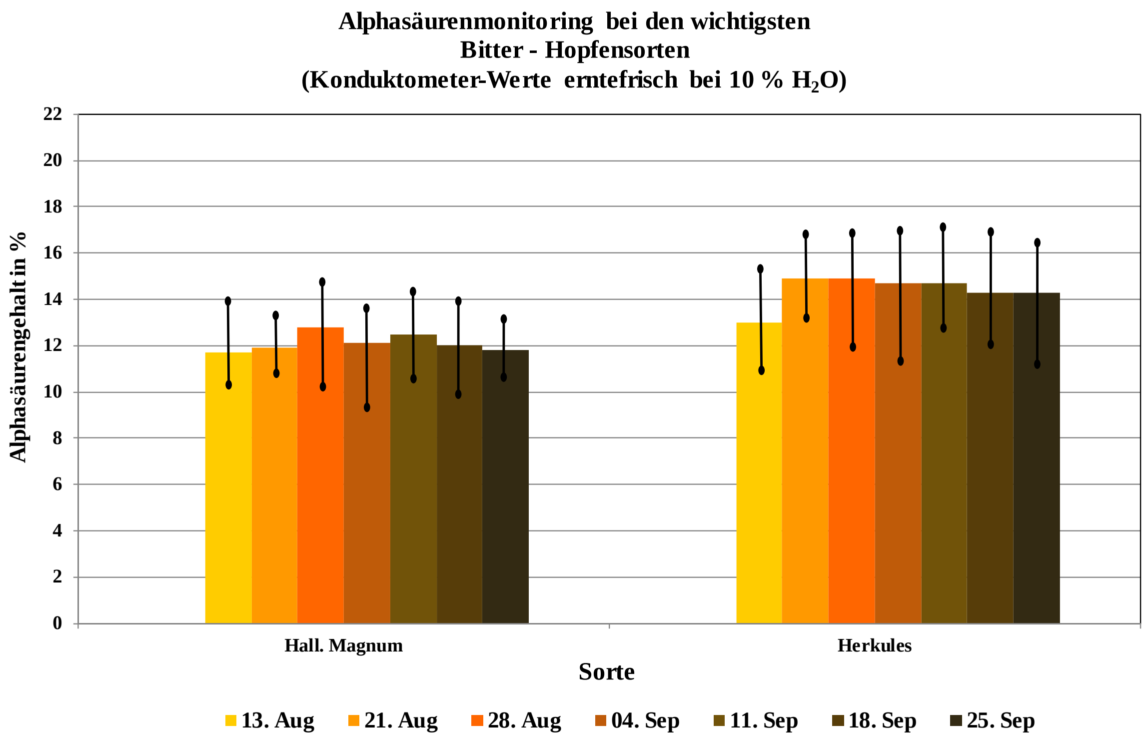

Fig. 5.25: Alpha acids monitoring in the high alpha varieties in 2018

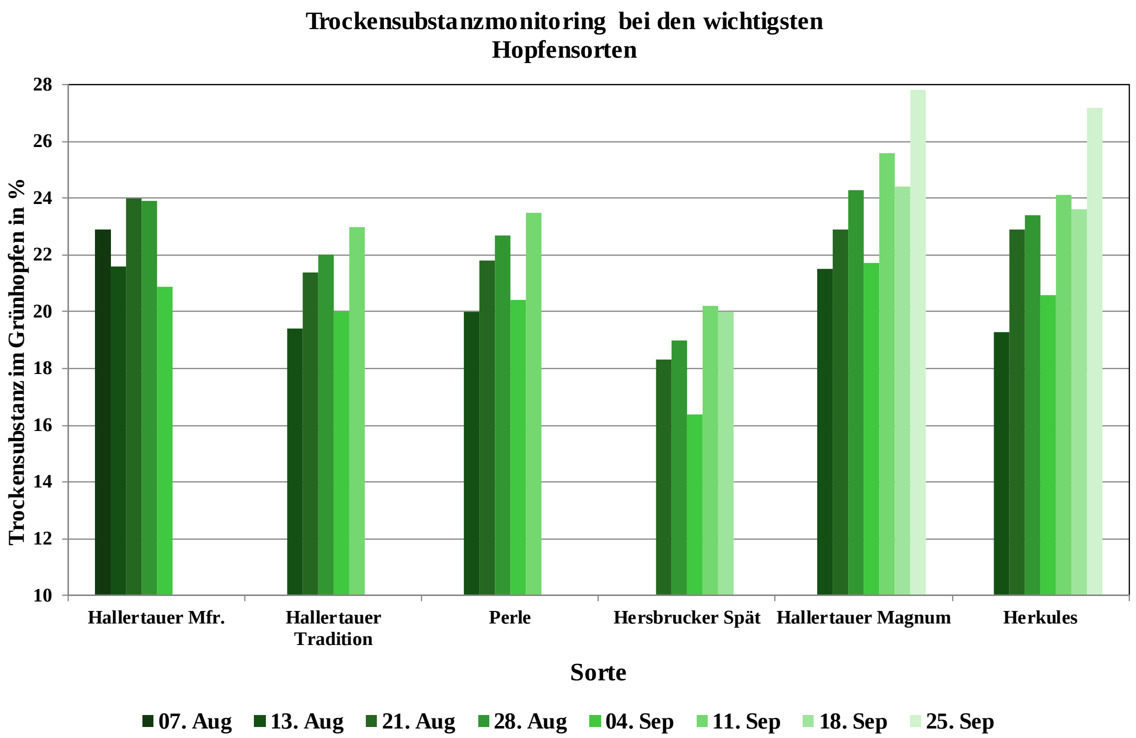

Fig. 5.26: Dry matter monitoring in the major hop varieties in 2018

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 provide valuable information about hop quality for the different crop years, as well as on diseases and pest infestation, technical production failings, or inappropriate treatment of the harvested hops.

While the project continues, the NQF data from 150 batches each of cultivars HT, PE, HM, and HS are to be expanded to include the corresponding alpha acids contents 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, since only 30 of the anticipated 600 data sets were submitted in 2018, this meant that stratification and an evaluation were once again not possible.

5.7.2 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 22 May to 23 July 2018, assessments were carried out on 10 different dates, at intervals of one week, in 30 representative hop yards (different varieties) in the regions Hallertau (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 aphids (count) and spider mites (infestation index).

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

5.7.3 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 *(Hop Analytics Working Group)*, 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 analyses are organized, conducted and evaluated by the Bayerische Landesanstalt für Landwirtschaft *(Bavarian State Research Center for Agriculture)* in its capacity as a neutral body.

The role of the Hopfenring (*Hop Growers' Syndicate*) within the project is to take samples from a total of 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.

5.8 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 Farming/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 is also part of their remit, as is collaborating with the various hops 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 below:

5.8.1 Written information

- The *Green Pamphlet* Hop 2018: *Hop growing, varieties, fertilization, 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 2 350 copies were distributed by the LfL to ÄELF and research facilities, and by Hopfenring Hallertau to hop growers.
- Current information on hop growing and the warning service alerts were sent out by the LfL to hop growers in 27 faxes via the Hopfenring multiple recipient fax (2018: 53 faxes in the Hallertau + 1 addition fax for Spalt with 1 010 subscribers).
- Advisory service information and specialist articles for hop growers were published in 2 ER Hopfenring circulars and also in 7 monthly issues of the Hopfen Rundschau.
- 2 scientific publications in *Brauwelt* and *Journal für Kulturpflanzen.*
- Press release referring to a hops presentation at the regional horticultural show in Würzburg from 17 to 19 August 2018

5.8.2 Internet and intranet

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

5.8.3 Telephone advisory and information services

The downy mildew warning service was set up for the period 08.05. - 03.09.2018 by Arbeitsgruppe Hopfenbau, Produktionstechnik (*WG Hop Farming/Production Techniques)* in Wolnzach in collaboration with Arbeitsgruppe Pflanzenschutz *(WG Plant Protection)* at Hüll and updated 81 times, for access on request either via answerphone (Tel. 08442/9257-60 and -61) or via the internet.

- The specialists from *WG Hop Farming/Production Techniques* supplied answers over the phone to highly specialized questions regarding hop production techniques in approximately 1 500 cases, or delivered advice in individual consultations, or on site.

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

- Weekly exchange of information during the growing season with Hopfenring specialist advisors
- 9 Hop production meetings in conjunction with the ÄELF
- 48 Specialist lectures
- 1 Field day event on the subject of *Leaf Stripping*
- 3 Guided tours of trial sites for hop growers and the hops industry
- 7 Conferences, trade events or seminars

5.8.5 Basic and continuing training courses

- Setting assignments for and examining 4 work projects as part of a Master's Certificate examination (vocational)
- 15 Instruction sessions at the Landwirtschaftschule *(agricultural college)* Pfaffenhofen for students studying hop production
- 1-Day course in the summer term at Pfaffenhofen agricultural college
- 1 Informational event for vocational school students from Pfaffenhofen
- 4 Meetings of the study group *Hop Management*

6 Plant Protection Management in Hop

Simon Euringer, M.Sc. Agrarmanagement

6.1 Pests and Diseases

6.1.1 Wireworm, lovage weevil and hop flea beetle

Thanks to the rapid growth of the hops and the fast development of the juveniles, in the growing season 2018 there were few issues with wireworm, lovage weevil and hop flea beetle. Now that the outdoor use of the neonicotinoid Thiametoxam has been banned, deployment of Actara in hop farming will no longer be possible. Its use was still permitted in the 2018 growing season.

6.1.2 The two-spotted spider mite

Tab. 6.1: Monitoring of infestation by the two-spotted spider mite in 30 locations in the Bavarian hop-growing areas

Date	Eggs Ø	Spiders Ø	Spider mite index per leaf		
			Ø	min.	max.
22 May	0.54	0.37	0.08	0.00	0.65
28 May	1.43	0.88	0.16	0.00	1.25
4 June	2.44	3.24	0.27	0.00	2.60
11 June	0.93	1.94	0.25	0.00	1.90
18 June	2.15	2.33	0.33	0.00	1.35
25 June	2.41	2.60	0.31	0.00	1.20
2 July	0.76	2.44	0.35	0.00	1.25
9 July	0.73	2.16	0.27	0.00	1.30
16 July	0.51	1.39	0.19	0.00	1.80
23 July	1.71	4.22	0.22	0.00	3.05
		Main treatment period 25.06 - 09.07 4 locations treated twice			

In 2018, infestation by the two-spotted spider mite came early and was heavy at all sites. It was possible to keep infestation successfully in check in most of the monitored hop yards, with a selective spraying operation at the end of June. However, the hot and dry summer weather continued into September, and it was not possible to manage the spider mite sufficiently well in badly affected yards, in spite of a number of control treatments. On 25 July, the plant protection product Ordoval was given official approval, so that it was possible to treat medium- and late-maturing varieties. The waiting time with Ordoval is 28 days.

6.1.3 Aphids

Aphid migration at the Hüll site commenced already at the beginning of May *(**Fehler! Verweisquelle konnte nicht gefunden werden.**)*. The warm, dry spring brought favourable conditions for the hop aphid, and infestation was early and heavy. In contrast to previous years, the side effects of Actara were no longer adequate for targeted aphid treatment, so that one or two applications of insecticide were necessary. In the 2018 season, the use of Confidor WG 70 and Warrant 700 WG was still permissible.

Now that the use in the open of the neonicotinoid agent Imidacloprid has been banned, it will no longer be possible to use these products in hop production, effective as of 2019.

According to the approval certificate, a maximum of 2 applications of Flonicamid (Teppeki) per hectare per year are allowed. In view of the issues surrounding residue, the LfL and the Deutsche Hopfenwirtschaftsverband e.V. *(German Hop Trade Association)* recommend that growers only proceed with a single application at most, as there is a risk of exceeding the maximum EU residue limits (MRL). Experience has shown that residue problems arise regularly in connection with Flonicamid, even after just a single application.

Availability of Pymetrozine in hop farming was already strictly limited in 2018. Since its production has now been discontinued, sales have been from remaining stocks only.

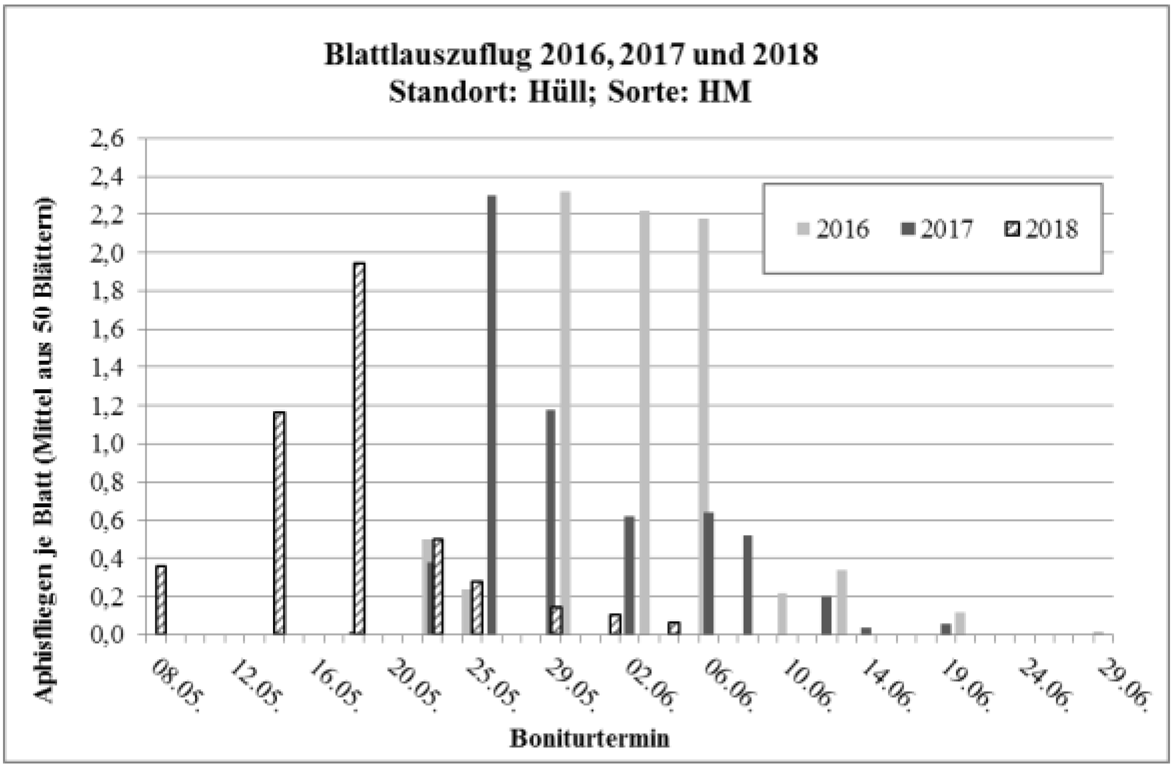

Fig. 6.1: Aphid migration in 2018 at the Hüll site

Tab. 6.2: Monitoring of aphid migration and infestation in 30 locations in the Bavarian hop-growing areas

Date	Aphid migration Ø	Aphids per leaf		
		Ø	min.	max.
22 May	0.24	3.32	0.00	21.96
28 May	0.39	6.00	0.12	64.76
4 June	0.02	11.51	0.06	113.84
11 June	0.00	11.63	0.00	309.00
18 June	0.02	41.12	0.00	809.04
25 June	-	0.83	0.00	4.64
2 July	-	0.56	0.00	3.20
9 July	-	0.12	0.00	0.90
16 July	-	0.12	0.00	1.60
23 July	-	0.14	0.00	1.18
		Main treatment period 25.06 - 09.07 2 locations treated twice		

If the situation continues, it is anticipated that Flonicamid will soon lose its biological effectiveness, due to its frequent use in a large part of the hop-growing area. First indications that this will happen have come from results of spray tower tests conducted in the laboratory to test sensitivity of aphids to active substances.

We must expressly draw attention to the fact that, in the event of an unexpectedly high concentration of hop aphids in the next few years, things could become very difficult with respect to control strategies that are effective and actually implementable.

6.1.4 Downy mildew

Reports of primary infection with downy mildew from growers were only very few. Numbers of zoosporangia caught in the spore traps were also relatively low over the whole season, and, as a result, only 4 spray alerts were necessary in the Hallertau to deal with secondary downy mildew infection.

Tab. 6.3: Downy mildew warning service in 2018

Fax No.	Date	Alert for primary downy mildew infection	Spray alerts		
			susceptible varieties	all varieties	late-maturing varieties
17	04.06.			X	
37	02.07.			X	
48	17.07.		X		
56	27.07.			X	
No. of spray alerts		0	1	3	0

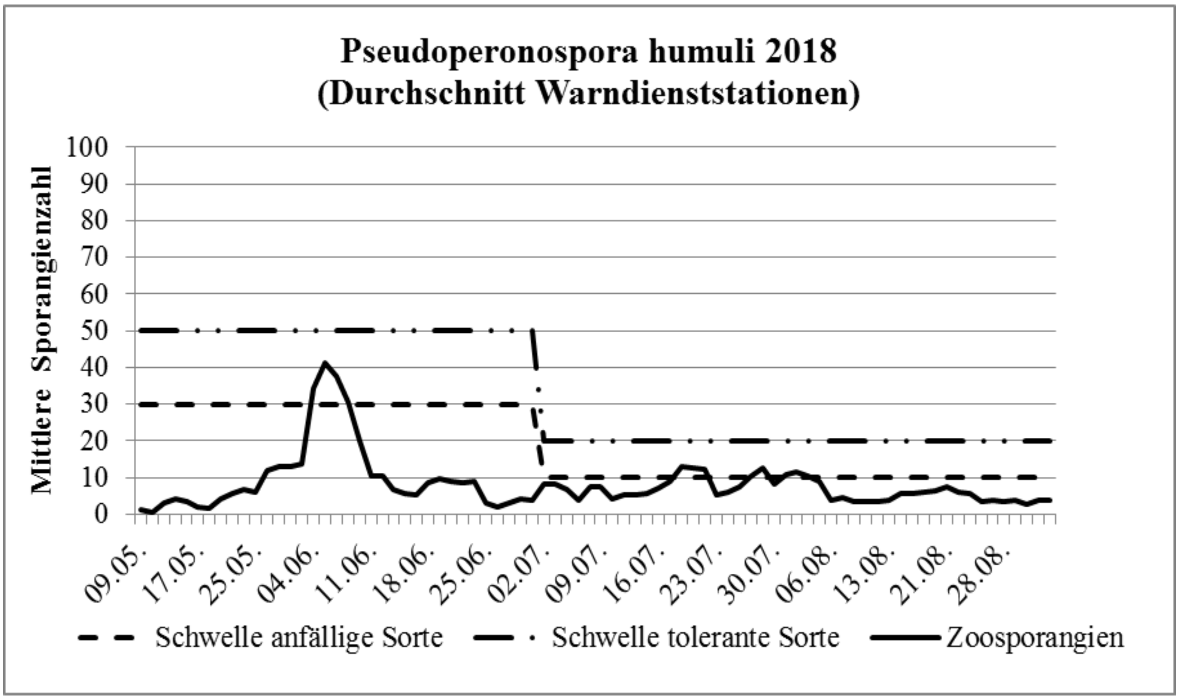

Fig. 6.2: Downy mildew warning service in 2018 - average zoosporangia migration at 5 locations in the Hallertau

6.1.5 Powdery mildew

Powdery mildew caused serious problems in the 2018 growing season, with the first case of infection in commercial production being reported as early as mid-May. Although numerous steps were taken to control the outbreak, the problem grew worse in many hop yards, particularly in dense stands of *Herkules*, or in those hops already suffering from drought stress, and things became so bad towards the end of the season that heavy losses in crop yield and reductions in quality resulted.

6.1.6 *Verticillium* wilt disease

There was also an increase in the occurrence of *Verticillium* wilt disease in 2018. As a result of wave of infections in June, entire trained bines died back in July, a sad sight in many hop yards, identifiable even from a distance.

6.2 GfH *Verticillium* Research Project

6.2.1 Research into and work on the problem of *Verticillium* on hop

Managing *Verticillium* wilt disease in German hop-growing areas is a long-term undertaking. The research conducted and guidance provided by the LfL play a crucial role in aiding hop growers in their struggle to control *Verticillium*.

Sanitation of soils contaminated with *Verticillium* and selection of breeding material tolerant to *Verticillium*

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Objective

Since the first outbreak in the Hallertau of lethal strains of *Verticillium nonalfalfae*, the pathogen causing the virulent form of hop wilt disease, the infected area has been seen to be expanding steadily. The pathogen is a soil-borne fungus with a broad host range, which can survive underground as a resting structure (sclerotium) for 4 to 5 years. There is no direct means of controlling it. An integrated approach is needed to manage the infection, and this involves the implementation of hygiene procedures, breeding efforts, appropriate cultural practices, and sanitation strategies. It is important to ensure that the knowledge already gleaned is soon translated into support for the hop growers as they implement management measures in the affected areas; it is also essential to see that efficient sanitation is carried out as quickly as possible.

Method

In surveys at commercially operated hop farms both with and without wilt problems in the Hallertau, data are to be collected which can inform viable and effective cultural measures to prevent and reduce this fungal infection. To support the work focused on breeding resistant varieties, the well-established field selection system for wilt tolerance screening of breeding lines is to be supervised, evaluated, and further developed. The necessary sanitation work to be carried out on contaminated land is to receive scientific supervision, in parallel with the development of new strategies for optimizing soil sanitation. In addition, existing techniques for diagnosing and analysing *Verticillium* are to be optimized and refined.

There is to be a review of a method of testing the soil which uses plants highly susceptible to wilt as indicators of whether sanitation measures are having the desired effect, to ascertain whether this is a useful approach.

Collaboration with commercially operated farms

For the wilt-affected areas, strategies were devised in collaboration with hop farmers to stop *Verticillium* spreading and, as far as possible, to reduce *Verticillium* infestation pressure. The infestation in these areas was defined as the first stage of infestation, on the basis of assessments of individual plants, and the hop yards characterized according to the ground conditions and a soil appraisal. The level of success of these control strategies will be judged in the coming crop years by how far the infection has spread and how the symptoms are expressed. In 2017, parallel to the assessment of symptoms, 500 hop samples, from the breeding yard at Hüll, the selection yards in Niederlauterbach and Engelbrechtsmünster, and from 22 commercial plots, were analysed for *Verticillium* using Real-time PCR (see 4.5). In 220 of these cases, an additional specific PCR was also performed.

The results verified the assessments from the individual plots and helped determine *Verticillium* proliferation and the virulent nature of the individual *Verticillium* species. In 20 of the 22 commercial plot cases, a combination of both mild and lethal strains was verified. The high proportion of virulent *Verticillium* strains is not representative of the Hallertau, but is due to the fact that these areas were specially chosen for wilt trials.

Sanitation of soils infected with *Verticillium*

The *Verticillium* research project envisages trialling and refining viable methods of sanitizing hop yards contaminated with *Verticillium.*

Objectives of the project

- to evaluate different methods of sanitation
- to adapt the methods to suit hop farming

Procedure

- using symptoms to establish the degree of infection
- digging up the infected crop
- implementation of sanitation options:
    - pulling the land out of production (fallow)
    - arable farming (crop rotation with a high proportion of grasses)
    - growing non-host plants (grasses)
    - biological soil decontamination: (incorporating biomass/exclusion of air by covering the ground)
- zero control:
    - continuing to grow the infected crop as a zero control until the sanitation operation has been completed on the affected land
    - digging up the infected crop
- growing a tolerant variety
- assessment horizon: at least 2 years

Fig. 6.3: Hop yard with extensive wilt damage

6.2.2 Aubergine (*Solanum melongena*) as an indicator plant for *Verticillium*

S. Euringer, K. Kaindl, K. Lutz in collaboration with IPZ 5c

Verticillium nonalfalfae is the fungal pathogen that causes hop wilt disease. It can survive for up to five years in the ground, thus constituting a constant source of infection for the hop plants. *Verticillium*-contaminated soils must first be identified before remedial sanitation measures can be set in train. Currently, there are no direct chemical control measures available, and the search is on for a fast and practicable method of evaluating the efficacy of measures to control *Verticillium* wilt disease; but this is something that does not yet exist. A PCR-based method of quantitation in the soil does not tell the hop grower what he needs to know: whether his hop yard is infected with or free of *Verticillium.* It is difficult to infect the hop plant itself, and so there is often a time lag before the wilt symptoms begin to show. For this reason, hops are not an option for testing soil in pots. The aubergine could serve as a potential indicator plant.

Procedure

In the growing months of 2017, hop plants with severe visible symptoms of wilt were identified by means of qPCR as being infected with *Verticillium nonalfalfae*.

After the plants had been dug up in spring 2018, the infected rootstocks were removed together with soil from the spot where they had been planted. The soil was put several times through a sieve, and any stones were removed, to make it more homogeneous. The dug-up rootstocks were cut into pieces approximately 3-5 cm in size, and then mixed in gradually with the infection material, using a sieving and mixing machine.

Fig. 6.4: Homogenizing the infection material

As potential indicator plants, three aubergine varieties were tested for their susceptibility to *Verticillium nonalfalfae*:

- Black Beauty (hybrid variety)
- Rosa Bianca (landrace)
- Violetta di Firenze (landrace)

Fig. 6.5: Aubergine growing in potting soil

Fig. 6.6: Aubergine showing Verticillium symptoms (day 74)

The hybrid variety Black Beauty already began sprouting 7 days after sowing. Germination in the landraces was far more heterogeneous, on average 14 days after sowing.The aubergines were potted on, and thus planted in the infection material, on day 17 (Black Beauty) and day 33 (landraces).

The first obvious symptoms were identified on day 74. The success in infecting the plants with *Verticillium* was verified by qPCR.

Fig. 6.7: Aubergine showing Verticillium symptoms (day 100)

The final assessment of all varieties was carried out on day 100. The following symptoms served as indicators for the assessment: plant height, BBCH stage, vigour, lower tier of leaves, yellowing, necrosis, drought stress.

Fig. 6.8: Final assessment of the aubergines (day 100); the control on the left, an infected plant on the right

Results

The experiment confirmed that the aubergine is suitable as an indicator plant for *Verticillium nonalfalfae*. The hybrid variety Black Beauty remained extremely vigorous and uniform throughout. The landraces had to be selected during potting on, to ensure that conditions were as uniform as possible from the date of infection. The expression of symptoms was successful in 50% of the plants potted in infected soil. Proof that the visual symptoms could be attributed to *Verticillium* wilt was provided by the qPCR test. The naturally infected soil and the non-infected soil (control) could not be taken from the same hop yard and, consequently, differences in nutrient supply were unavoidable. Plants that were better developed suffered greater nutrient and drought stress. Apart from the classic *Verticillium* symptoms (yellowing, necrosis, leaves rolling in on themselves) the most obvious symptoms were reduced height in combination with the BBCH stage. Diagramming of the assessment data showed how suitable the varieties were as indicator plants for *Verticillium nonalfalfae.* Violetta di Firenze indicated most clearly that the soil was infected.

Outlook

In order to test the effectiveness of different treatments to mitigate the disease, a pot system for the greenhouse, independent of the growing season, is to be developed. Aubergine ─ to be more precise, the variety Violetta di Firenze ─ is suitable as an indicator plant.

6.2.3 Remote sensing in hop for an objective assessment of *Verticillium* damage in hop yards

S. Euringer and T. Sixt in collaboration with IPZ 5c

Before any judgements can be made regarding the effectiveness of measures to combat *Verticillium* wilt disease, an objective evaluation over a longer period is necessary. In addition to the highly time-consuming assessment of individual plants, one option is to make use of remote sensing. Drones can be deployed to monitor selected individual plots throughout the growing season, or over a period of several years. In order to be able to assess how far *Verticillium* is spreading across the Hallertau, it would be necessary to carry out an exhaustive and costly survey from the air. The BayernAtlasPlus, an online application set up by the Bayerische Vermessungsverwaltung *(Bavarian Agency for Surveying and Geoinformation)*, makes available maps that cover almost the whole of the Hallertau region, status quo August 2016. The date is particularly apt, because the damage done by *Verticillium* is most easily recognizable shortly before harvest. As a soil-borne fungus, *Verticillium nonalfalfae* remains stationary in its soil location and, in its dormant form, can survive there for up to 5 years. Thus, these maps can give some idea of the spread of *Verticillium* across the Hallertau.

Verification of abnormal hop yards through aerial survey flight data

Irregularities in hop yards can occur for a host of different reasons. Therefore, aerial survey flight data need to be checked if they are to be used as a basis for estimating the extent to which *Verticillium* is spreading through the Hallertau. To this end, 20 hop yards showing conspicuous damage in the BayernAtlasPlus online app were identified at random; the growers were then contacted. After individual plant assessments, photographs were taken by drones and subsequently compared with the online maps. In 20 cases out of 20, a virulent strain of *Verticillium* was detected by qPCR. Since it is easy to localize advanced infections with *Verticillium* on aerial photographs, it is not surprising that the proportion of virulent forms of *Verticillium* is high. However, this result does not paint a representative picture. Care was taken to ensure that, for evaluation of the aerial pictures, the hop yards under scrutiny were spread out across the whole hop-growing area. The next aerial survey carried out by the *Bavarian Agency for Surveying and Geoinformation* took place in July 2018, but the data are not yet available.

Outlook

The data gathered allow a first estimate of the extent of spread of *Verticillium* across the Hallertau. However, before a reliable appraisal is possible, more data will have to be collected. It remains to be seen whether the 2018 aerial survey can deliver results that are equally useful for *Verticillium* research.

7 Ecological Issues in Hop Cultivation

Dr. Florian Weihrauch, Dipl.-Biol.

The job of the Working Group is basically to collate the knowledge gathered so far and to carry out applied research into the ecological and environmentally compatible production of hops. This includes diagnosing, observing and monitoring the infestation of hops by pests and their biological antagonists, in the context of progressive climate change and the consequent impact on biocenoses. At the same time, the work involves the development and evaluation of biological and other environmentally sound means of plant protection. The Working Group relies primarily on attracting the funding for its research into ecological issues in hop cultivation.

7.1 Developing Methods of Controlling the Hop Flea Beetle, *Psylliodes attenuatus*, in Organic Hop Farming: Completion of the Project

The StMELF-funded research project *Developing Methods of Controlling the Hop Flea Beetle Psylliodes attenuatus in Ecological Hop Cultivation* was scheduled to run from March 1, 2015 to June 30, 2018. The object was to develop an effective means of controlling the hop flea beetle for organic hop production that was practicable on the ground. At the same time, the idea was to collate as much of the basic knowledge about the pest as possible, in view of the fact that the most recent detailed studies concerned with the biology of this species are over a century old (Heikertinger 1913; Tölg 1913). An attempt was to be made to identify an attractant specific to the species, e.g. a kairomone or, ideally, a potent pheromone, as the basis for a potentially definitive method of control. A search through the databases Pherobase and PheroNet beforehand revealed that no semiochemicals of that kind are at present known for *P. attentuatus*. In view of the fact that effective attractants for flea beetles of the species *Phyllotreta*, which infest mainly Asteraceae, have recently been identified (e.g. Beran et al. 2011), the prospect of achieving success in the case of *P. attenuatus* seemed good.

The thinking was that suitably effective semiochemicals could be identified and then used as an attractant in glue traps to lure and catch *P. attenuatus*. With a control method of this kind, it would be possible to manage the pest in an eco-friendly way, without recourse to pesticides. Such an approach would mean that implementation of the method would not be limited solely to ecological hop production. Consequently, the declared primary objective of the project was to be the search for attractants specific to *P. attenuatus*, and this goal was then pursued in collaboration with our colleagues from the Netherlands.

At the same time, various mechanical techniques were to be tested as further methods of control. These included the use of bait or trap plants (young nettles available in springtime), and mechanical trapping with a specially designed, glue-lined 'flea beetle trap'. There was also the idea of controlling the species during its larval phase in the ground (May to June), with the aid of an entomopathogenic fungus (*Metarhizium anisopliae*), deployed in granulate form or as a suspension. Finally, trials were devised to test the repellent efficacy of hop extraction products (beta acids), and the use of yellow trays containing olive oil and other attractants to trap the flea beetles. The effectiveness of all these methods had never before been put to the test in hop farming under scientific conditions.

7.1.1 Findings 2018

In the summer of 2018, the 2017 trial, involving control of flea beetle larvae using entomopathogenic fungi, was repeated in Laipersdorf in our own interests. It was agreed with Dr Dietrich Stephan of JKI that it would be preferable to concentrate on the easier-to-handle granulate, and to dispense with the temperature-sensitive conidia suspension of *Metarhizium anisopliae*. In its place, the product *Attracap*, which contains a similar entomopathogen fungus, *Metarhizium brunneum* (CB 15 strain), was used as the second trial block. Both granulates were spread in the individual plots on 12.06.2018 (1 200 ml per plot) and immediately ploughed under. Once again, to monitor the degree of success, a photo eclector was placed centrally on the hilled row in each of the 12 plots on 12.07.2018 ***(Fehler! Verweisquelle konnte nicht gefunden werden.)***. Again, all the eclectors were emptied at weekly intervals and the flea beetle catch counted. This was done over a period of seven weeks up to 29.08.2018, shortly before harvest.

The total count of 40 162 beetles from the 12 m^2 trap area is considerably higher than that recorded in the previous year, 2017*(*Fig. 7.2*)*. The highest single number was registered on 19 July, when, in an area measuring one square metre, 2 731 beetles hatched out in one week. Presumably the date when the eclectors were installed, 12.07.2018, was too late to take in the start of hatching. Once again, it was the case that no differences could be found between the three variants tested, JKI granulate, *Attracap*, and the control, in terms of beetle production. The tendency was for the number of beetles hatching to be lowest in the control. The numbers recorded for 2018 on site at Laipersdorf certainly confirm the huge development potential of 6 million individuals per hectare that *P. attenuatus* is capable of fulfilling, in an area where hops are grown without application of a soil insecticide like *Thiamethoxam*.

Fig. 7.1: Positioning of photo eclectors on the hilled row, to trap newly hatched flea beetles at the site in Laipersdorf, 13.07.2017 (Photos: M. Mühlbauer).

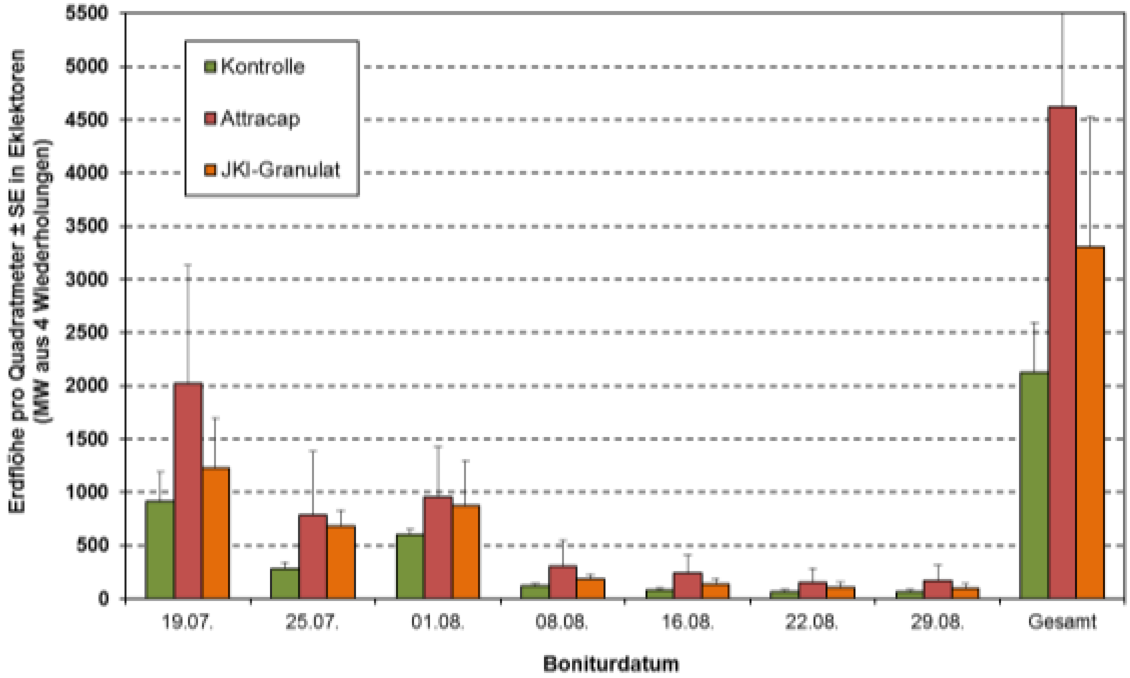

Fig. 7.2: Numbers of newly hatched flea beetles caught in photo eclectors at the experimental ecological yard in Laipersdorf (cultivar SIR) from 12.07. to 29.08.2018, on the hilled row. An average catch of, at a conservative estimate, 2 000 beetles per m² of hilled row, i.e. in only one third of the total area, would mean, as in the previous year, an annual number of 6 million flea beetles, or 3 000 animals per hop plant.

7.1.2 Headline information on the ecological flea beetle project

In the period 2015 to 2018, several methods of managing the hop flea beetle, *Psylliodes attenuatus,* were trialled at four different research sites: Haushausen (Hallertau, Upper Bavaria), Ursbach (Hallertau, Lower Bavaria), Bad Gögging (Hallertau, Lower Bavaria) and Laipersdorf (Hersbruck, Middle Franconia). All are organically managed hop yards.

Parallel to these trials, extensive 3-year laboratory tests were conducted at Wageningen Plant Research (Netherlands), to identify the semiochemicals involved in chemical communication in *P. attenuatus*.

Historical details of the life cycle of *P. attenuatus*, which produces only one generation per year in Central Europe, were reviewed and elaborated (cf. Fig. 7.3*)*.

During the the lab tests, five 'volatile organic compounds' (VOCs) were detected that exhibited a distinctly different pattern between untreated control samples and those infested with hop flea beetles. Four of the five compounds are terpenoids, and of these (E)-alpha-bergamotene, sesquiphellandrene and linalool have been provisionally identified.

During the open air trials, the terpenoid scent, contained in yellow trays, proved to be the only attractant so far with the potential to lure *P. attenuatus.* Neither beta-caryophyllene, cis-3-hexenyl-acetate, ocimene, R+-limonene, (1S)-β-pinene, nor olive oil had any effect as an attractant. *(*Fig. 7.4*)*.

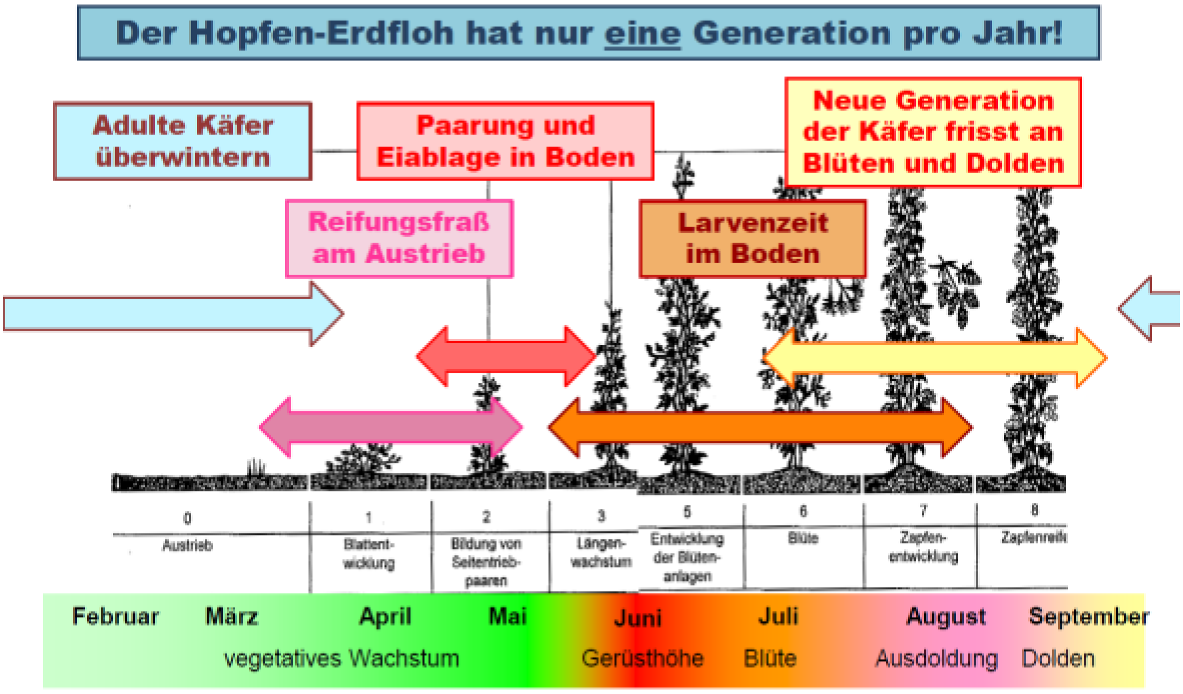

Fig. 7.3: Life cycle of the hop flea beetle, Psylliodes attenuatus, in Central Europe.

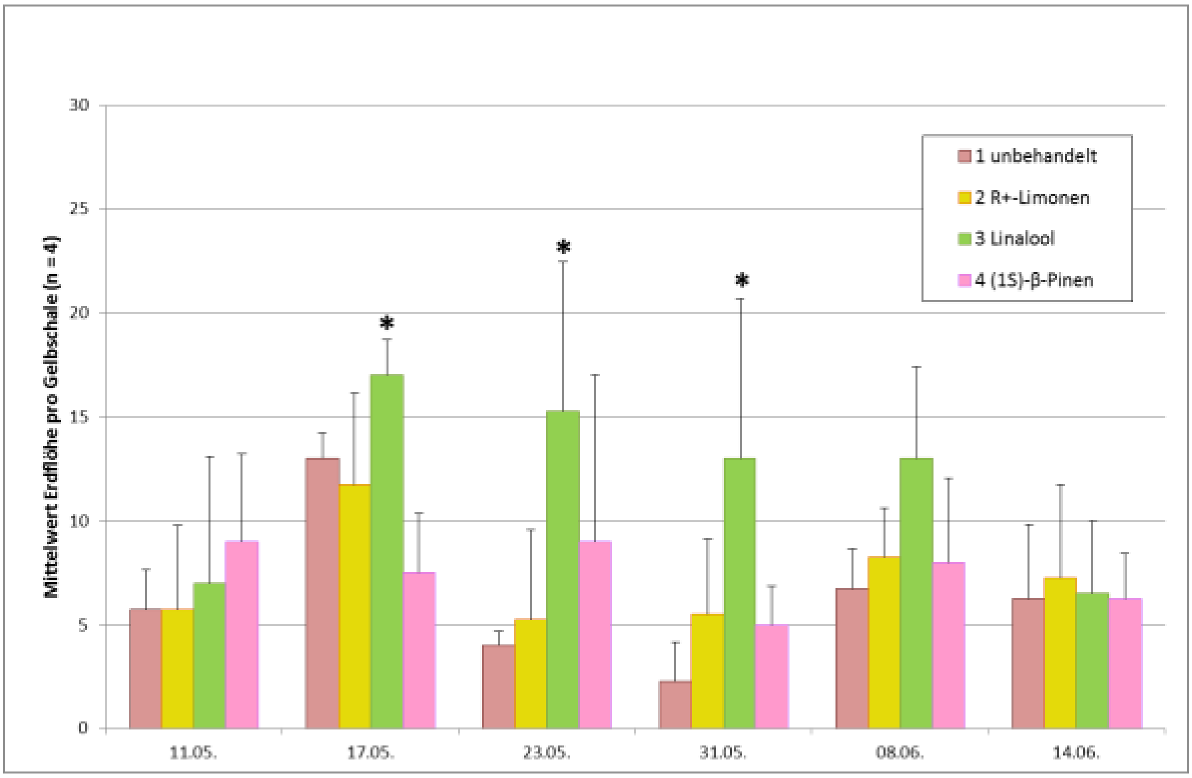

Fig. 7.4: Hop flea beetle catch numbers at the experimental ecological hop yard in Ursbach, early summer 2017. On 17.05., 23.05. and 31.05.2017, attraction was significantly higher in traps baited with linalool (ANOVA, p <0.05).

The result of the quantitative determination via photo eclectors of new flea beetles hatching at the height of summer revealed a damage potential at the Laipersdorf site of over 6 million beetles per hectare (or 3 000 individuals per hop plant), in one organically managed hop yard.

Nettles used as bait plants to lure the flea beetles away from the hops had no effect.

A trial using hop beta acids to repel the hop flea beetles and keep them away from the hops demonstrated that this strategy does not work.

Also without any effect were trials lasting two years directed at controlling flea beetle larvae in the ground by applying different formulations of entomopathogenic fungi (*Metarhizium anisopliae, M. brunneum*).

Two-year experiments with the aim of actively catching the flea beetles in glue-baited traps were not particularly effective. Six operations involving walking the crop in the springtime were hard work, but produced a projected maximum catch of only 50 000 flea beetles per hectare, i.e. less than 1 % of the total potential of the pest. Approaches like this are nothing more than action for the sake of it, to no effect.

Literature:

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Tölg F. 1913. Psylliodes attenuata Koch, der Hopfen- oder Hanf-Erdfloh. I. Teil. Morphologie und Biologie der Präimaginalstadien. Verhandlungen der kaiserlich-königlichen zoologisch-botanischen Gesellschaft in Wien 63: 1-25

7.2 Establishing Predator Mites in Commercial Hop Production with the Aid of Undersown Plants

Above all in organic hop production, it is important that an effective sustainable biological method of managing spider mites should be available, as an alternative to the preventive use of whey and sulphur, methods which put the existing beneficials at risk. In view of the current debate about certification of spray agents, environmental impact and the danger to bees posed by the application of plant protection products in agriculture, it has become increasingly attractive, also for conventionally managed farms, to employ effective biological control strategies in the context of integrated plant protection to manage the two-spotted spider mite.

The main objective is to establish the autochthonous predator mite species *Typhlodromus pyri* as a biological control agent. This is an indigenous species, widely encountered in German wine growing and fruit farming, for which various species of harmful mites (spider mites, rust mites, grapeleaf rust mites), as well as grass pollen, are a feeding source. Owing to the fact that it is not highly specialized, and because it can make use of alternative food sources, *T. pyri* can build up stable populations over the longer term. The establishment of a permanent population of *T. pyri* should therefore lead to a continuous reduction in the numbers of spider mites and stop them infesting the hops and causing harm.

Fig. 7.5: Frost-damaged section of grape vine, occupied by predator mites (T. pyri), positioned in the trained bine and used to inoculate the hop yard,

Fig. 7.6: Leaf from a bean plant with a mix of predator mites, positioned in the trained bine of the hop

Fig. 7.7: Well-established undersown tall fescue grass (on the right) in the research yard at Ursbach, compared with the usual vegetation

The strategy of additionally deploying farmed allochthonous predator mites is to be optimized, as an additional control option to fall back on in the event of the feared appearance of two-spotted spider mites in huge numbers. For the trial, a mix of the two predator mite species *Phytoseiulus persimilis* and *Neoseiulus californicus* was used, since this combination had delivered promising results in previous trials. Now the details with respect to the best possible method, timing, and rate of application needed to be clarified.

The hardy undersown ground cover is made up of tall fescue grass, *Festuca arundinacea*, and a grassland mixture that includes meadow foxtail, *Alopecurus pratensis*, bluegrass, *Poa pratensis*, and meadow fescue, *Festuca pratensis.* The choice was made because, from time to time, the predator mites use grass pollen as an alternative feeding source. The grasses will ensure their survival in the springtime between the dormant period in the winter and the commencement of spider mite infestation on the hops. There is also an added advantage in that the undersown ground cover has a positive effect on the micro-climate of the hop yard throughout the year, to the benefit of the predator mites.

A further experimental element is the planting of strawberries, plants that have woody tissue, instead of undersown ground cover, based on the practice in wine growing and fruit farming, to provide a place in the tractor lanes where the predator mites can overwinter in the hop yard.

In the first year of the project, development of spider mite infestation at the five research sites varied greatly. On average, three-figure numbers of spider mites per leaf were counted in one location, on several assessment dates, depending on the treatment variant; at another site, infestation did not even reach four spider mites per leaf. The success achieved by deploying predator mites was similarly inconsistent. The assessment results from the Laipersdorf site are shown below by way of example. It must be said that predator mites were successfully established at all the sites, so that the mites and/or their eggs were found at each site on every assessment date.

Tab. 7.1: Total number of predator mites/predator mite eggs found in all plots during the individual assessments (1 to 6) at each of the research sites

	1	**2**	**3**	**4**	**5**	**6**
Benzendorf	2/5	4/2	6/9	0/16	6/27	2/33
Laipersdorf	2/1	4/17	4/11	3/16	6/31	1/60
Oberulrain	66/66	166/149	278/366	798/299	74/19	9/6
Starzhausen	29/26	37/48	91/178	97/93	382/156	745/60
Ursbach	0/24	1/20	0/55	1/39	0/46	16/124

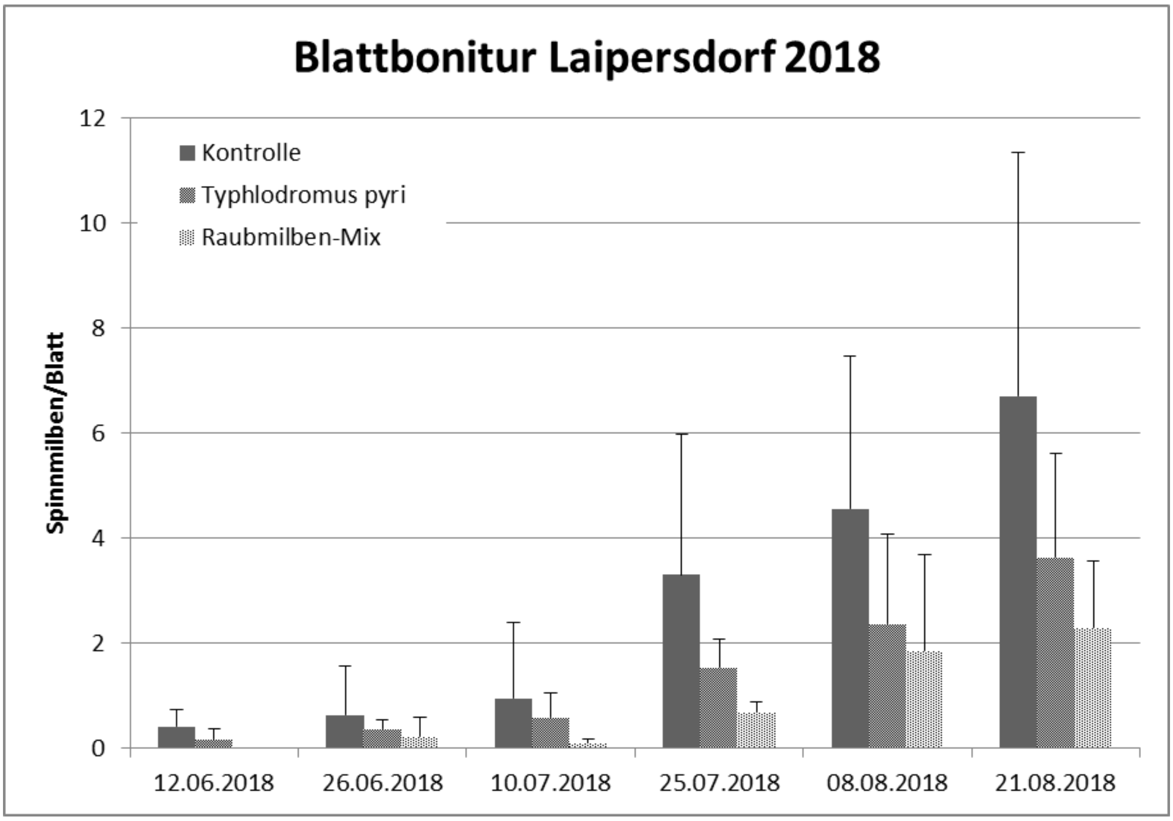


Fig. 7.8: Spider mite infestation at the research site in Laipersdorf (growing region Hersbruck) on the six assessment dates, with two different predator mite variants and a control without spider mite treatment

8 Hop Quality and Analytics

ORR Dr. Klaus Kammhuber, Dipl.-Chemiker

8.1 General Information

Working Group IPZ 5d carries out all analytical testing needed in the IPZ Hops Department to support issues arising from testing by the other Working Groups, especially the hop breeding unit. Ultimately, hop is cultivated for its compounds; and this means no hop breeding and no hop research without hop analytics.

Present in hop are three groups of substances of value; ranked in order of importance, these are the bitter compounds, the essential oils, and the polyphenols *(*Fig. 8.1*)*.

Fig. 8.1: The constituent components of value in hop

The alpha acids are considered to be the key element contributing to hop quality, because they are a determinant for the bittering potential; hop is added to beer on the basis of its alpha acids content (internationally, approx. 4.3 g alpha acids to 100 l beer). Alpha acids also play an increasingly important role in the way hops are paid for. Payment is made either by weight of the alpha acids (kg alpha acids), or based on a system specified in supplements to the supply contracts, with a surcharge or a price reduction depending on whether alpha acids levels are above or below a specified neutral range.

Hop affects beer in multiple ways; its most important properties, however, are the bittering contribution and the delicate and agreeable flavour the hop imparts to the beer. ***(Fehler! Verweisquelle konnte nicht gefunden werden.)****.*

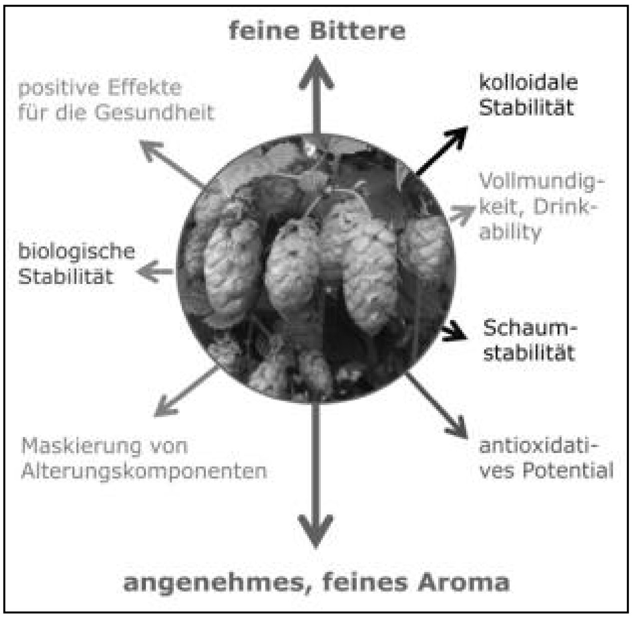


Fig. 8.2: The effect of hop in beer

8.2 The Craft Brewer Movement is Revolutionizing Hop Ideology

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 and hops are now subjects that are much more talked about. The craft brewers are looking for hops with special aromas, sometimes not even typical of hop, and these are grouped under the term s*pecial flavor hops*. As a result, a more discerning appreciation of the different hop varieties and hop-growing regions has developed.

8.2.1 Dry hopping is experiencing a renaissance

Craft brewers have rediscovered the technique of dry hopping *(Kalthopfung, Hopfenstopfen)*, a skill going back to the nineteenth century, now enjoying a renaissance. In principle, dry hopping is a cold extraction method. Hops are again added to the finished beer in the storage tank, usually on the basis of their oil content. Beer is a polar solvent, made up of 92 % water and 5 % ethanol, so that chiefly polar components are dissolved out of the hops *(*Fig. 8.3*)*.

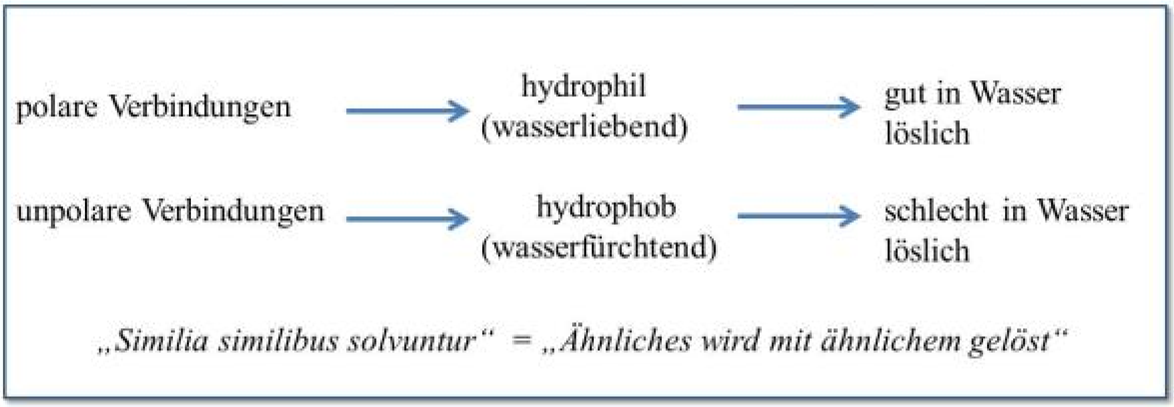


Fig. 8.3: The solubility behaviour of hop components is based on polarity

Alpha acids dissolve only in trace amounts because they are not isomerized. Chiefly low molecular esters and terpene alcohols are transferred to the beer – the reason why dry hopped beers acquire fruity and flowery flavours. Non-polar substances, like myrcene, are also dissolved in trace amounts. Polyphenols as a group, too, are polar, and easily soluble. Unfortunately, undesirable substances like nitrate are also transferred outright to the beer. On average, hop contains 0.9% nitrate. However, the limit of 50 mg/ltr for drinking water does not apply to beer. Plant protection agents generally tend to be non-polar and are therefore not readily soluble in water. No accumulation is noticeable in dry hopped beers, as opposed to conventionally brewed beers.

On the whole, the craft brewing movement represents a huge opportunity for hop production and is set to bring about a fundamental change in the hops industry. 20% of global hop output is used for 2% of world beer production. In the United States, the acreage devoted to hop growing again increased, from 12 670 hectares in 2010 to 23 200 hectares in 2018.

In Germany, too, the acreage has risen to a record high of 20 144 hectares. The last time the area was larger was in 1997. It will be exciting to see how hop production develops around the world.

8.2.2 The aromatic substances are gaining in importance

Eating and drinking can be said to be a holistic experience of sensual pleasure, during which smell, taste, trigeminal stimuli and 'that certain something' are all processed side by side in the brain. *(*Fig. 8.4*)*. The perception of smell is the most important of them because olfactory impressions go straight to the unconscious, where they can trigger emotions. But also 'that certain something', in which social elements, atmosphere, mood, and conviviality all play a role, is a major factor in the experience of pleasure.

Fig. 8.4: Eating and drinking is a holistic experience of sensual pleasure

The craft brewer movement now puts more emphasis on the aromatic substances in hop, and this poses a challenge for analytical testing. The hop essential oils are composed of approximately 300-400 single different substances.

Hops, beer, and wine are food products whose aromas/flavours cannot be characterized satisfactorily, even though a lot of their compounds can be identified; it is exactly this that makes them so interesting to consumers. Aroma/flavour is the result of the many complex interactions of a large number of aromatic substances *(*Fig. 8.5*)*, but a reductionist analytical approach still makes sense. It is important to define key substances which can serve as markers for a delicate hop aroma, and to understand which substances enter the beer. However, this approach should not lose sight of the bigger picture.

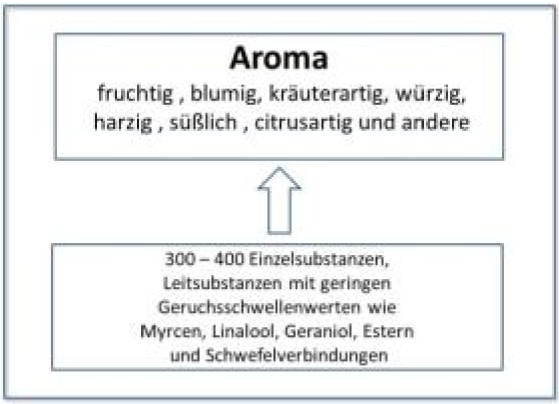


Fig. 8.5: Flavour/aroma is the result of many complex interactions of a large number of aromatic substances

Craft brewers want hops with 'exotic aromas' like mandarin orange, melon, mango, or blackcurrant.

8.3 Optimization of Constituent Compounds as a Breeding Goal

8.3.1 Requirements of the brewing industry

The brewing industry accounts for 95 % of hop output, making it still the biggest consumer of hops at present; and it is set to remain so in the future. *(*Fig. 8.6*).*

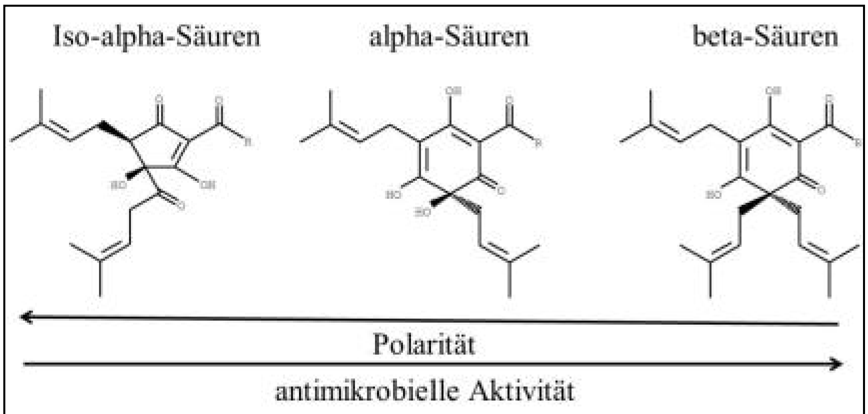
Fig. 8.6Uses of hop

The requirements of the brewing industry and the hops trade in terms of the compounds contained in hop are changing continually. However, the consensus is that breeding programmes need to produce hops with the highest possible alpha acids content and alpha acids stability, in spite of the fluctuations in the crops from year to year. A low concentration of cohumulone is no longer deemed so important as a quality criterion. In fact, for downstream and Beyond Brewing products there is even a demand for high alpha varieties with high cohumulone levels. However, a low concentration of cohumulone has a positive influence on foaming stability.

8.3.2 Alternative applications

Until now, a mere 5 % of the hop harvested has been used in alternative applications, but there is scope for expansion in this area. The cones can be used, but the rest of the plant can be put to good use, too. The woody inner parts of the hop bine, known as ‘shives’, can be removed and make suitable material for safety insulation purposes and in composite insulation mats, thanks to their good insulating properties and excellent mechanical strength. They can also be turned into fibres to make moulded parts like door panels for cars. However, no technical applications worth mentioning have yet been found.

Where the cones are concerned, it is primarily the antimicrobial properties of their bitter compounds that lend themselves to alternative uses. In catalytic amounts (0.001-0.1 % by weight), the bitter compounds already show antimicrobial and preservative activities, in the following ascending order: iso-α acids, α acids and β acids (Fig. 8.7).



R=$CH_2CH(CH_3)_2$	n-
R= $CH(CH_3)_2$	Co-
R= $CH(CH_3)CH_2CH_3$	Ad-
R= $CH_2CH_2CH(CH_3)_2$	Prä-
R= CH_2CH_3	Post-

Fig. 8.7: Order of antimicrobial activity of iso-α acids, α acids and β acids

The more non-polar the molecule, the greater the antimicrobial activity. The bitter compounds destroy the pH gradients at the cell membranes of bacteria. The bacteria can then no longer absorb nutrients and die off. *(*Fig. 8.8*).*

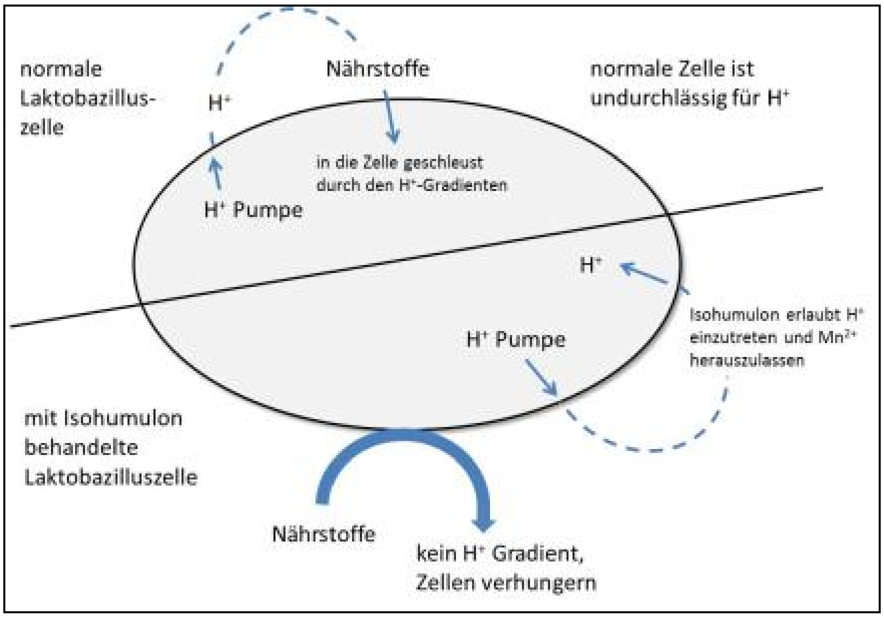


Fig. 8.8: Destruction of the pH gradients, as shown in a lactobacillus cell, as per Buggey, L., Price, A., Stapely, S., J.

Iso-alpha acids inhibit the inflammation process and have a positive effect on fat and sugar metabolism. In beer they protect against *helicobacter pylori*, which can cause stomach cancer. The β acids are effective against the growth of gram-positive bacteria such as listeriae and chlostridiae, and they can also inhibit the tuberculosis pathogen *mycobacterium tuberculosis*. As a result, hop bitter compounds can be employed as natural biocides wherever bacteria need to be kept at bay. In the sugar refining and ethanol industries, formalin is already being successfully replaced by β acids. Thanks to their anitmicrobial activity, 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. It is highly likely that hop will be in greater demand in the future for these applications, thus one of the breeding goals at Hüll is to raise β acids content. The present record is a content of approximately 20 %. There is even a breeding line that produces only β acids and no a acids. This variety is used in producing teas.

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 highly polyphenol-rich plant. Polyphenols are generally thought to have a highly positive influence on health because of their antioxidant effect and because they can scavenge free radicals. Substances with a very high antioxidative potential are oligomeric proanthocyanidins (up to 1.3%), glycosidically bound quercetin (up to 0.2%) and kaempferol (up to 0.2%). Multifidols, at up to 0.5%, are also a principal component of hop. The name is derived from the tropical plant *jatropha multifida* because these compounds are found in its sap. These substances have anti-inflammatory properties. Traces of prenylated flavonoids, e.g. 8-prenylnaringenin (one of the most potent phyto-oestrogens), are also present, so that hop has a slight oestrogenic effect.

Of all the hop polyphenols, xanthohumol is the one that grabs the attention of the public, and scientific studies on the subject have now sprung up everywhere. In the meantime, scientific evidence from EFSA (the European Food Security Authority) now supports the health claims for xanthohumol, and this means that it can be marketed for use in food supplements and functional foods. For detailed information on the story of xanthohumol and its effects, go to the website of T.A. XAN Development S.A.M. https://www.xan.com/.

Xanthohumol can be used in treatments for more or less everything *(Fig. 8.9)*, the most promising discovery being that it works in treating cancer.

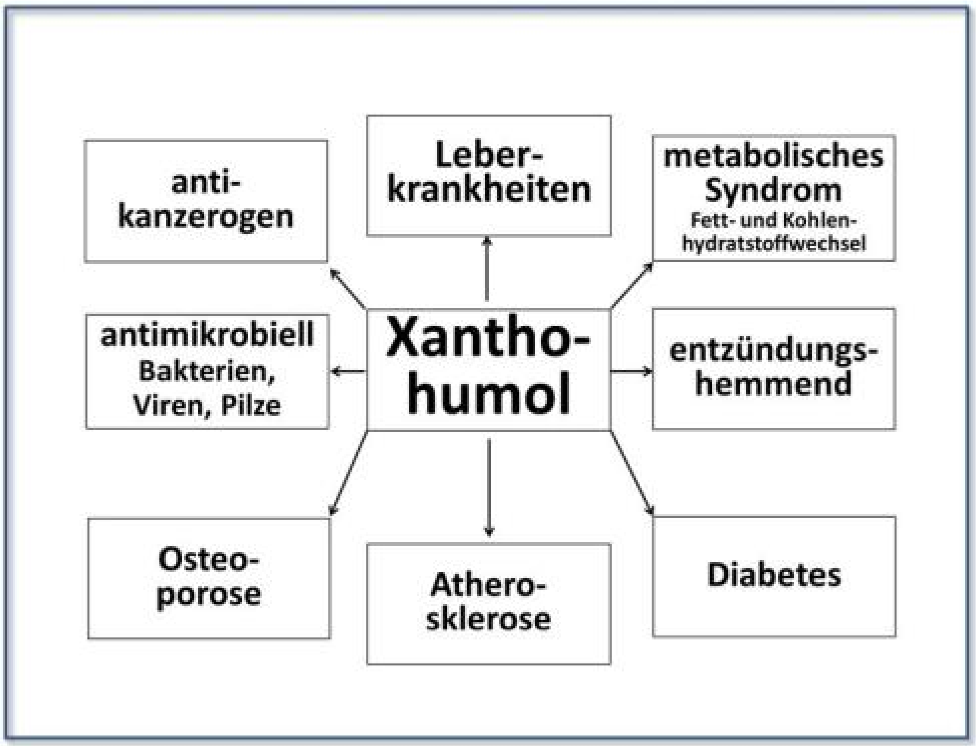


Fig. 8.9: Xanthohumol can help treat almost anything

Conversion of these substances is continually taking place during the brewing process *(*Fig. 8.10*).*

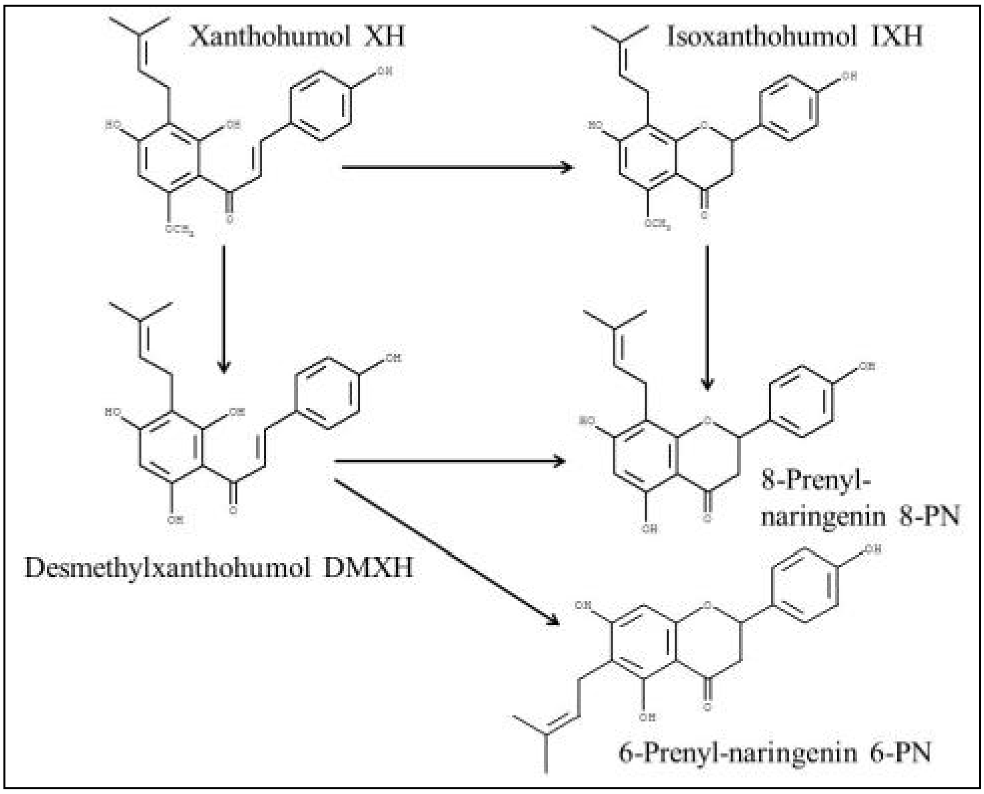


Fig. 8.10: Conversion of prenylated flavonoids during the brewing process

Fehler! Verweisquelle konnte nicht gefunden werden. shows the concentrations of prenylflavonoids in hops and beer

Tab. 8.1: Concentrations of prenylflavonoids in hops and beers

	XH	IXH	8-PN	6-PN	DMXH
Hop (% TM)	0.48	0.008	0.002	0.007	0.12
Beer (µg/l)					
Lager/Pilsner (USA)	9 - 34	400 - 680	13 – 17	31 – 38	0
Pilsner (Europe)	12 - 28	570-1 060	8 – 33	22 – 55	0
Porter (USA)	690	1 330	240	560	0
Porter (Europe)	n.d.	n.d.	42	n.d.	0
Hefeweizen (USA)	5	300	8	11	0
Hefeweizen (Europe)	n.d.	n.d.	10 12	n.d.	0
Ale (USA)	240	3440	110	200	0
Ale (Europe)	n.d.	n.d.	9 – 21	n.d.	0
Stout (Europe)	340	2100	24 – 139	170	0

n.d. = not detectable

References:

Stevens JF, Page JE: Xanthohumol and related prenylflavonoids from hops and beer: to your good health! Phytochem 65 (2004) 1317-1330.

Stevens JF, Taylor AW, Deinzer ML: Quantitative analysis of xanthohumol and related prenylflavonoids in hops and beer by liquid chromatography-tandem mass spectrometry.J Chromatogr A832 (1999) 97-107.

Rong H, Lazou K, De Keukeleire D, Milligan SR, Sandra P: Quantitation of 8-prenylnaringenin, a novel phytoestrogen in hops (Humulus lupulus L), hopproducts, and beers, by benchtop HPLC-MS using electrospray ionization. Chromatographia 51 (2000) 545-552.

Schaefer O, Bohlmann R, Schleuning WD, Schulze-Forster K, Hümpel M: Development of a radioimmunoassay for the quantitative determination of 8-prenylnaringenin in biological matrices. J Agric Food Chem 53 (2005) 2881-2889.

During the wort boiling process, xanthohumol is isomerized to form iso-xanthohumol and desmethylxanthohumol to form 8- und 6-prenylnaringenin. For this reason, desmethylxanthohumol is not found in beer, and the concentrations of prenylated naringenins are much higher than in hop.

The oestrogenic effect of 8-prenylnaringenin (8-PN) is due to the fact that 8-prenylnaringenin has a similar structure to the female sexual hormone 17-β-oestradiol. Soya, too, contains oestrogen-active substances, such as the isoflavones daidzein and genistein, although their activity is weaker than that of 8-PN.

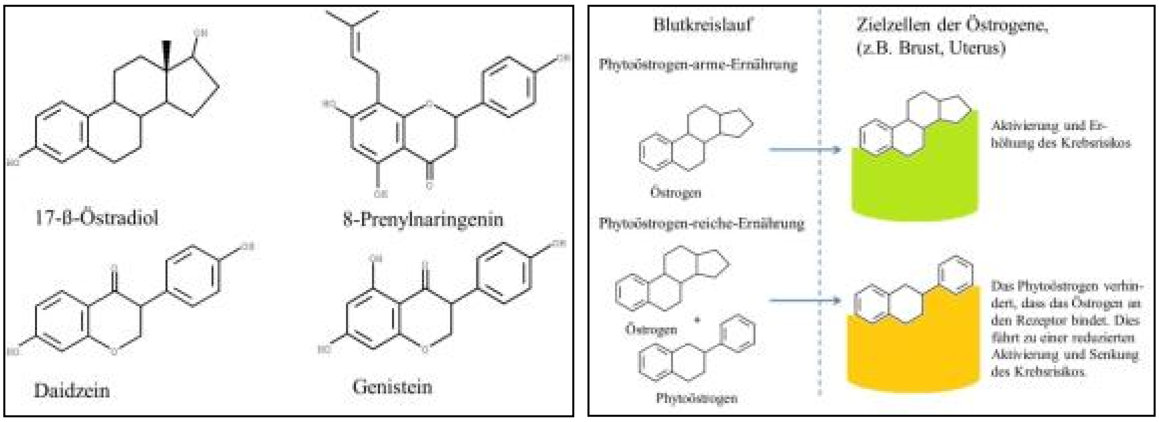


Fig. 8.11: Structures of phyto-oestrogen compared with 17-ß-oestradiol and the effect of these substances according to Prof. Dr. med. Richard Béliveau and Dr. med. Denis Gingras

8-Prenylnarigenin and the other phyto-oestrogens can occupy the oestrogen receptors of targeted cells, such as breast and uterus cells, and thus prevent oestrogen from binding to the receptor. In this way, the incidence of hormone-induced types of cancer like breast and prostate cancer can be reduced *(*Fig. 8.11*)*. In Asia, large amounts of soya-based foods are consumed, and hormone-induced types of cancer occur less frequently there than in Europe and the USA.

Aroma hops generally 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 the analytics team.

8.4 World Hop Collection (2017 Crop)

The essential oils from the world hop collection are analysed every year, using headspace gas chromatography; the bitter compounds are analysed with the help of HPLC. *Tab. 8.2* gives the results for the crop year 2017. The table can be used as an aid to identifying what variety an unknown hop cultivar belongs to.

Tab. 8.2: World hop collection (2017 crop)

Cultivar	Myr-cene	2-M.-iso-butyrate	Sub. 14 b	Sub. 15	Lina-lool	Aroma-dendrene	Unde-canone	Hu-mulene	Farne-sene	ɡ-Muu-rolene	β-Seli-nene	a-Seli-nene	β,ɡ-Ca-dinene	Seli-nadien	Gera-niol	a-acids	β acids	β/a	Cohu-mulone	Colu-pulone
Admiral	9944	2574	1	274	142	0	7	729	6	20	3	5	44	0	1	14.2	5.2	0.37	43.8	66.2
Agnus	2563	348	1	15	22	0	3	311	0	22	4	8	43	0	2	10.4	5.7	0.55	32.9	56.3
Ahil	5393	1394	131	10	68	0	2	514	53	22	6	12	43	1	11	6.2	3.4	0,55	32.9	55.8
Alliance	2919	214	0	2	49	0	4	693	3	26	3	5	51	0	0	3.9	2.2	0.57	29.5	51.3
Apolon	5989	415	163	24	72	0	1	502	69	21	5	10	40	1	8	6.5	3.4	0.52	26.5	47.1
Aquila	7034	432	0	531	75	47	7	82	0	28	48	105	29	145	8	4.3	3.5	0.82	44.8	68.4
Ariana	7039	1046	313	274	47	0	12	755	0	27	24	49	51	1	2	7.7	4.6	0.59	40.1	57.1
Aromat	1233	8	3	37	128	0	14	764	42	27	1	5	46	0	1	1.8	3.2	1.81	25.5	40.5
Atlas	4235	1864	105	10	53	0	0	489	32	23	8	15	44	0	12	6.0	3.2	0.53	38.5	60.8
Aurora	6626	923	6	396	153	0	8	662	52	19	3	4	43	0	1	9.1	3.9	0.43	19.8	45.9
Backa	8460	2023	0	74	71	0	11	697	16	26	3	4	46	0	0	7.1	4.8	0.67	38.9	61.7
Belgisch Spalter	5323	636	1	81	67	14	2	397	0	26	20	47	40	84	0	4.5	2.7	0.61	27.0	50.0
Blisk	4581	987	93	11	62	0	0	577	36	28	6	12	51	0	9	6.7	3.0	0.44	32.7	56.4
Bobek	1044	981	70	313	185	0	5	687	35	23	3	5	45	0	6	5.4	5.8	1,07	23.2	45.5
Bor	8442	289	6	321	35	0	2	725	0	17	3	4	38	0	2	6.9	3.7	0.53	22.4	46.4
Bramling Cross	8784	1055	15	17	108	0	10	639	0	28	6	12	50	10	1	2,2	2.9	1,33	35.0	60.4
Braustern	4075	486	0	191	26	0	2	566	0	22	3	4	46	0	1	6.7	4.3	0.64	27,2	48.4
Brewers Gold	2312	693	73	46	44	0	0	392	0	25	5	10	48	0	9	6.6	4.0	0,61	37.4	63.8
Brewers Stand	1173	3261	298	140	174	40	14	84	0	218	72	154	352	237	15	7.6	4.0	0.52	25.7	46,3
Buket	6389	927	1	385	80	0	3	591	26	25	3	4	49	0	2	8.1	4.0	0.49	20.6	51.5
Bullion	3714	1024	79	65	47	0	1	396	0	24	6	12	31	0	2	5.1	4.0	0.80	37.9	63.6
Callista	8122	953	264	15	231	0	4	755	0	41	60	128	71	0	1	2.8	6.7	2.36	15.6	35.9
Cascade	8387	1111	122	55	58	0	2	584	24	31	13	27	50	1	5	5.6	5.5	0.98	33.4	50.4

Cultivar	Myr-cene	2-M.-iso-butyrate	Sub. 14 b	Sub. 15	Lina-lool	Aroma-dendrene	Unde-canone	Hu-mulene	Farne-sene	ɡ-Muu-rolene	β-Seli-nene	a-Seli-nene	β,ɡ-Ca-dinene	Seli-nadien	Gera-niol	a acids	β acids	β/α	Cohu-mulone	Colu-pulone
Centennial	1105	1974	268	24	79	0	0	504	0	29	3	4	57	0	21	7.1	2.5	0.36	27.3	52.3
Chang bei 1	3425	31	10	5	94	0	8	584	8	29	20	43	45	50	1	2.4	3.4	1.43	20.8	38.6
Chang bei 2	3666	21	14	4	94	0	8	603	8	31	19	39	48	52	1	2.3	3.3	1.45	19.7	38.3
Chinook	4381	1007	53	17	19	0	2	461	0	75	13	21	142	32	3	8.7	2.9	0.33	30.5	53.5
Columbus	4042	843	85	24	30	0	4	387	0	51	11	19	92	35	2	12.9	4.5	0.35	35.7	59.5
Comet	1598	611	51	22	44	0	6	20	0	10	61	125	9	27	2	6.6	2.6	0.39	40.2	59.5
Crystal	4866	29	13	15	76	56	1	523	0	42	40	78	45	101	0	1.5	6.6	4.57	15.2	30.7
Density	1305	624	0	7	126	0	12	658	0	20	4	8	35	0	0	2.0	2.8	1.41	35.3	59.6
Diva	6689	741	14	139	101	0	9	661	9	27	84	189	55	0	4	5.7	5.7	1.00	23.3	45.2
Dr. Rudi	1146	1779	137	144	116	0	7	732	0	20	3	6	39	0	1	6.5	4.6	0.70	38.2	59.9
Early Choice	6780	529	0	109	16	0	4	587	0	16	29	71	34	0	0	1.5	1.0	0.70	34.9	53.0
Eastwell Golding	4533	195	0	34	43	0	4	684	0	20	3	4	41	0	0	4.3	3.0	0.71	25.2	46.2
Emerald	4587	321	22	59	16	0	4	744	0	21	3	5	42	0	1	3.9	3.8	0.97	26.3	45.2
Eroica	6587	1914	271	824	1	0	5	459	0	4	7	14	33	0	1	8.1	6.1	0.75	39.8	63.5
Estera	5440	545	0	22	69	0	4	654	18	20	3	4	42	0	0	2.9	2.1	0.72	31.8	49.9
First Gold	4490	1132	4	76	59	0	4	662	11	24	76	176	51	0	2	8.3	4.5	0.54	29.8	51.6
Fuggle	4153	643	0	23	53	0	3	610	22	20	3	5	44	0	0	3.0	2.2	0.75	30.3	49.0
Galena	4131	1611	286	360	1	0	5	479	0	21	7	15	40	0	1	9.0	6.8	0.75	40.3	62.4
Ging Dao Do Hua	9268	2697	0	21	75	0	15	616	0	63	42	86	112	0	9	4.6	4.7	1.02	44.9	67.2
Glacier	6588	303	12	15	68	0	2	748	0	22	3	5	46	0	1	2.6	4.6	1.76	18.3	38.7
Golden Star	8473	2911	0	9	66	0	14	689	0	62	40	87	104	1	6	3.6	3.9	1.09	47.4	69.1
Granit	7809	407	53	60	34	0	5	571	0	14	7	13	36	0	1	4.4	3.4	0.78	22.2	44.9
Green Bullet	1764	868	109	66	82	0	7	695	0	19	3	5	36	0	0	6.9	4.7	0.68	40.9	65.5
Hallertau Blanc	2474	2724	794	122	182	0	6	169	0	5	342	793	54	1	7	9.4	5.2	0.55	20.0	36.9
Hallertauer Manum	5563	594	164	102	23	0	2	723	0	17	3	4	44	0	1	11.3	6.4	0.57	26.2	43.2

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Cultivar	Myrcene	2-M.-isobutyrate	Sub. 14 b	Sub. 15	Linalool	Aromadendrene	Undecanone	Humulene	Farnesene	g-Muurolene	ß-Selinene	a-Selinene	ß,g-Cadinene	Selinadien	Geraniol	a acids	β acids	β/α	Cohumulone	Colupulone
Hallertauer Merkur	3651	736	130	23	68	0	2	637	0	25	4	6	53	0	1	12.0	5.4	0.45	15.7	38.7
Hallertauer Mfr.	2456	432	2	5	77	0	3	688	0	30	4	6	58	0	1	3.7	4.4	1.18	20.3	38.9
Hallertauer Taurus	7017	483	88	98	124	0	1	616	0	22	42	96	46	0	1	13.2	4.2	0.32	20.7	43.0
Hallertauer Traditon	4267	682	39	18	98	0	2	714	0	21	3	5	50	0	0	6.6	4.5	0.69	24.5	45.7
Harmony	4484	335	2	52	112	0	3	550	0	22	53	124	45	0	1	6.6	5.9	0.88	21.8	42.0
Herald	5213	1174	3	564	32	0	7	460	0	18	17	39	42	0	4	11.0	4.2	0.38	31.2	59.8
Herkules	6091	928	343	425	30	0	5	693	0	19	3	4	43	0	3	17.3	5.1	0.29	31.6	49.9
Hersbrucker Pure	6066	666	0	154	130	20	5	521	4	26	22	47	39	80	1	3.5	2.1	0.60	21.4	44.5
Hersbrucker Spät	2742	236	56	8	87	39	2	510	0	35	30	63	46	75	1	3.9	7.1	1.82	15.8	32.2
Huell Melon	1518	6228	2	193	94	0	13	151	61	70	267	586	121	175	26	6.5	7.3	1.11	27.9	47.8
Hüller Anfang	2947	649	21	1	82	0	3	760	0	37	4	7	62	0	0	1.5	2.7	1.80	27.0	41.1
Hüller Aroma	5744	426	1	2	100	0	7	782	0	29	3	5	50	0	0	1.7	2.8	1.63	27.2	45.1
Hüller Fortschritt	5365	246	19	3	99	0	7	764	0	26	3	5	48	0	0	1.7	3.3	1.96	28.0	43.0
Hüller Start	2765	164	0	7	34	0	5	764	0	35	3	6	59	0	0	1.5	2.8	1.90	25.8	42.6
Kazbek	3402	909	91	70	42	0	1	401	0	24	7	13	35	1	2	4.3	4.1	0.94	35.9	60.6
Kirin 1	5906	2455	0	6	67	0	13	612	0	72	41	92	120	0	6	3.5	3.9	1.10	46.8	68.5
Kirin 2	7635	2554	0	13	67	0	15	628	0	69	46	93	119	0	6	3.9	3.9	1.02	47.1	69.6
Kitamidori	2572	46	20	126	11	0	0	654	25	24	3	4	45	0	1	7.0	4.3	0.61	19.4	36.5
Kumir	4633	287	4	58	67	0	2	700	8	22	3	5	47	0	1	7.9	4.1	0.52	20.5	43.9
Late Cluster	1990	3739	278	175	164	48	17	98	0	202	69	142	344	197	15	7.5	4.2	0.56	25.9	46.4
Lubelski	8605	90	33	11	121	0	14	811	30	29	6	12	53	0	2	3.6	4.4	1.20	23.5	40.4
Mandarina Bavaria	1180	2511	77	90	80	0	10	755	4	44	64	217	82	1	27	6.5	5.2	0.80	31.2	51.2
Marynka	5195	907	1	223	40	0	1	249	137	15	5	10	32	0	6	8.0	3.2	0.40	19.5	48.4
Mt. Hood	1236	419	68	6	59	0	2	478	0	46	4	7	74	0	2	3.5	5.4	1.56	19.5	40.2
Neoplanta	4490	507	0	154	21	0	3	517	14	23	2	4	45	0	0	5.6	3.7	0.65	36.2	64.9

Variety	Myrcene	2-M.-iso-butyrate	Sub. 14 b	Sub. 15	Linalool	Aromadendrene	Undecanone	Humulene	Farnesene	ɡ-Muurolene	ß-Selinene	a-Selinene	ß,ɡ-Cadinene	Selinadien	Geraniol	a acids	β acids	β/a	Cohumulone	Colupulone
Neptun	3007	435	207	27	55	0	1	384	0	22	2	3	47	0	1	13.7	4.9	0.36	21.9	42.1
Northern Brewer	3011	510	0	178	34	0	2	451	0	20	2	4	40	0	1	8.7	4.1	0.47	25.2	47.2
Nugget	3916	476	5	124	43	0	1	454	0	14	7	13	31	0	1	11.7	4.5	0.39	25.5	50.0
NZ Hallertauer	7766	1343	0	118	93	4	3	417	21	21	17	36	32	54	1	1.9	4.7	2.48	29.9	56.7
Opal	3141	291	56	78	94	0	2	457	1	23	1	4	47	1	2	7.2	5.1	0.71	12.2	30.8
Orion	3331	654	24	24	57	0	5	479	0	28	2	4	52	0	0	6.1	4.2	0.69	27.1	53.1
Perle	2957	330	0	168	14	0	1	515	0	18	2	4	40	0	0	6.0	4.2	0.69	31.0	53.7
Phoenix	4637	933	0	66	25	0	1	654	7	22	42	99	51	0	1	10.3	4.2	0.41	24.2	44.8
Pilgrim	8997	1953	2	1070	46	0	3	710	0	20	52	123	49	1	6	7.5	3.7	0.50	35.4	59.0
Pilot	1032	1713	5	445	135	0	7	109	0	13	178	426	51	0	2	7.0	3.7	0.52	35.9	58.9
Pioneer	5241	1231	5	965	30	0	2	463	0	17	19	42	41	0	5	9.3	3.7	0.39	32.1	58.0
Polaris	3591	315	67	404	14	0	0	431	0	19	3	3	43	0	1	17.8	4.3	0.24	21.9	41.7
Premiant	4839	422	1	100	64	0	2	650	10	18	2	4	41	0	0	7.4	3.8	0.52	21.9	44.8
Pride of Ringwood	6452	241	2	4	22	0	10	29	0	18	56	124	33	0	1	7.8	5.3	0.69	33.3	54.1
Progress	2136	3395	309	153	189	44	14	95	0	206	74	151	330	256	15	7.5	3.7	0.49	25.6	46.9
Record	6972	97	0	2	81	0	7	766	0	22	4	8	45	0	0	1.9	4.1	2.18	23.9	40.8
Relax	4215	451	49	11	28	0	4	772	1	35	4	6	56	0	5	0.2	9.1	50.1	27.6	28.6
Rottenburger	4511	137	0	3	58	0	6	761	0	26	3	6	49	0	0	1.7	4.4	2.60	22.8	37.4
Rubin	4191	745	161	126	44	0	2	535	0	25	52	109	49	0	5	13.3	4.2	0.31	30.2	49.1
Saazer	5597	11	3	15	85	0	9	776	49	26	4	6	54	1	3	3.8	4.3	1.13	22.7	40.3
Saphir	4281	260	9	98	114	13	6	463	0	26	15	34	42	40	2	2.8	5.1	1.85	10.8	40.3
Serebrianker	3555	232	1	18	79	0	0	405	1	40	29	58	63	0	2	1.1	4.1	3.76	19.8	36.0
Sladek	5432	255	7	75	72	0	2	721	5	23	3	5	48	0	1	8.1	4.4	0.55	17.7	41.1
Smaragd	4606	143	46	90	98	0	1	624	2	22	4	10	45	0	2	5.0	5.2	1.05	12.4	28.7
Sorachi Ace	4175	780	0	103	29	0	2	668	8	28	3	5	55	0	3	6.4	5.4	0.84	28.9	53.6

Variety	Myr-cene	2-M.-iso-butyrate	Sub. 14 b	Sub. 15	Lina-lool	Aroma-dendrene	Unde-canone	Hu-mulene	Farne-sene	ɡ-Muu-rolene	ß-Seli-nene	a-Seli-nene	ß,ɡ-Ca-dinene	Seli-nadien	Gera-niol	a acids	β acids	β/a	Cohu-mulone	Colu-pulone
Southern Promise	5323	240	45	103	1	0	10	636	0	20	9	19	38	32	0	5.6	4.1	0.74	23.7	52.1
Southern Star	5503	121	33	11	10	0	9	698	19	27	3	5	47	0	1	7.1	4.6	0.65	29.0	50.9
Spalter	6437	3	2	21	102	0	12	784	55	19	3	5	54	0	5	3.8	4.8	1.28	23.4	42.1
Spalter Select	1066	785	164	22	368	38	28	565	83	34	30	67	44	94	1	4.2	4.4	1.07	19.6	39.4
Strisselspalter	2802	310	51	29	96	46	3	513	0	37	32	69	48	79	1	3.3	6.8	2.04	15.1	32.2
Südafrika	7051	158	6	15	10	0	2	608	0	28	43	93	47	2	1	3.3	3.9	1.19	31.3	50.1
Talisman	5781	589	1	221	30	0	2	540	0	20	3	4	45	0	1	8.3	4.4	0.52	25.6	48.2
Tettnanger	7558	2	2	26	115	0	12	794	68	12	3	6	51	0	5	2.7	4.6	1.69	24.3	41.6
Vojvodina	6857	289	0	106	22	0	3	602	3	20	2	4	40	0	1	3.9	2.6	0.67	29.7	59.1
WFG	1054	18	1	13	136	0	16	819	44	29	4	7	52	0	2	2.7	3.7	1.36	24.4	40.8
Willamette	2530	512	0	28	75	0	0	507	17	24	4	6	49	2	1	2.9	3.2	1.10	31.9	54.1
Wye Challenger	6597	1495	1	81	49	0	4	596	2	20	30	71	43	0	0	3.8	4.1	1.07	27.5	45.9
Wye Northdown	6268	541	1	92	50	0	1	555	3	21	4	6	45	0	0	5.9	4.8	0.80	25.0	47.0
Wye Target	4888	1125	2	126	84	0	7	409	0	36	7	13	72	16	1	11.8	4.9	0.41	34.2	57.6
Wye Viking	1446	1057	3	325	80	0	15	534	125	20	26	61	43	0	2	6.3	4.7	0.74	22.7	40.9
Yeoman	4906	995	74	74	31	0	1	517	0	19	30	69	43	0	3	11.9	5.2	0.43	25.1	45.6
Zatecki	5279	450	0	38	73	0	3	626	14	21	2	4	43	0	1	2.8	2.3	0.80	29.9	48.8
Zenith	8462	451	2	154	96	0	4	672	1	22	59	141	48	0	1	7.5	3.1	0.41	24.1	47.4
Zeus	4592	790	76	30	23	0	3	397	0	52	11	19	101	36	1	12.7	4.5	0.35	34.4	58.2
Zitic	4950	47	2	74	37	0	4	731	11	20	6	10	42	0	4	3.9	4.0	1.04	19.6	40.1
Wye Viking	1446	1057	3	325	80	0	15	534	125	20	26	61	43	0	2	6.3	4.7	0.74	22.7	40.9

Essential oils=relative values, β-caryophyllene=100, a and β acids in % ltr., analogues in % of the a or β acids.

Sub. 14b = methyl-isoheptanoate, Sub. 15 = trans-(β)-ocimene

8.5 Work on Expanding and Improving Aroma Analytics

For five years now, the laboratory at Hüll has had a new gas chromatography/mass spectrometry system; it is one of the most cutting-edge pieces of analytical equipment in the State Research Center for Agriculture. With the aid of this equipment, it has so far been possible to identify 143 substances, by comparing the mass spectra and using the available standards. *Tab. 8.3* gives the number of identified substances, arranged in chemical categories.

Tab. 8.3: Identified aromatic substances in chemical categories

Category	Number	Category	Number
Hemiterpenes	3	Ketones	14
Monoterpenes	26	Aldehydes	3
Sesquiterpenes	37	Carboxylic acid	2
Esters	32	Sulphur compounds	10
Alcohols	10	Other	4

Analytics of hop aromatic substances pursues two goals. First, to find substances suitable for differentiating varieties, but which do not necessarily make any contribution to the aroma/flavour. These are chiefly sesquiterpenes like β-caryophyllene, humulene and β-farnesene. Second, to identify substances that actually are responsible for the aroma/flavour. Aroma-active substances such as sulphur compounds are often present in only very low concentrations in hop, and special enrichment processes are necessary so that they can be analysed.

Important key aromatic substances in hop and their olfactory impressions are listed in *Tab. 8.4.*

Tab. 8.4: Important key aromatic substances in hop

Aromatic substance	Concentration in hop [mg/100 g]	Odour threshold value in water [µg/l]	Olfactory impression
Myrcene	20 – 2 300	10 – 125	piney, metallic
a-Terpinol	1- 10	200	lilac
Linalool	4 -10	6	floral, citrussy
Citronellol	0,4 - 4	40	citrussy
Geraniol	1 - 10	20	floral, rose-like
Ester (isobutylisobutyrate, 2-methylbutyl-isobutyrate)	3 - 35 14 - 47	30 -60	fruity
4-mercapto-4-methyl-2-pentanone (4-MMP)	0 – 0.008	0.0001	blackcurrant
3-mercaptohexanol (3-MH)	0 – 0.003	0.2	blackcurrant, passion fruit
3-mercaptohexylacetate (3-MHA)	0 – 0.003	0.017	grapefruit, passions fruit

8.5.1 Identification and quantitation of low molecular weight esters

Esters convey fruity olfactory impressions. Their odour threshold values are not particularly low, but synergistic effects can occur. Especially the low molecular weight esters are readily soluble in water. 32 esters were identified using the mass spectrometer. Standards for 8 esters are available *(*Fig. 8.12*).* At present, work on a quantitative determination is in progress.

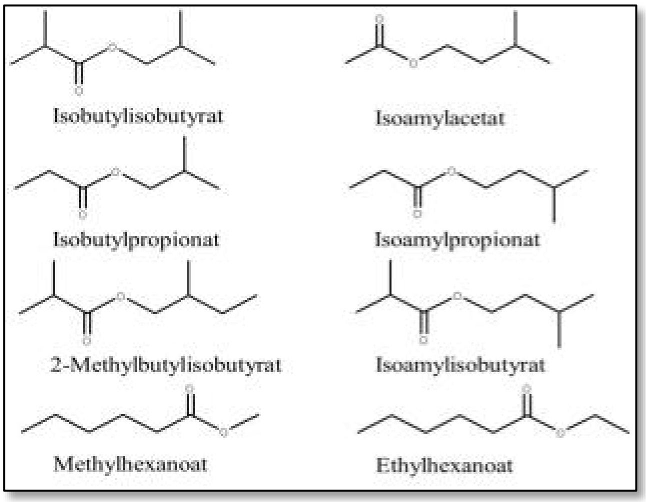


Fig. 8.12: Available standards for low molecular weight esters for quantitative determination

The hop esters found in dominant quantities are isobutylisobutyrate and 2-methylbutylisobutyrate. Higher molecular weight esters are almost insoluble. Methylhexanoate has a solubility in water of 1.33 g/l, ethylhexanoate of 0.67 g/l. Heptanoic acid methyl ester, octanoic acid methyl ester, pelargonic acid methyl ester and 4-decanoic acid methyl ester, which are also found in hop, are virtually insoluble.

8.5.2 Terpene alcohols

Terpene alcohols are readily soluble in water. Linalool and geraniol are key compounds responsible for the aroma/flavour of hop in beer. Nerol is the cis isomer of geraniol. Sometimes terpene alcohols can also be interconverted. β-citronellol is formed during fermentation through reduction of geraniol. Geranylacetate, geranylisobutyrate and geranic acid methyl ester are split hydrolytically to form geraniol, geranic acid and geranic acid ethyl ester. Fig. 8.13 gives the standards available for quantitative determination.

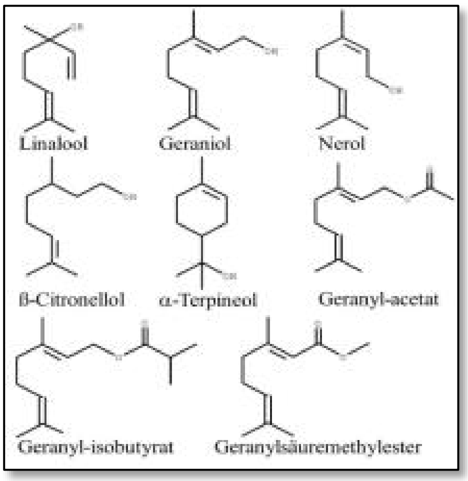


Fig. 8.13: Standards for terpene alcohols available for quantitative determination

8.5.3 Polyfunctional thiols

Analytical standards exist *(*Fig. 8.14*)* for the three polyfunctional thiols in Tab. 8.4, which belong to the key aromatic substances in hop, and quantitative tests have already been done.

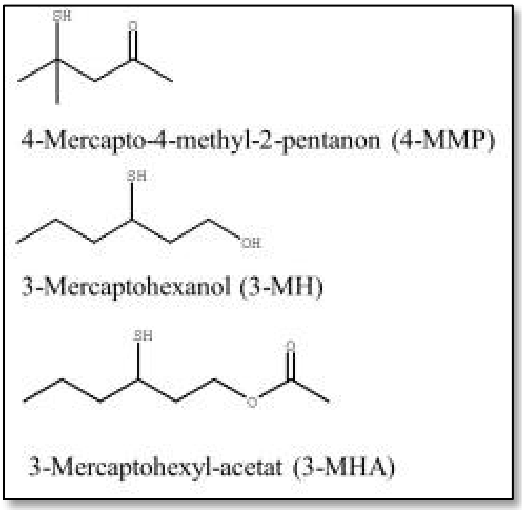


Fig. 8.14: Standards for polyfunctional thiols available for quantitative determination

8.6 Quantitative Determination of Multifidols

Three multifidols are found in hop: co-multifidol-glycoside, n-multifidol-glycoside and ad-multifidol-glycoside *(*Fig. 8.15*)*, but the most homologous is the co-multifidol-glycoside. It is readily soluble in water and enters the beer in its entirety. The taste threshold value is 1.8 mg/l. In 54 % of the beers tested, the concentration is higher than 1.8 mg/l. For this reason, work on a quantitative analysis is ongoing, in collaboration with Hopsteiner and Berlin Technical University (TU Berlin). Primarily co-multifidol-glycoside is found in hop.

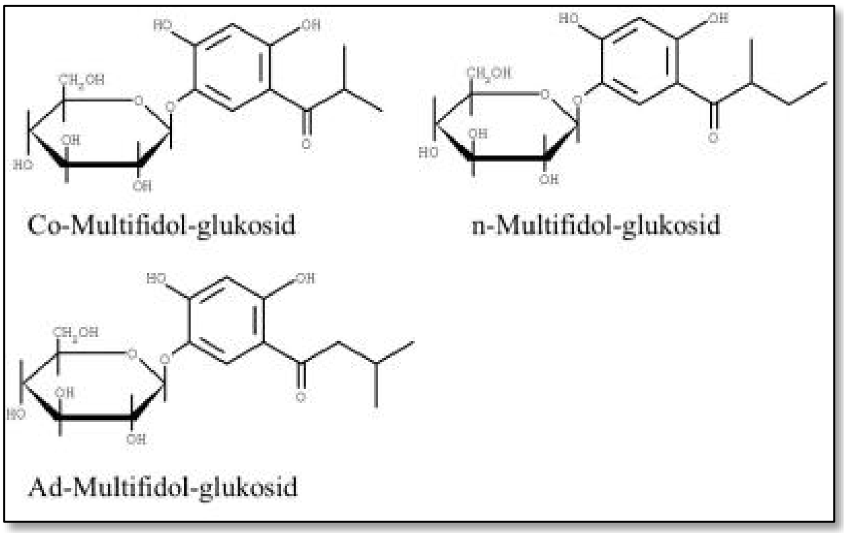


Fig. 8.15: Hop multifidols

Dr. Wietstock of TU Berlin has isolated this compound by preparative HPLC, at 94% purity. The idea is to calibrate flavone as a secondary standard with the isolated co-multifidol-glycoside. Flavone is not found in hop, but it also has a maximum absorption of 280 nm and is therefore ideal as an internal standard for the co-multifidol-glycoside. *(*Fig. 8.16*).*

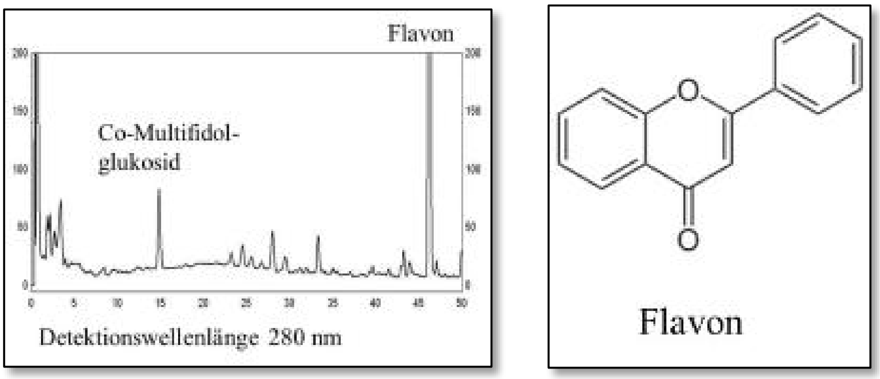


Fig. 8.16: Chromatogram of a hop sample at 280 nm, and the structure of flavone

8.7 Alpha Acids Analytics Quality Assurance for Hop Supply Contracts

8.7.1 Multi-laboratory ring analysis of the 2018 crop

Since 2000, hop supply contracts have included a supplementary agreement concerning a acids content. The price agreed in the contract applies when the a 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 the Hop Analytics Working Group 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. Again in 2018, WG IPZ 5d was tasked with organizing and evaluating the multi-laboratory ring analysis, in order to guarantee the quality of a acids analytics.

In 2018, the following labs participated in the ring analysis. BayWA AG Tettnang participated for the first time in 2018.

- Hallertauer Hopfenveredelungsgesellschaft *(Hallertau Hop Processing Society)* (HHV), Au/Hallertau plant
- Hopfenveredlung *(Hop Processing)* St. Johann GmbH, Wolnzach
- Hopfenveredlung *(Hop Processing)* St. Johann GmbH & Co. KG, St. Johann
- Hallertauer Hopfenveredelungsgesellschaft (HHV), Mainburg plant
- Hallertauer Hopfenverwertungsgenossenschaft *(Hop Sales Cooperative)* (HVG), Mainburg
- AGROLAB Boden-und Pflanzenberatungsdienst *(Soil and Plant Advisory Service*) GmbH
- Bayerische Landesanstalt für Landwirtschaft, Arbeitsbereich Hopfen, *(Bavarian State Research Center for Agriculture, Hops Department)*, Hüll
- BayWa AG Tettnang

The ring analysis began in 2018 on 4 September and finished on 2 November, with most of the hop batches having been analysed in the labs during this time. Altogether, ring analyses were performed nine times (9 weeks). The sample material was very kindly provided by the Hopfenring Hallertau. Each sample was always taken from a single bale, to ensure a high level of homogeneity.

For each analysis, the samples were ground on the Monday in a hammer mill at Hüll, 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 for evaluation a week later. In 2018, a total of 34 samples were analysed.

The evaluation findings were passed on to the individual labs as soon as possible. Fig. 8.17 is an example of what an ideal ring analysis should look like. The numbers beside the labs (1-8) do not correspond to the order in which the labs appear in the above list.

Nr. 24: HMN (16.10.2018)

Labor	KW		mittel	s	cvr
1	4,64	4,65	4,65	0,007	0,2
2	4,75	4,69	4,72	0,042	0,9
3	4,80	4,65	4,73	0,106	2,2
4	4,76	4,77	4,77	0,007	0,1
5	4,67	4,70	4,69	0,021	0,5
6	4,71	4,72	4,72	0,007	0,1
7	4,63	4,77	4,70	0,099	2,1
8	4,70	4,72	4,71	0,014	0,3

mean	4,71
sr	0,054
sL	0,0000
sR	0,054
vkr	1,15
vkR	1,15
r	0,15
R	0,15
Min	4,63
Max	4,80

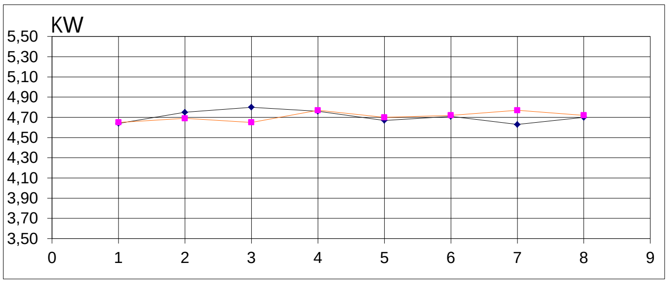


Fig. 8.17: Example of a ring analysis evaluation

The outlier test was calculated as per DIN ISO 5725. Cochran's test was applied for within-lab assessment; Grubb's test was used for inter-lab assessment.

Cochran: $$C = \frac{s_{max}^2}{\sum s_i^2}$$

With 8 laboratories and one duplicate determination, at a = 1% C must be smaller than **0.794** and at a = 5% C must be smaller than **0.680**, otherwise it counts as an outlier.

Grubbs: $$G = \frac{|x_{max} - \bar{x}|}{s}$$

With 8 laboratories and one duplicate determination, at a = 1% G must be smaller than **2.274** and at a = 5% G must be smaller than **2.126**, otherwise it counts as an outlier.

The outliers in 2018 are shown in Tab. 8.5

Tab. 8.5: Outliers 2018

	Cochran		**Grubbs**	
Sample	a = 0,01	a = 0,05	a = 0,01	a = 0,05
7				Lab. 7
Total:	**0**	**0**	**0**	**1**

As of 2013, there are now 5 alpha classes and new tolerance limits. Tab. 8.6 shows the new classes and the outliers in 2018.

Tab. 8.6 Updated alpha acids classes and tolerance limits with outliers in 2018

	< 5.0 %	5.0 % - 8.0 %	8.1 % - 11.0 %	11.1 % - 14 %	> 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 2018	0	0	0	0	0

In 2018 there were no cases where the permitted tolerance limits were overrun.

Fig. 8.18 shows all analysis results for each lab as deviations relative to the mean (= 100 %) differentiated by a acids levels <5 %, >=5 % and <10 % and >=10 %. The charts show clearly whether the analysis results of a particular lab tend to be too low or too high.

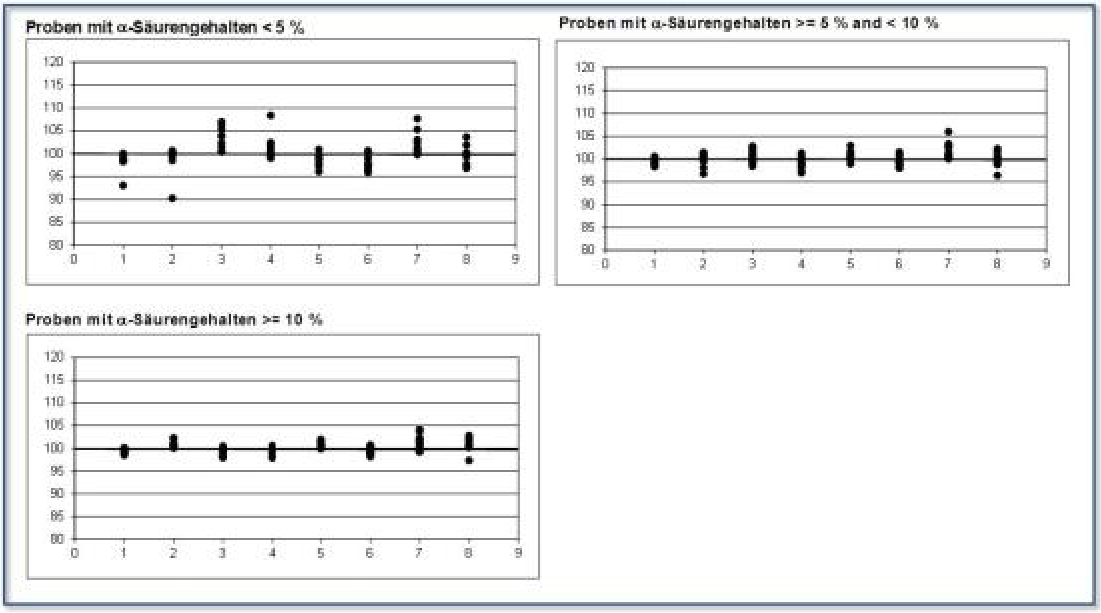


Fig. 8.18: Analysis results of the labs in relation to the mean

The Hüll lab is number 5.

8.7.2 Evaluation of analysis reliability checks

Since 2005, analysis reliability checks have been carried out in addition to the multi-lab ring analysis. These are evaluated by WG IPZ 5d and the findings sent back to the labs involved and to the Hopfenpflanzer- und Hopfenwirtschaftsverband (*Hop Growers'Association* and *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. 8.6*). *Tab. 8.7* gives the results for 2018.

Tab. 8.7: Analysis reliability checks in 2018

Sample	Initial test	Initial	Reliability check			Mean	Result
designation	**laboratory**	**test**	**1**	**2**	**3**	**value**	**validated**
Hall. Tradition Nr. 162247	Agrolab	5.8	5.3	5.3	5.5	5.37	no
Saphir Nr. 16292	Agrolab	3.6	3.2	3.3	3.4	3.30	yes
Hall. Mittelfrüh Nr 16079	Agrolab	4.6	4.3	4.3	4.4	4.33	yes
KW 37 NBR	HHV Au	8.3	8.1	8.3	8.3	8.23	yes
KW 37 HMG	HHV Au	11.6	11.5	11.5	11.4	11.47	yes
KW 37 HKS	HHV Au	17.2	17.0	17.0	17.3	17.10	yes
QK 18/000941	HV Wolnzach	11.7	11.5	11.6	11.8	11.63	yes
QK 18/000949	HV Wolnzach	12.0	12.0	12.1	12,4	12.17	yes
QK 18/000951	HV Wolnzach	12.7	12.5	12.7	12.8	12,67	yes
HHKS KW 39 - 19910	HVG Mainburg	9.8	10.3	10.3	9.9	10.17	yes
HPER KW 39 - 17811	HVG Mainburg	5,2	5.3	5.4	5.4	5.37	yes
ENBR KW 39 - 942362	HVG Mainburg	3.7	3.7	3.8	4.0	3.83	yes
Northern Brewer Nr. 26281	Agrolab	7.6	7.3	7.3	7.4	7.33	yes
Herkules Nr. 26283	Agrolab	15.9	15.5	15.7	15.8	15.67	yes
Hersbrucker Spät Nr. 26213	Agrolab	2.2	1.8	1.8	2,0	1.87	yes
KW 41 EHKS	HHV Au	12,0	11.7	11.8	12.0	11.83	yes
KW 41 EPLA -1	HHV Au	17.0	16.9	17,1	17.2	17.07	yes
KW 41 EPLA-2	HHV Au	16.3	16.2	16.2	16.4	16.27	yes
Agrolab Nr. 26621	HV St. Johann	14.0	13.5	13.6	13.8	13.63	yes
Agrolab Nr. 17691	HV St. Johann	4.3	4.0	4.2	4.2	4.13	yes
Agrolab Nr. 23371	HV St. Johann	12.3	12.0	12.1	12.4	12.17	yes
KW 43 - 24656 HPLA	HVG Mainburg	18.6	18.9	18.9	19.0	18.93	yes
KW 43 - 23964 HHKS	HVG Mainburg	15.2	15.4	15.5	15.5	15.47	yes
KW 43 - 15012 HHMG	HVG Mainburg	9.6	9.6	9.7	9.9	9.73	yes

8.8 Wöllmer Analyses of the New Cultivars from Hüll

The primary role of hop in brewing is to impart a delicate bitterness to the beer. The alpha acids content is an indicator of the bitterness potential of the hop; but the quality of the bitterness is another factor. Apart from the alpha acids, there are many other bittering substances in hop which contribute to the quality of the bitterness. *(*Fig. 8.19*).* In his thesis, Dr. Dresel identified many of these substances by means of LC-MS (thesis TUM 2013).

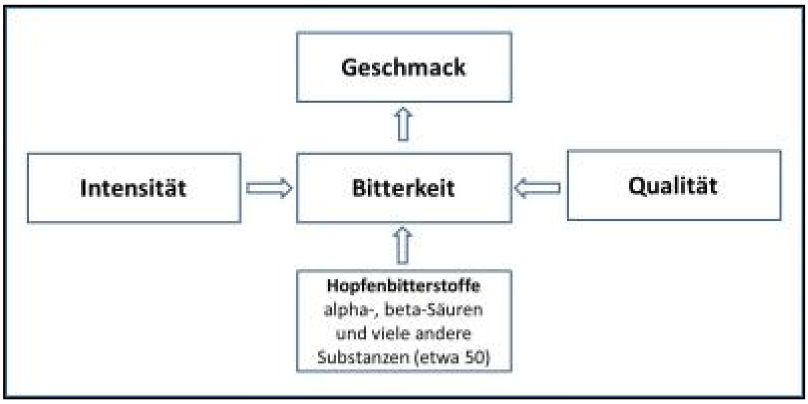


Fig. 8.19: Intensity and quality of the bitterness is determined by many different substances

A hundred years ago, Wöllmer developed a method of differentiating hard and soft resins. The total resin is extracted with ether and split into two resin fractions.The portion soluble in hexane is designated the soft resin fraction; the portion that is not soluble is termed the hard resin fraction. Soft resin is made up of alpha and beta acids and some non-specific components. *(Fig.8.20)*

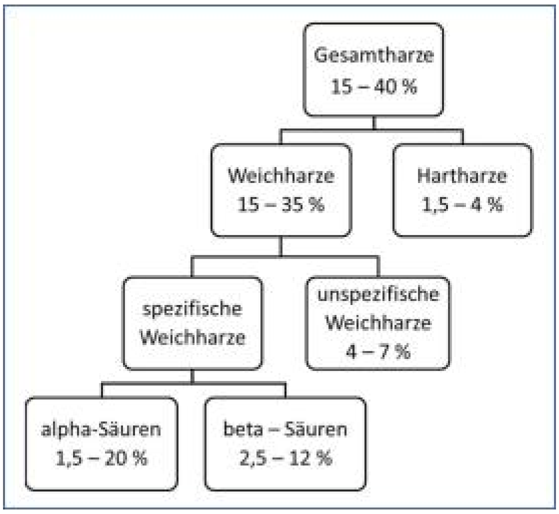


Fig. 8.20: Schematics of a Wöllmer analysis

Non-specific compounds found in soft resin are, for example, cis allo-iso-humulones, hulupones, tricyclohumenes, tricyclolupones, dehydrotricyclolupones and many other substances.

Hard resin consists of compounds only slightly soluble in water, such as xanthohumol and compounds derived from xanthohumol, such as desmethylxanthohumol, xanthohumol B and C. 8-Prenylnaringenin and 6-prenylnaringenin are present in trace amounts. Hard resin components easily soluble in water are the glycosidically bound quercetins and kaempferols and the multifidols.

These compounds were analysed by HPLC in earlier work and the results published (Kammhuber, K.: Differentiation of the World Hop Collection by Means of the Low Weight Molecular Polyphenols, Brewing Science, March/April 2012, Vol. 65, pp. 16 -23).

Tab. 8.8 gives the results for the new Hüll cultivars.

Tab. 8.8: Wöllmer analyses of the new cultivars from Hüll (2017 crop)

Cultivar	Total resin	a acids CV	a acids HPLC	Soft resin	Hard resin	β fraction	β acids HPLC	xanthohumol HPLC
Ariana	24.65	11.92	11.06	21.93	11.05	10.01	5.97	0.62
Ariana	24.68	12.07	11.14	22.21	10.02	10.14	6.04	0.62
Callista	19.82	4.28	3.78	17.47	11.86	13.19	8.72	0.77
Callista	18.89	4.13	3.58	16.75	11.31	12.62	8.57	0.73
Hallertau Blanc	24.70	12.39	11.81	22.75	7.89	10.36	6.79	0.51
Hallertau Blanc	23.76	11.84	11.52	21.84	8.08	10.00	6.58	0.49
Huell Melon	25.87	7.87	7.68	23.00	11.10	15.13	10.26	0.91
Huell Melon	25.24	7.88	7.49	22.28	11.71	14.40	10.02	0.89
Mandarina Bavaria	24.80	10.33	9.96	21.84	11.92	11.51	7.47	0.91
Mandarina Bavaria	25,66	10.91	10.41	22.73	11.41	11.82	7.91	0.96
Opal	21.65	9.49	8.59	19.86	8.27	10.36	6.46	0.52
Opal	21.67	9.51	8.62	19.67	9.25	10.16	6.51	0.52
Polaris	35.40	22.71	21.35	31.93	9.80	9.22	5.13	1.02
Polaris	35.38	23.07	21.51	32.08	9.33	9.01	5.18	1.03
Saphir	17.52	4.56	3.55	15.52	11.40	10.96	6.58	0.52
Saphir	16.68	4.37	3.35	14.82	11.18	10.45	6.16	0.49
Smaragd	18.99	7.42	6.62	17.40	8.35	9.98	6.43	0.38
Smaragd	19.49	7.64	6.72	17.64	9.52	10.00	6.57	0.38
89/002/025	19.11	7.30	6.41	17.22	9.91	9.91	6.42	0.41
89/002/025	19.63	7.59	6.60	17.65	10.07	10.06	6.66	0.42
96/001/024	16.49	4.85	3.85	14.31	13.24	9.46	6.25	0.60
96/001/024	17.02	5.07	4.13	14.88	12.55	9.81	6.71	0.63

Size data: total resin, soft resin, alpha acids, beta acids xanthohumol in % hop, hard resin in % of total resin

β fraction = soft resin - conductometric value

Bitterness value according to Wöllmer is defined: bitterness value = alpha acids + β fraction/9

Since the β fraction is relatively constant, the bitterness value was later equated to the alpha acids concentration. A first pointer to non-specific soft resins is the quotient alpha CV/alpha HPLC. The alpha CV is non-specific, the alpha HPLC highly specific. The higher this value, the higher the concentration of non-specific soft resins. *Fig. 8.21* gives the results for the new Hüll cultivars (in each case a duplicate determination, crop year 2017).

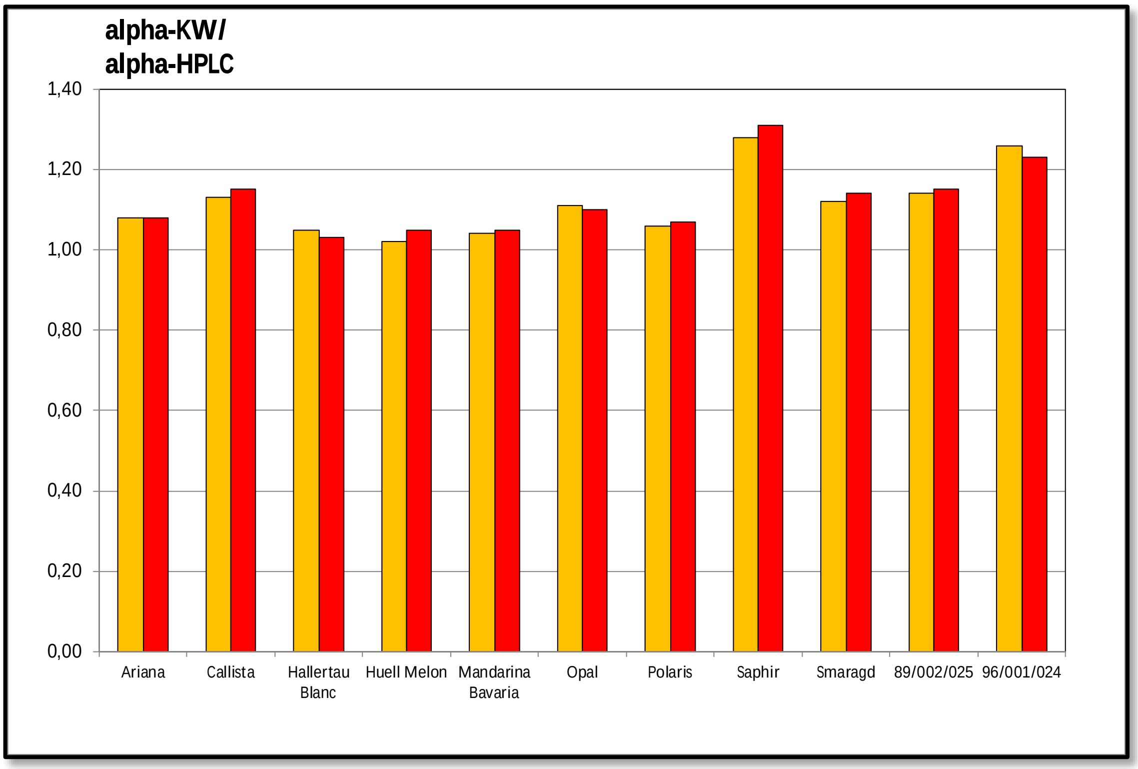


Fig. 8.21: Quotient alpha CV/alpha HPLC (2017crop)

The quotient is highest for cultivar *Saphir*, and almost as high for breeding line 96/001/024. Cultivars *Callista*, *Smaragd*, and breeding line 89/002/025 have relatively high values. High alpha cultivars, such as *Polaris*, have a value close to one.

For more conclusive results, deduct the alpha and beta acids from the soft resin and look at the percentage of non-specific substances. *(*Fig. 8.22*).*

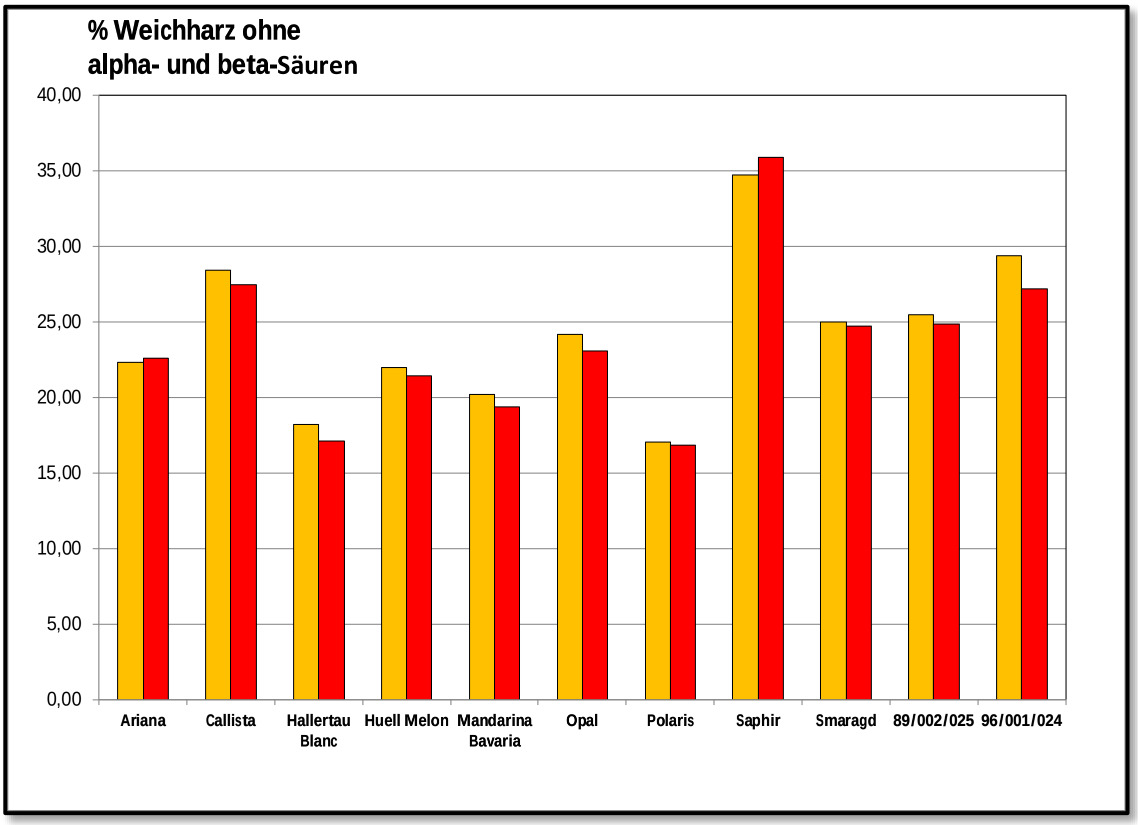


Fig. 8.22: Non-alpha and non-beta portion of the soft resin

At 35 %, cultivar *Saphir* has the highest quotient of non-specific soft resins. Cultivars *Callista*, *Smaragd*, and breeding lines 89/002/025 and 96/001/024 are also characterized by a high proportion of non-specific soft resins. A high concentration of non-specific resins is an indicator of a pleasant, delicate and harmonious bitterness.

8.9 Examination of the Biogenesis of Bitter Compounds and Oils in New Breeding lines

Every year, extensive biogenesis testing of the new breeding lines is carried out, in order to be able to target the right times for harvesting. Tab. 8.9 shows the harvest dates.

Tab. 8.9: Harvest dates from biogenesis testing

T0	T1	T2	T3	T4	T5	T6
16.08.	21.08.	28.09.	04.09.	11.09.	18.09.	25.09.

Fig. 8.23 to 8.30 show the biogenesis of the total oils and bitter compounds of the new cultivars from Hüll. The oil content is given in ml oil/100 g hop, and alpha acids content as a conductometric value in %.

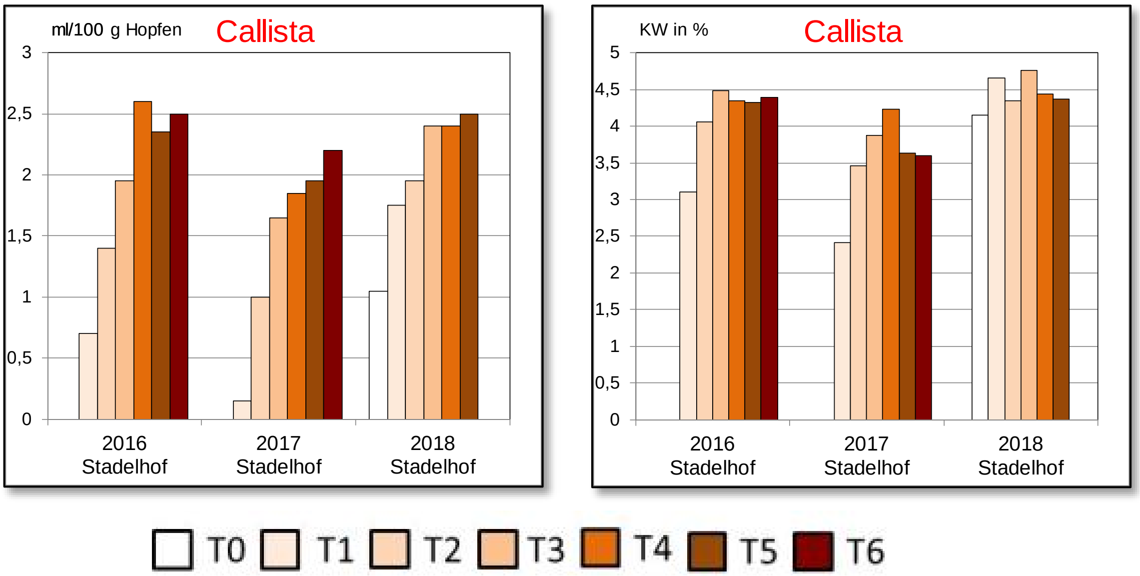


Fig. 8.23: Biogenesis, Callista

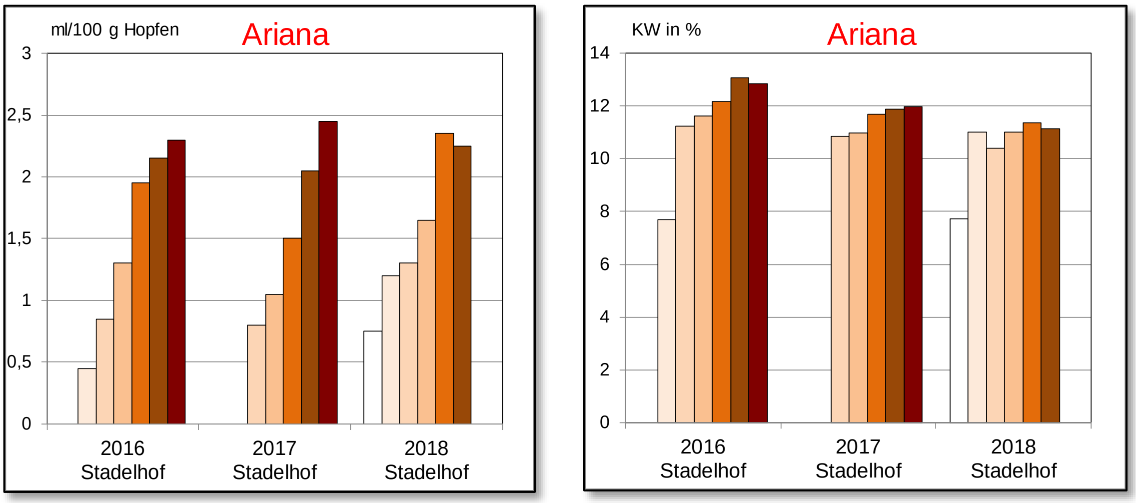


Fig. 8.24: Biogenesis, Ariana

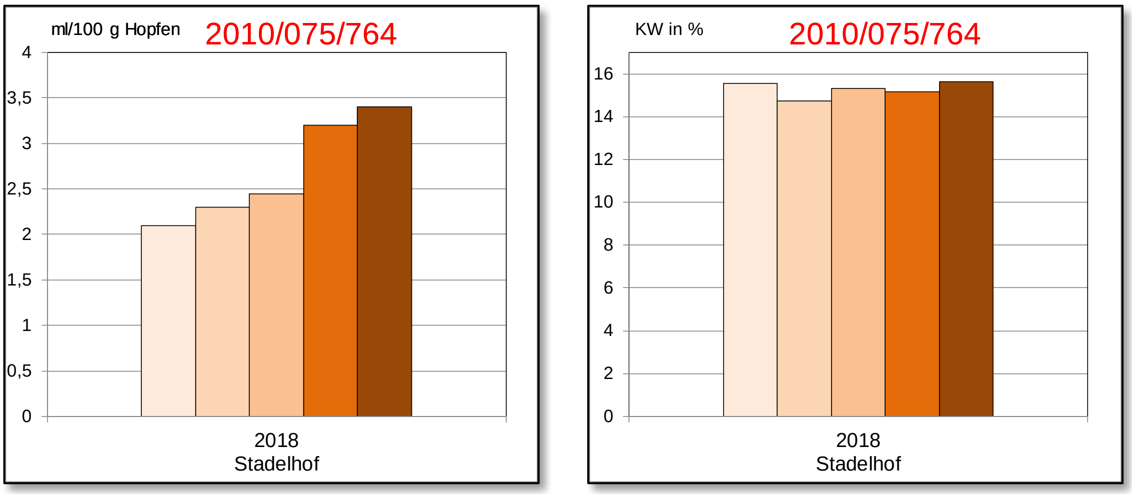


Fig. 8.25: Biogenesis, breeding line 2010/075/764

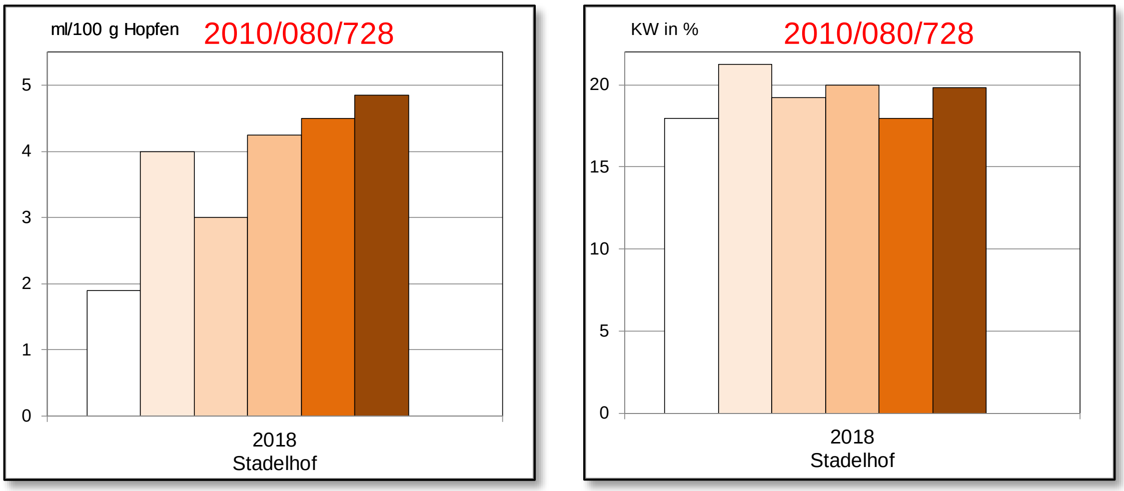


Fig. 8.26: Biogenesis, breeding line 2010/080/728

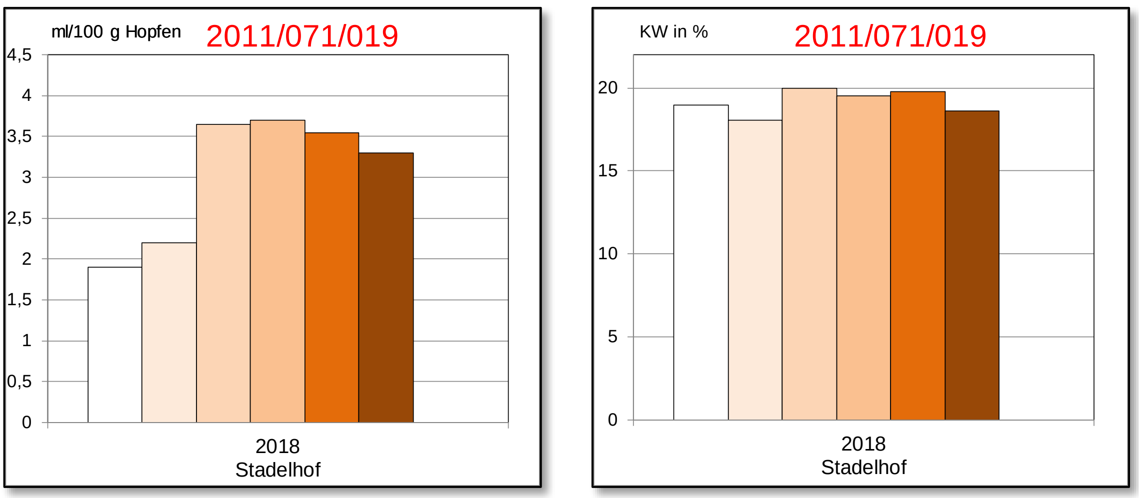


Fig. 8.27: Biogenesis, breeding line 2011/071/019

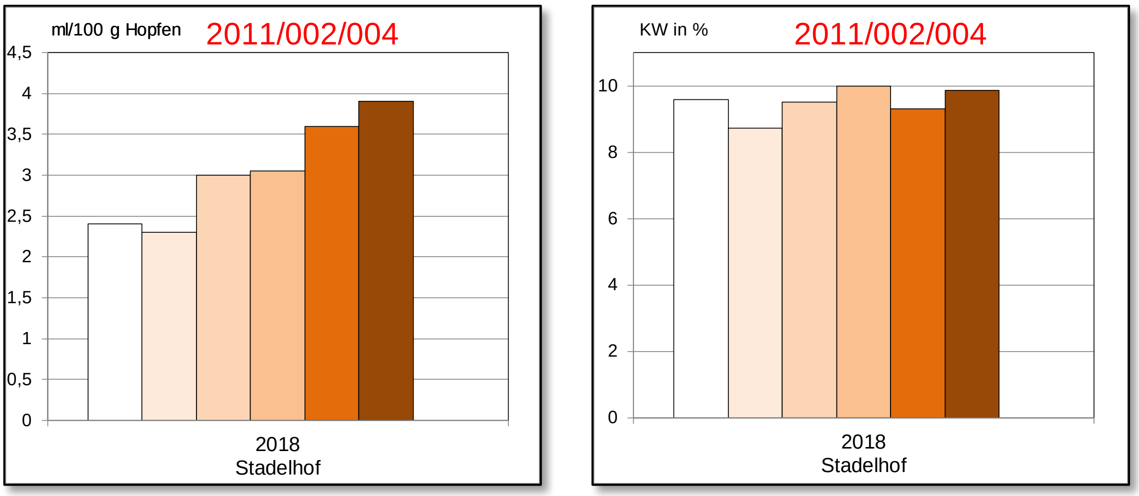


Fig. 8.28: Biogenesis, breeding line 2011/002/004

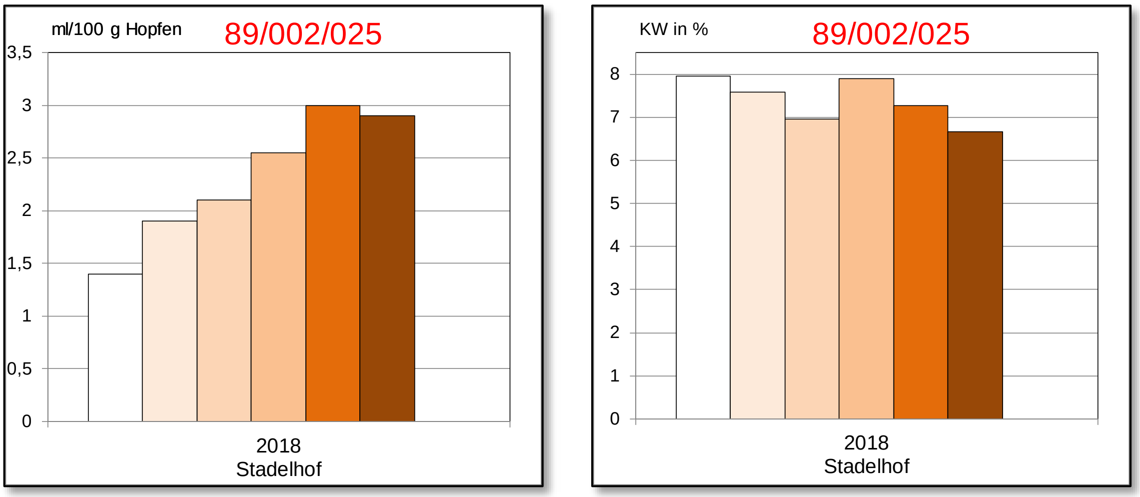


Fig. 8.29: Biogenesis, breeding line 89/002/025

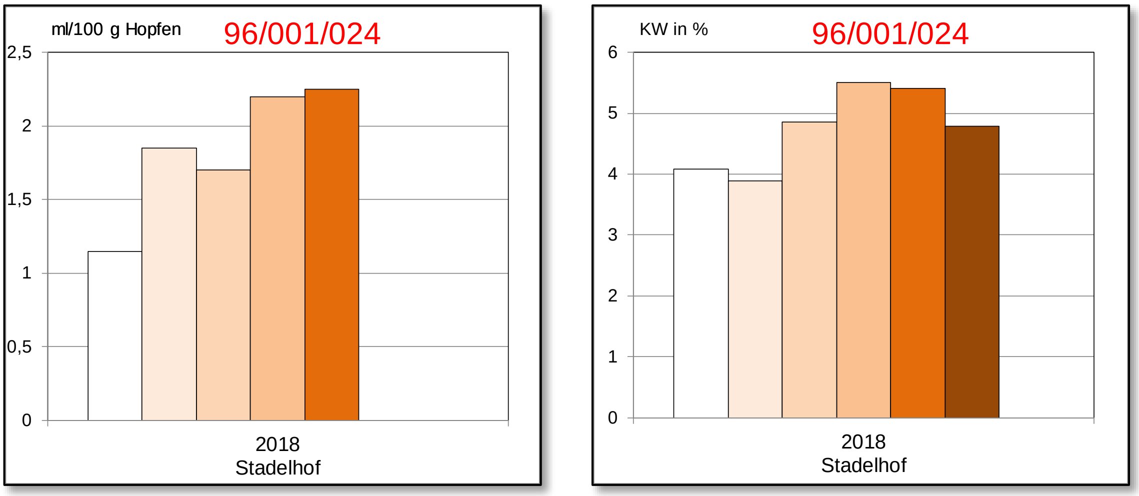


Fig. 8.30: Biogenesis, breeding line 89/002/025

All the charts show that oil content is very much influenced by the harvest date, far more so than the alpha acids content.

8.10 Developing Calibrations on the Basis of Conductometric and HPLC Data with the New Near Infrared Reflectance Spectroscopy Device

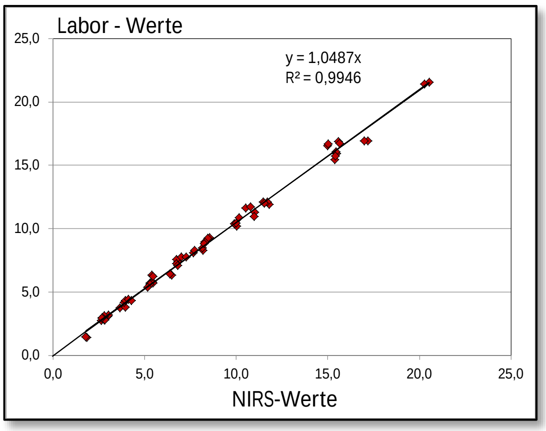
In the spring of 2017, a new NIRS device was purchased, all funding having been provided by the Gesellschaft für Hopfenforschung *(Society of Hop Research*) *(*Fig. 8.31*).*

Fig. 8.31: New NIRS equipment

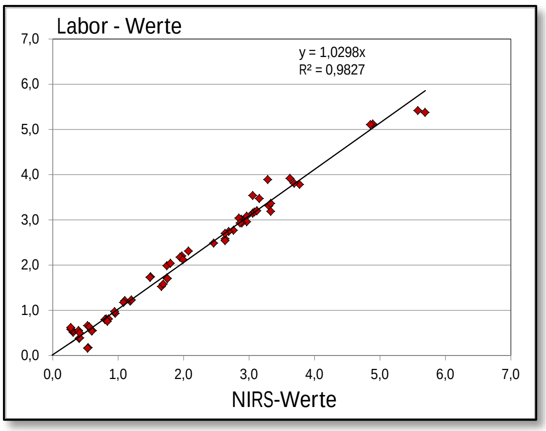
The device is compatible with the equipment at AQU in Freising. The same measuring cells can be used as with the old Foss equipment. The wavelength range goes from 600 to 2500 nm in 1 nm steps. At present, a calibration is running which, through mathematical transformation of the calibration of the old Foss device, has been adapted to suit the new device.

In the past two years, work has begun on developing our own calibration on this device, based on conductometric and HPLC data. Fig. 8.32 shows the correlations of the individual parameters between lab values and NIRS values

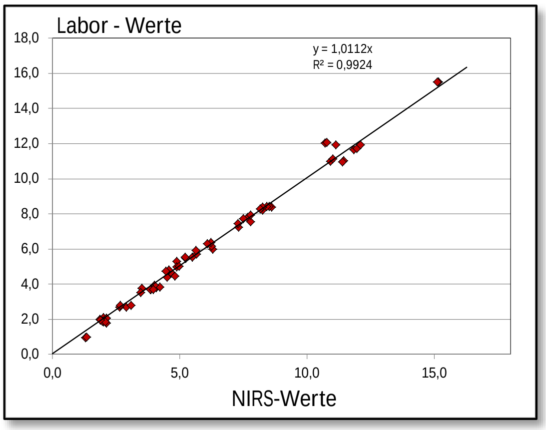
Conductometric value in %



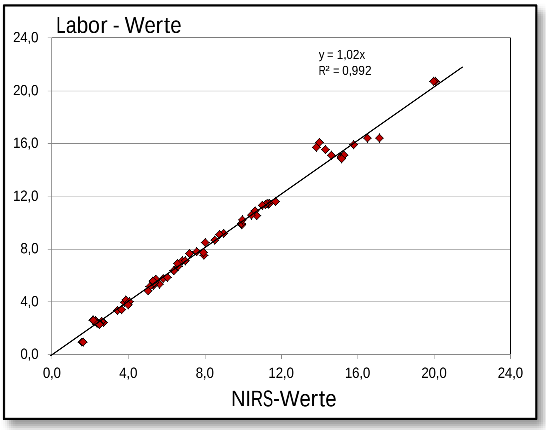
Cohumulone in %



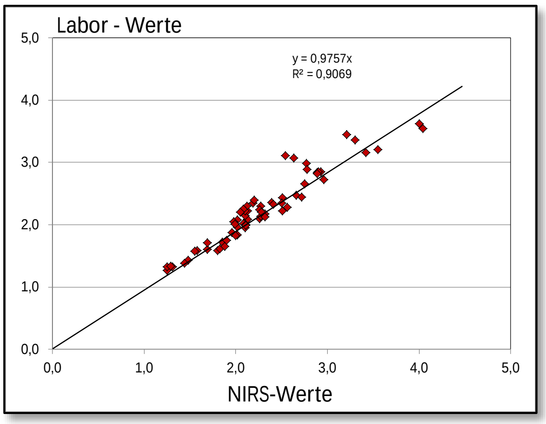
n + Adhumulone in %



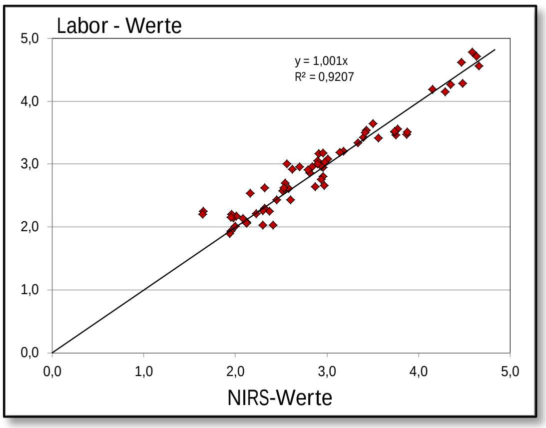
Alpha acids in %



Colupulone in %



n + Adlupulone in %



Beta acids in %

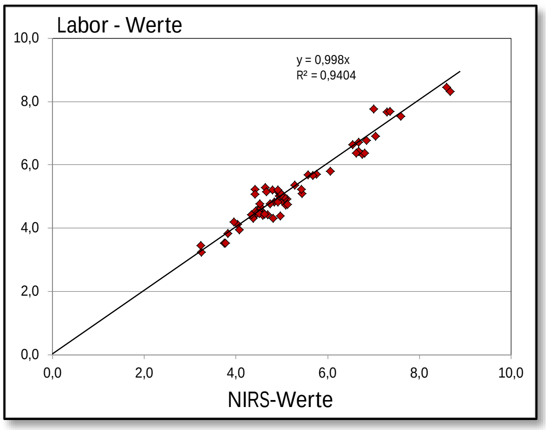


Fig. 8.32: Correlations between lab values and NIRS values

The NIRS values and the lab values are already very close. Especially in the case of the conductometric value, the coefficient of determination at R^2 = 0,9946, is very good. Now, the new device needs as many samples as possible with wet chemical reference values, in order to create new calibrations. As soon as the results delivered by the new device are as good as those from the old equipment, the old device will be replaced.

8.11 Verification of Varietal Authenticity in 2018

Verification of varietal authenticity is a mandatory task for Working Group IPZ 5d, to provide administrative assistance to the food control authorites.

Varietal verifications for the food control authorities
(rural district administration authorities): 5
Number of these not accepted: 0

9 Publications and Specialist Information

9.1 Overview of PR Activities

	Number		Number
Practice-relevant information and scientific papers	36	Guided tours	34
LfL publications	2	Exhibitions/shows and posters	5
Specialist information	25	Expert assessments and opinions	17
Radio and TV broadcasts	2	Practical work experience	9
Internet features	8	Participation in working groups	40
Internal events	4	Trade fairs visited	1
Conferences, symposia, and seminars	14	Lectures and talks	150

9.2 Publications

9.2.1 Practice-relevant information and scientific papers

Euringer, S.; Seigner, E., Kaindl, K.; Lutz, A., Baumgartner, A. (2018): Aubergine als Zeigepflanze für *Verticillium*-verseuchte Böden. Hopfen-Rundschau, 10, 15. Oktober, Hrsg.: Verband Deutscher Hopfenpflanzer , 338 - 339

Euringer, S.; Seigner, E., Lutz, A.; Fuss, S. (2018): Research about *Verticillium* on hops. EBC Symposium, Recent Advances in Hop Science, Hrsg.: European Brewery Convention (EBC), 15 - 15

Fuß, S. (2018): Pflanzenstandsbericht - April/Mai/Juni/Juli/August. Hopfen-Rundschau, August

Kammhuber, K. (2018): Der Erntezeitpunkt beeinflusst die Schwefelverbindungen des Hopfens. Brauwelt Wissen, 21-22 (2018), Brauwelt, Hrsg.: Fachverlag Hans Carl GmbH, 602 - 605

Kammhuber, K. (2018): Ergebnisse von Kontroll- und Nachuntersuchungen für Alphaverträge der Ernte 2017. Hopfen-Rundschau, 08, Hopfen Rundschau, Hrsg.: Hopfenpflanzerverband, 270 - 272

Lutz, A.; Kammhuber, K., Heinzlmaier, M.; Kneidl, J.; Neuhof-Buckl, E.; Petzina, C.; Wyschkon, B. (2018): Bonitierung und Ergebnisse der Deutschen Hopfenausstellung. Hopfen-Rundschau, 12, Hrsg.: Verband Deutscher Hopfenpflanzer, 407 - 411

Münsterer, J. (2018): Berufschüler besuchen Hopfenforschung in Hüll. Hopfen-Rundschau, 69. Jahrgang; Nr. 7, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 228

Münsterer, J. (2018): Flavor-Hopfen optimal trocknen. Brauwelt, 36 (2017), Hrsg.: Fachverlag Hans Carl, 1063 - 1065

Obster, R. (2018): Erste Erfahrungen und Auswertungen im Modellvorhaben "Demonstrationsbetriebe integrierter Pflanzenschutz" im Hopfenanbau. Hopfen-Rundschau, 69. Jahrgang; Nr. 10, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 335 - 336

Obster, R., Gebendorfer, H. (2018): LfL Hoftag: Alternatives Hopfenputzen. Hopfen-Rundschau, 69. Jahrgang; Nr. 8, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 267 - 269

Obster, R., Portner, J. (2018): Arbeitstreffen der Demonstrationsbetriebe integrierter Pflanzenschutz - Hopfen. Hopfen-Rundschau, 69. Jahrgang; Nr. 5, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 154

Portner, J. (2018): Ermittlung des Stickstoffdüngebedarfs von Hopfen in Bayern. Hopfen-Rundschau, 69. Jahrgang; Nr. 4, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 120 - 121

Portner, J. (2018): Flavor-Hopfen - für einen besonderen Biergenuss - LfL präsentiert Hopfen auf der Landesgartenschau in Würzburg. Hopfen-Rundschau, 69. Jahrgang; Nr. 11, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 370 - 372

Portner, J. (2018): Hop Stunt Viroid- und Zitrusviroid-Monitoring. Hopfenrundschau International, 69. Jahrgang; Nr. 5, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 156

Portner, J. (2018): Kostenfreie Rücknahme von Pflanzenschutzverpackungen PAMIRA 2018. Hopfen-Rundschau, 69. Jahrgang; Nr. 8, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 263

Portner, J. (2018): N_{min}-Untersuchung 2018 und endgültige N_{min}-Werte in Bayern. Hopfen-Rundschau, 69. Jahrgang; Nr. 5, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 152 - 153

Portner, J. (2018): Peronosporabekämpfung - Planen Sie Ihren Mitteleinsatz. Hopfen-Rundschau, 69. Jahrgang; Nr. 6, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 190

Portner, J. (2018): Rebenhäcksel baldmöglichst ausbringen! Hopfen-Rundschau, 69. Jahrgang; Nr. 8, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 262

Portner, J. (2018): Zwischenfruchteinsaat im Hopfen planen! Hopfen-Rundschau, 69. Jahrgang; Nr. 6, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 192

Portner, J. (2018): Übermittlung von Angaben im Hopfensektor. Hopfen-Rundschau, 69. Jahrgang; Nr. 5, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 150 - 151

Portner, J., Gebendorfer, H. (2018): Verschärfte Bestimmungen - Stickstoffdüngung im Hopfen muss noch bedarfsgerechter werden - Infoversammlung. Hopfen-Rundschau, 69. Jahrgang; Nr. 3, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 80 - 82

Portner, J., Kammhuber, K. (2018): Fachkritik zur Moosburger Hopfenschau 2018. Hopfen-Rundschau, 69. Jahrgang; Nr. 10, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 346 - 349

Reindl, A., Zehetmeier, M., Fuß, S., Portner, J. (2018): Treibhausgasemissionen im Hopfenbau. Hopfenrundschau International, 2018/2019, Hrsg.: HVG Hop Processing Cooperative, 16 - 24

Reindl, A., Zehetmeier, M.; Fuß, S.; Portner, J. (2018): Treibhausgasemissionen im Hopfenbau. Hopfenrundschau International, 2018/2019, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 16 - 23

Roßberg, D., Portner, J. (2018): Erhebungen zur Anwendung von Pflanzenschutzmitteln im Hopfen. Journal für Kulturpflanzen, 70 (1), Hrsg.: JKI, 25 - 31

Roßberg, D., Portner, J. (2018): PAPA - Hopfen. Hopfen-Rundschau, 69. Jahrgang; Nr. 10, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 342 - 345

Schlagenhaufer, A. (2018): Chlorophyllmessungen im Hopfen zur Bestimmung des Stickstoffernährungszustands. Hopfen-Rundschau, 69. Jahrgang; Nr. 10, Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 334

Seigner, E. (2018): Simon Euringer - Neuer Leiter des Pflanzenschutzes in Hüll - ein gefragter Mann. Hopfenrundschau International, 2018/2019, Hrsg.: Verband Deutscher Hopfenpflanzer, 123 - 123

Seigner, E.; Lutz, A., Kammhuber, K. (2018): Hops from Germany - Special Flavor Hops from Hüll, Hrsg.: Verband Deutscher Hopfenpflanzer

Undas, A. K., Weihrauch, F.; Lutz, A.; van Tol, R.; Delatte, T.; Verstappen, F.; Bouwmeester, H. (2018): The use of Metabolomics to Elucidate Resistance Markers Against Damson-Hop Aphid. Journal of Chemical Ecology, 44 (7-8), Hrsg.: International Society of Chemical Ecology , 711 - 726

Weihrauch, F. (2018): 2. Europäische Kupferfachtagung in Berlin. Hopfen-Rundschau, 69 (1), Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 11 - 11

Weihrauch, F. (2018): Entwicklung eines Maßnahmenkatalogs zur Förderung der Biodiversität im Hopfenbau: Was ist überhaupt möglich? Julius Kühn Archiv, 461, 61. Deutsche Pflanzenschutztagung, 11.-14. September 2018, Universität Hohenheim: Kurzfassungen der Vorträge und Poster, Hrsg.: Julius Kühn-Institut, 223 - 223

Weihrauch, F. (2018): Entwicklung von Methoden zur Bekämpfung des Hopfen-Erdflohs Psylliodes attenuatus im ökologischen Hopfenbau, Projekt-Abschlussbericht, StMELF, 51 Seiten

Weihrauch, F. (2018): Sortenliste 2017 des Internationalen Hopfenbaubüros (IHB). Hopfen-Rundschau, 69(3), Hrsg.: Verband Deutscher Hopfenpflanzer e.V., 84 - 92

Weihrauch, F. (2018): Spider mite management in hop cultivation: state of play, ten years later. DGaaE-Nachrichten, 32(1), Hrsg.: Deutsche Gesellschaft für allgemeine und angewandte Entomologie, 49 - 50

Wolf, S. (2018): Control of Agriotes spp. by the entomopathogenic fungus Metarhizium brunneum (Attracap ®) in hops. DGaaE-Nachrichten, 32(1), Hrsg.: Deutsche Gesellschaft für allgemeine und angewandte Entomologie, 48 - 48

9.2.2 LfL publications

Name(s)	Working Group	LfL publication	Title
Hops Department	IPZ 5	LfL-Information	Annual Report 2017 - Speciality Crop Hop
Portner, J.	IPZ 5a	LfL-Information	Hop 2018 - Grünes Heft *(Green Pamphlet)*

9.2.3 Radio and TV broadcasts

Date	Name(s)	Title	Channel/ Programme
02.03.2018	Weihrauch, F.	Neonicotinoid use in hop production	BR/*Unser Land*
17.11.2018	Lutz, A. Kammhuber, K.	Beer that's good for your health, snail slime, hand prosthetics, dinosaurs	BR/*Gut zu wissen*

9.2.4 Internet features

Author(s)	Title	Target group
Euringer, S. Seigner, E.	Research into and work on the problem of *Verticillium* on hop	Hop growers, hops and brewing industry
Portner, J.	The latest hop production information, and warning service reports	Hop growers
Portner, J.	LfL advanced training courses; KuLaP application 2019; update of areas the application concerns	Hop growers
Portner, J.	Plant protection and latest information	Hop growers
Seigner, E.	Marker-assisted breeding for hop	Hop growers, hops and brewing industry
Seigner, E.	Establishing a detached leaf testing system to assess hop's tolerance to downy mildew	Hop growers, hops and brewing industry
Seigner, E.	Crossbreeding with Tettnanger landrace	Hops and brewing industry, anyone interested in hop
Seigner, E. Lutz, A.	New varieties from Hüll - hop aromas from traditionally hoppy to uniquely fruity	Hops and brewing industry

9.3 Conferences, Talks and Lectures, Guided Tours, Exhibitions/Shows

9.3.1 Seminars, symposia, trade conferences, workshops

Date	Speaker(s)	Event	Venue	Target group
10.01.2018	Münsterer, J.	LfL seminar on the basics of hop drying	Hüll	Hop growers
16.01.2018	Münsterer, J.	LfL seminar on the basics of hop conditioning	Hüll	Hop growers
22.01.2018	Münsterer, J.	Workshop on belt dryers	Hüll	Hop growers
25.01.2018	Münsterer, J.	Workshop on hop drying in a hop kiln	Hüll	Hop growers
26.01.2018	Euringer, S. Seigner, E. Fuss, S. Stampfl, J. Weihrauch, F. Wolf, S.	Workshop on *Verticillium* wilt disease on hop - *Verticillium* in the soil	Hüll	Phytosociological Institute, Bad Goisern – Austria, Bioland, Agency for Food, Agriculture and Forestry, Pfaffenhofen, Hopfenring
01.02.2018	Münsterer, J.	Workshop on belt dryers	Hüll	Hop growers from the Elbe-Saale region
22.02.2018	Münsterer, J.	Workshop on belt dryers	Hüll	Hop growers from the Hallertau region
28.02.2018	Fuss, S. Stampfl, J.	Workshop on irrigation and fertigation	Hüll	Hop growers from the Hallertau region
07.06.2018	Portner, J.	Field day event on application of farm manure on hop	Osselts-hausen	Hop growers
04.07.2018	Portner, J.	Feld day event on issues to do with leaf stripping	Mießling, Schmatz-hausen	Hop growers
16.08.2018	IPZ 5	Training in hop plant assessment	Hüll	Agrolab employees
18.09.2018	Portner, J.	Hop plant assessment	Moosburg	Hops experts, hop growers, the hops trade, brewers
17.10.2018	IPZ 5	Assessment of hop samples from German hop-growing areas	Hüll	Hop experts, hop growers, the hops trade, brewers
17.10.2018	Weihrauch, F.	Round table 2018 on current issues of plant protection for organic hops	Hüll	Organic hop farmers,farms interested in converting to organic, specialist advisors

9.3.2 Internal events hosted

Date	Event	Venue	Target group
07.03.2018	Meeting "Grünes Heft Hopfen" *(Green Pamphlet on Hop)*	Hüll	Staff from regional offices responsible for hop
11.04.2018	DIPS meeting	Wolnzach	Demonstration farms IPS
16.11.2018	Hop advisory committee	Hüll	Experts on hop from the hops and brewing industry, TUM faculty of brewing
11.12.2018	Implementation of the fertilizer ordinance (DüV) in hop production – coordination between federal states	Wolnzach	Desk officers responsible for fertilization matters

9.3.3 Expert assessments and opinions

Date	Dealt with by	Title	Cient
22.08.2018	Fuß, S.	Official hop harvest forecast for 2018 for the Hallertau hop-growing region	StMELF
15.11.2018	Kammhuber, K.	Peer review	*Journal of Agricultural and Food Chemistry*
18.06.2018	Portner, J.	Hop farming and the use of copper	BMEL
14.06.2018	Portner, J.	Work on hops on Sundays and national holidays	LRA Eichstätt
18.05.2018	Portner, J.	Proposals for GAK - MSUL - hops	StMELF
10.04.2018	Portner, J.	EU hop harvest report 2017	StMELF and BMEL
27.03.2018	Portner, J.	Distance requirements - regulations for farmers	StMELF
16.02.2018	Portner, J.	Hops section of the Bavarian Agricultural Report 2018	StMELF
23.04.2018	Portner, J. Stampfl, J.	Expert opinion on irrigation require-ment of hop in the Spalt area	AELF
05.10.2018	Seigner, E.	Peer review	Journal *BrewingScience*
26.11.2018	Weihrauch, F.	Peer review	Journal *Agricultural and Forest Entomology*
27.09.2018	Weihrauch, F.	Peer review	Journal *Agricultural and Forest Entomology*
10.08.2018	Weihrauch, F.	Assessment of ICOAS conference papers	FiBL Austria
02.08.2018	Weihrauch, F.	Evaluation of project outlines	BMBF / PT Jülich
22.07.2018	Weihrauch, F.	Peer review	Journal *Zootaxa*
08.05.2018	Weihrauch, F.	Peer review	Journal *Crop Protection*
15.10.2018	Weihrauch, F. Doleschel, P.	Assessment of Swedish application for approval of use of non-organic hops in the production of organic beer	BMEL, Referat 414

9.3.4 Specialist information

Euringer, S.; Seigner, E., Lutz, A.; Baumgartner, A.: 'Aubergine als Zeigerpflanze für *Verticillium*-verseuchte Böden', Hüll, 30.08.2018, Hopfenrundfahrt 2018, Verband der Deutschen Hopfenpflanzer (Poster)

Euringer, S.; Seigner, E.: 'Forschung und Arbeiten zur *Verticillium*-Problematik bei Hopfen' (Internet-Beitrag)

Euringer, S.; Seigner, E.: 'Projekt zur Welkeforschung bei Hopfen', Freising (LfL-intern-Beitrag)

Lutz, A., Kammhuber, K.: 'Biogenese 2018 - Daten der Hopfenernte 2018 - Erntezeitpunkt T-1 09.08.2018', Hüll, 09.08.2018 (Versuchsergebnisse)

Lutz, A., Kammhuber, K.: 'Biogenese 2018 - Daten der Hopfenernte 2018 - Erntezeitpunkt T0 14.08.2018', Hüll, 16.08.2018 (Versuchsergebnisse)

Lutz, A., Kammhuber, K.: 'Biogenese 2018 - Daten der Hopfenernte 2018 - Erntezeitpunkt T1 21.08.2018', Hüll, 22.08.2018 (Versuchsergebnisse)

Lutz, A., Kammhuber, K.: 'Biogenese 2018 - Daten der Hopfenernte 2018 - Erntezeitpunkt T2 28.08.2018', Hüll, 29.08.2018 (Versuchsergebnisse)

Lutz, A., Kammhuber, K.: 'Biogenese 2018 - Daten der Hopfenernte 2018 - Erntezeitpunkt T3 04.09.2018', Hüll, 05.09.2018 (Versuchsergebnisse)

Lutz, A., Kammhuber, K.: 'Biogenese 2018 - Daten der Hopfenernte 2018 - Erntezeitpunkt T4 11.09.2018', Hüll, 12.09.2018 (Versuchsergebnisse)

Lutz, A., Kammhuber, K.: 'Biogenese 2018 - Daten der Hopfenernte 2018 - Erntezeitpunkt T5 18.09.2018', Hüll, 19.09.2018 (Versuchsergebnisse)

Lutz, A.; Seigner, E., Kneidl, J,; Kammhuber, K.: 'Hüller Zuchtstamm 89/02/25 mit klassisch-feinem Aroma - Großflächenversuchsanbau und Brauversuche' (Poster)

Lutz, A.; Seigner, E., Kneidl, J.; Kammhuber, K.: 'Hüller Zuchtstamm 96/01/24 mit klassisch-feinem Aroma - Großflächenversuchsanbau und Brauversuche' (Poster)

Portner, J.: 'Aktuelle Hopfenbauhinweise und Warndienstmeldungen', Wolnzach (Internet-Beitrag)

Portner, J.: 'Fortbildungsveranstaltungen der LfL; KuLaP-Antragstellung 2019; Aktualisierung der Antragsflächen', Wolnzach, 21.11.2018 (Internet-Beitrag)

Portner, J.: 'Pflanzenschutz und Aktuelles', Wolnzach, 06.08.2018 (Internet-Beitrag)

Seigner, E., Albrecht, T.: 'Präzisionszüchtung für Hopfen' (Internet-Beitrag)

Seigner, E., Forster, B.: 'Etablierung eines Blatt-Testsystems zur Beurteilung der Toleranz von Hopfen gegenüber Falschem Mehltau' (Internet-Beitrag)

Seigner, E., Lutz, A.: 'Kreuzungszüchtung mit der Landsorte Tettnanger' (Internet-Beitrag)

Seigner, E., Lutz, A.; Kammhuber, K.; Albrecht, T.; Mohler, V.; Büttner, B.: 'Genombasierte Präzisionszüchtung für zukunftsweisende Qualitätshopfen', 19.04.2018 (Projekt-Zwischenbericht)

Seigner, E.; Lutz, A., Kneidl, J.; Kammhuber, K.: '2011/02/04 - a New Huell Special Flavor Hop - Large Scale Field Trials and Brewing Trials' (Poster)

Seigner, E.; Lutz, A., Kneidl, J.; Kammhuber, K.: 'Breeding line 89/02/25 with classical noble aroma - Large Scale field trials and brewing trials' (Poster)

Seigner, E.; Lutz, A.: 'Entwicklung von leistungsstarken, gesunden Hopfen mit hohen Alphasäuregehalten und besonderer Eignung für den Anbau im Elbe-Saale-Gebiet - 2. Sachbericht ' (Projekt-Zwischenbericht)

Seigner, E.; Lutz, A.: 'Kreuzungszüchtung mit der Landsorte Tettnanger', 19.03.2018 (Projekt-Zwischenbericht)

Seigner, E.; Lutz, A.: 'Neue Hüller Sorten - mal klassisch hopfig - mal einzigartig fruchtig' (Internet-Beitrag)

Seigner, E.; Portner, J.: 'Große Ehrung für zwei Wissenschaftler der LfL mit dem Hopfenorden des Internationalen Hopfenbaubüros ', Freising, Hopfenrundfahrt 2017, Verband Deutscher Hopfenpflanzer e.V. (LfL-intern-Beitrag)

9.3.5 Talks and lectures

Speaker(s)	Subject/title	Event	Venue, date	Attendees
Doleschel, P.	Update from the Hops Department	Hop production meeting	Hedersdorf, 05.02.2018	15
Doleschel, P.	Update from the Hops Department	Hop production meeting	Spalt, 05.02.2018	36
Doleschel, P.	Update from the Institute for Crop Science and Plant Breeding	Scientists, brewers, malters, breeders, experts on variety	Freising, 06.02.2018	20
Doleschel, P.	Address	General meeting, members of the Hopfenring	Aiglsbach, 06.03.2018	300
Doleschel, P.	Coordinating group plant production	Summer work meeting IPZ	Bad Alexandersbad, 26.07.2018	43
Doleschel, P., Portner, J.; Euringer, S.; Seigner, E.; Lutz, A.; Kammhuber, K.; Weihrauch, F.	LfL Hop Research and Extension Service	Global Hop Summit	Hüll, 28.08.2018	45

Speaker(s)	Subject/title	Event	Venue, date	Attendees
Doleschel, P., Portner, J.; Euringer, S.; Seigner, E.; Kammhuber, K.; Weihrauch, F.	LfL Hops department 2018/2019	Annual review session GfH-LfL	Hüll, 27.11.2018	15
Euringer, S.	Research project presentation: Biological soil decontamination (*Verticillium*)	Supervisory board meeting HVG Hop Producer Group	Wolnzach, 16.01.2018	28
Euringer, S.	*Verticillium* workshop Barth company	Disseminator training for the hops trade	Mainburg, 14.03.2018	16
Euringer, S.	Remote sensing for hop	TWA meeting	Wolnzach, 11.04.2018	25
Euringer, S.	Presentation of GfH *Verticillium* research project	Summer work meeting IPZ	Bad Alexandersbad, 25.06.2018	43
Euringer, S.	Implementation of the plant inspection ordinance – propagation material	Workshop plant inspection ordinance	Hüll, 11.07.2018	9
Euringer, S.	Presentation of *Verticillium* screening yard and sanitation trial	HVG on-site inspection of hops with representatives of Augustiner Brauerei	Engelbrechtsmünster, 17.07.2018	7
Euringer, S.	Plant protection in hop	Global Hop Summit	Hüll, 28.08.2018	45
Euringer, S.	Aubergine as indicator plant for *Verticillium*	Hops tour	Hüll, 30.08.2018	180
Euringer, S.	Plant protection in hop production	GfH Connecting Days	Hüll, 20.11.2018	20
Euringer, S., Fuß, S.	Research project presentation: Biological soil decontamination (*Verticillium*)	Information event BBE Steiner company	Mainburg, 25.09.2018	15
Euringer, S., Portner, J.	Plant protection in hop production: situation at present, outlook for 2019 and leaf wall area for hop	Plant protection and leaf wall area for hop	Braunschweig, 06.12.2018	9
Euringer, S., Portner, J.; Weihrauch, F.	Plant protection in German hop production - situation at present, perpectives	Plant protection conference hop	Pfaffenhofen, 31.08.2018	40
Euringer, S., Seigner, E.	Research into *Verticillium* wilt disease: present situation and objectives	BayWa table talk	Bruckbach, 24.01.2018	28
Euringer, S., Seigner, E.	Research into *Verticillium* wilt disease: present situation and objectives	LfL hop production meeting	Biburg, 29.01.2018	50
Euringer, S., Seigner, E.	Research into *Verticillium* wilt disease: present situation and objectives	LfL hop production meeting	Oberhatzkofen, 30.01.2018	60
Euringer, S., Seigner, E.	Research into *Verticillium* wilt disease: present situation and objectives	LfL hop production meeting	Unterpindhart, 31.01.2018	120
Euringer, S., Seigner, E.	Research into *Verticillium* wilt disease: present situation and objectives	LfL hop production meeting	Osseltshausen, 01.02.2018	105

Speaker(s)	Subject/title	Event	Venue, date	Atten-dees
Euringer, S., Seigner, E.	Research into *Verticillium* wilt disease: present situa-tion and objectives	LfL hop production meeting	Hedersdorf, 05.02.2018	25
Euringer, S., Seigner, E.	Research into *Verticillium* wilt disease: present situa-tion and objectives	LfL hop production meeting	Spalt, 05.02.2018	42
Euringer, S., Seigner, E.	Research into *Verticillium* wilt disease: present situa-tion and objectives	Biolandwoche hop production day	Plankstetten, 06.02.2018	34
Euringer, S., Seigner, E.	Research into *Verticillium* wilt disease: present situa-tion and objectives	LfL hop production meeting	Mainburg, 07.02.2018	170
Euringer, S., Seigner, E.	Research into *Verticillium* wilt disease: present situa-tion and objectives	LfL hop production meeting	Lindach, 07.02.2018	45
Euringer, S., Seigner, E.	Research into *Verticillium* wilt disease: present situa-tion and objectives	LfL hop production meeting	Marching, 09.02.2018	43
Euringer, S., Seigner, E.	Research on *Verticillium* in hop	European Brewery Conven-tion (EBC)	Nürnberg, 11.09.2018	100
Euringer, S., Seigner, E.; Lutz, A.; Fuß, S.	Presentation and discus-sion of programme GfH *Verticillium* project	Meeting *Verticillium* project	Hüll, 26.01.2018	9
Euringer, S., Weihrauch, F.; Portner, J.	Plant protection in hop - current situation in Ger-many and leaf wall area	Commodity Expert Group (CEG) Minor Uses in Hops	Žatec-Slovenia 24.11.2018	15
Fuß, S.	Workshop on irrigation	Workshop irrigation	Hüll, 28.02.2018	15
Fuß, S.	Field day event - issues to do with leaf stripping in hop	Hop production field day event	Mießling/ Schmatzh., 04.07.2018	250
Kammhuber, K.	What influences hop aro-ma? An analytical and sensory approach.	LfL hop production meeting	Biburg, 29.01.2018	50
Kammhuber, K.	What influences hop aro-ma? An analytical and sensory approach.	LfL hop production meeting	Ober-hatzkofen, 30.01.2018	60
Kammhuber, K.	What influences hop aro-ma? An analytical and sensory approach.	LfL hop production meeting	Unter-pindhart, 31.01.2018	120
Kammhuber, K.	What influences hop aro-ma? An analytical and sensory approach.	LfL hop production meeting	Osseltshau-sen, 01.02.2018	105
Kammhuber, K.	What influences hop aro-ma? An analytical and sensory approach.	LfL hop production meeting	Spalt, 05.02.2018	42
Kammhuber, K.	What influences hop aro-ma? An analytical and sensory approach.	LfL hop production meeting	Hedersdorf, 05.02.2018	25
Kammhuber, K.	What influences hop aro-ma? An analytical and sensory approach.	LfL hop production meeting	Mainburg, 07.02.2018	170

Speaker(s)	Subject/title	Event	Venue, date	Atten-dees
Kammhuber, K.	What influences hop aroma? An analytical and sensory approach.	LfL hop production meeting	Lindach, 07.02.2018	45
Kammhuber, K.	What influences hop aroma? An analytical and sensory approach.	LfL hop production meeting	Marching, 09.02.2018	43
Kammhuber, K.	Do we still need Wöllmer analyses?	GfH general meeting of members	Wolnzach, 11.04.2018	25
Kammhuber, K.	Qualitative and quantitative characterization of the trichoma-free and-attached aromatic substances in hop cones and hop leaves for better appraisal of the the aroma potential of male and female hop plants.	StMELF, LfL guided tour	Freising, 15.05.2018	15
Kammhuber, K.	Hop analytics at Hüll	Barth-Haas-Group guided tour	Hüll, 20.11.2018	20
Lutz, A.	Hop breeding, past and present	Old Weihenstephan brewers' association	Freising, 18.10.2018	50
Lutz, A.	Assessment of hop samples from the 2018 crop	IGN get-together of hop regulars	Niederlauterbach, 22.10.2018	25
Lutz, A.	Hop varieties - special aspects	IGN hops event	Obermettenbach, 23.08.2018	120
Lutz, A.	Hop-growing season 2018, weather, maturing of different varieties, pests and diseases	Hops tour	Hallertau, 30.08.2018	180
Lutz, A., Seigner, E.	Breeding of robust high alpha varieties for the Elbe-Saale region	Elbe-Saale hops event	Grävernitz, 27.07.2018	200
Lutz, A., Seigner, E.	The new aroma varieties from Hüll - some hoppy-spicy, some fruity	Barth-Haas-Group	Hüll, 20.11.2018	20
Lutz, A., Seigner, E.	Potential of two breeding lines as successors to Tettnanger and Spalter	GfH-LfL annual review session	Hüll, 27.11.2018	12
Lutz, A., Seigner, E.	Progress in breeding the new varieties from Hüll	GfH-LfL annual review session	Hüll, 27.11.2018	12
Lutz, A., Seigner, E.	The new varieties from Hüll	Staff meeting IPZ 5	Hüll, 03.12.2018	30
Lutz, A., Kneidl, J., Seigner, E.	National honorary awards for hops - an important marketing instrument	Grüne Woche Berlin *(Green Week)*	Berlin, 26.01.2018	100
Lutz, A., Kneidl, J. Seigner, E.	National honorary awards for hops - an important marketing instrument	BRAU Beviale	Nürnberg, 15.11.2018	100
Münsterer, J.	Improving performance and quality in hop drying	General meeting of members of the society for the promotion of medicinal and aromatic plant production in Bavaria e.V.	Allershausen/ Tünzhausen, 27.02.2018	70

Speaker(s)	**Subject/title**	**Event**	**Venue, date**	**Atten-dees**
Münsterer, J.	New findings on control of belt dryers	Spring meeting Elbe/Saale	Herren-schwende, 29.05.2018	45
Münsterer, J.	Field day event on issues to do with leaf stripping	Hop production field day event	Mießling/ Schmatzh., 04.07.2018	250
Obermaier, M., Weihrauch, F.	Establishing predator mites in commercial hop produc-tion with the aid of under-sown plants	Hop production educational trip	Sallingberg, Rohr in NB, 07.08.2018	55
Obermaier, M.	Establishing predator mites in commercial hop produc-tion with the aid of under-sown plants	Hop production educational trip	Sallingberg, Rohr in NB, 08.08.2018	35
Obermaier, M., Weihrauch, F.	Establishing predator mites in commercial hop produc-tion with the aid of under-sown plants	Hops tour	Hüll, 30.08.2018	180
Obermaier, M, Weihrauch, F.	Establishing predator mites in commercial hop produc-tion with the aid of under-sown plants	36th conference of the study group Beneficial Arthropods and Entomopathogenic Nematodes	Bremen, 27.11.2018	42
Obster, R.	The latest on plant protec-tion in hop production	The latest on plant protec-tion in hop production, hops hall HVG	Spalt, 30.05.2018	70
Obster, R.	Field day event on issues to do with leaf stripping	Hop production field day event (DIPS)	Mießling/ Schmatzh., 04.07.2018	250
Obster, R.	Model and demo project *Demonstration farms - integrated plant protection*	Vlf tours (Kelheim rural district)	Einthal, Els-endorf, 07.08.2018	55
Obster, R.	Model and demo project *Demonstration farms - integrated plant protection*	Vlf tours (Freising rural district)	Einthal, Els-endorf, 08.08.2018	30
Obster, R.	Model and demo project *Demonstration farms - integrated plant protection*	Vlf tours	Einthal, Elsendorf, 09.08.2018	50
Obster, R.	Model and demo project *Demonstration farms - integrated plant protection*	Hops tour	Hüll, 30.08.2018	180
Obster, R.	Model project *Demonstra-tion farms - integrated plant protection, sub-project hop farming in Bavaria*	61st plant protection conference	Hohenheim, 11.09.2018	80
Obster, R., Portner, J.	First insights and evalua-tions of model project *Demonstration farms - integrated plant protection in hop farming*	TWA meeting Society of Hop Research GfH	Wolnzach, 11.04.2018	25
Portner, J.	Implementation of the new fertilization ordinance in hop	Disseminator training hops trade	Hüll, 17.01.2018	35

Speaker(s)	Subject/title	Event	Venue, date	Atten-dees
Portner, J.	Establishing nitrogen requirement in hop, in line with the new fertilization ordinance	Informational event agri-trade	Hebrontshau-sen, 22.01.2018	20
Portner, J.	Establishing nitrogen requirement in hop, in line with the new fertilization ordinance	BayWa table talk	Bruckberg, 24.01.2018	30
Portner, J.	Establishing nitrogen requirement in hop, in line with the new fertilization ordinance	LfL hop production meeting	Biburg, 29.01.2018	45
Portner, J.	Establishing nitrogen requirement in hop, in line with the new fertilization ordinance	LfL hop production meeting	Ober-hatzkofen, 30.01.2018	50
Portner, J.	Establishing nitrogen requirement in hop, in line with the new fertilization ordinance	LfL hop production meeting	Unter-pindhart, 31.01.2018	120
Portner, J.	Establishing nitrogen requirement in hop, in line with the new fertilization ordinance	LfL hop production meeting	Osseltshau-sen, 01.02.2018	110
Portner, J.	Establishing nitrogen requirement in hop, in line with the new fertilization ordinance	LfL hop production meeting	Hedersdorf, 05.02.2018	15
Portner, J.	Establishing nitrogen requirement in hop, in line with the new fertilization ordinance	LfL hop production meeting	Spalt, 05.02.2018	40
Portner, J.	Establishing nitrogen requirement in hop, in line with the new fertilization ordinance	LfL hop production meeting	Lindach, 07.02.2018	45
Portner, J.	Establishing nitrogen requirement in hop, in line with the new fertilization ordinance	LfL hop production conference	Mainburg, 07.02.2018	140
Portner, J.	Establishing nitrogen requirement in hop, in line with the new fertilization ordinance	LfL hop production meeting	Marching, 09.02.2018	40
Portner, J.	Implementation of the fertilization ordinance in hop	Training for local hop advisors	Wolnzach, 09.02.2018	10
Portner, J.	Soil fertility	Meeting of the hop study group	Haunsbach, 22.02.2018	15
Portner, J.	Arguments in favour of hop irrigation	Informational event on irrigation	Niederlauter-bach, 19.04.2018	15

Speaker(s)	Subject/title	Event	Venue, date	Atten-dees
Portner, J.	Field day event on issues to do with leaf stripping	Field day event on issues to do with leaf stripping in hop	Mießling, Schmatzhausen 04.07.2018	250
Portner, J.	Guidelines for integrated plant protection in hop farming	Meeting of the supervisory board and advisory council, HVG and Hop Growers' Association	Dresden, 26.07.2018	30
Portner, J.	Implementation of the fertilization ordinance in hop	Summer work meeting IPZ	Bad Alexan-dersbad, 26.07.2018	25
Portner, J.	Guidelines for integrated plant protection in hop farming	Plant protection symposium	Siebenecken, 31.08.2018	45
Portner, J.	Presentation of research projects of WG Hop Farming/Production Tech-niques	Meeting WG Nutrient Balance	Freising, 06.09.2018	15
Portner, J.	A critical look at hop 2018	Opening of the hops and barley trade show	Moosburg a.d. Isar, 20.09.2018	60
Portner, J.	Arguments in favour of hop irrigation	Informational event on irrigation	Niederlauter-bach, 01.10.2018	25
Portner, J.	Arguments in favour of hop irrigation	Local council meeting	Wolnzach, 08.11.2018	40
Portner, J.	Arguments in favour of hop irrigation	Informational event on irrigation	Geisenfeld-winden, 19.11.2018	25
Portner, J.	Research projects of WG Hop Farming/Production Techniques	GfH Connecting Days	Hüll, 20.11.2018	25
Portner, J.	Data and facts concerning hop farming	Technical discussion on plant protection in hop	Braun-schweig, 06.12.2018	9
Portner, J.	Plant protection applica-tion technology in hop	Technical discussion on plant protection in hop	Braun-schweig, 06.12.2018	9
Portner, J., Obster, R.	First insights and evalua-tions of model project *Demonstration farms - integrated plant protection in hop farming*	LfL colloquium series	Freising, 20.11.2018	25
Portner, J., Obster, R.	First insights and evalua-tions of model project *Demonstration farms - integrated plant protection in hop farming*	JKI working conference onDIPD	Berlin, 22.11.2018	25
Portner, J., Wolf, S.; Weihrauch, F.	The latest on plant protec-tion in hop 2018	Spring meeting Elbe/Saale	Hinsdorf, 13.03.2018	45
Schlagenhaufer, A.	Application of commercial farm manure in hop		Osseltshau-sen, 07.06.2018	150

Speaker(s)	Subject/title	Event	Venue, date	Atten-dees
Schlagenhaufer, A.	Vlf hops educational trip	Vlf hops educational trip	Einthal/ Elsendorf, 07.08.2018	55
Schlagenhaufer, A.	Vlf hops educational trip	Vlf hops educational trip	Einthal/ Elsendorf, 08.08.2018	30
Schlagenhaufer, A.	Vlf hops educational trip	Vlf hops educational trip	Einthal/ Elsendorf, 09.08.2018	50
Schlagenhaufer, A.	Hops tour 2018	Hops tour	Hüll, 30.08.2018	180
Seigner, E.	Applied research on hops at the Bavarian State Research Center for Agriculture	Certified Brewmaster Course	Hüll, 28.06.2018	39
Seigner, E.	Moderation of the session: Hop Breeding, Hop Growing	EBC (European Brewery Convention) Hop Symposium	Nürnberg, 11.09.2018	100
Seigner, E., Lutz, A.	Crossbreeding with Tett-nanger landrace	Hops staff meeting at the Ministry for Rural Affairs, Baden-Württemberg	Stuttgart, 22.02.2018	15
Seigner, E., Lutz, A.	Applied research on hops at the Bavarian State Research Center for Agriculture	Guided tour for students of gastronomic sciences from Pollenzo University	Hüll, 12.04.2018	34
Seigner, E., Lutz, A.	Hop Breeding Research	Global Hop Summit	Hüll, 28.08.2018	45
Seigner, E., Lutz, A.	Hop breeding, application for plant variety protection rights (PVP) and variety release	Visit of the Russian union of Russian barley, malt, hops, and brewery producers to StMELF	München, 26.09.2018	25
Seigner, E., Lutz, A.	LfL hop breeding research	Guided tour Barth-Haas-Group	Hüll, 20.11.2018	20
Seigner, E., Lutz, A.	Phenotyping PM resistance for genome-wide association mapping	GHop project partners	Stuttgart, 21.11.2018	10
Seigner, E., Lutz, A.	Marker-assisted selection for hop	GHop project partners	Stuttgart, 21.11.2018	10
Seigner, E., Lutz, A.	Information on current status of the GHop project	Annual review session GfH-LfL	Hüll, 27.11.2018	12
Seigner, E., Lutz, A.	Breeding for PM resistance in hop - PM isolates and detached leaf assay	Annual review session GfH-LfL	Hüll, 27.11.2018	12
Seigner, E., Lutz, A.; Kammhuber, K.; Albrecht, T.; Mohler, V.	Genome-based marker-assisted selection for the quality hops of the future	TWA meeting	Wolnzach, 11.04.2018	25
Stampfl, J.	Irrigation and fertigation of hops		Wolnzach, 25.01.2018	10
Stampfl, J.	Workshop on irrigation	Workshop on irrigation	Hüll, 28.02.2018	15

Speaker(s)	Subject/title	Event	Venue, date	Atten-dees
Stampfl, J.	Interim report: Improvement of nutrient use efficiency in hop through fertigation	AR meeting of HVG	Wolnzach, 11.12.2018	20
Stampfl J.	Improvement of nutrient use efficiency in hop	Lecture as part of Bachelor's degree course in agriculture	Freising, 17.12.2018	15
Weihrauch, F.	The latest from hop research: results 2017 and a look at upcoming projects	Bioland hop production day	Kloster Plankstetten, 06.02.2018	34
Weihrauch, F.	Current research projects concerned with plant protection in hop production	Technical discussion plant protection in hop	Bonn, 28.02.2018	23
Weihrauch, F.	Research project: Hops and Biodiversity - are the two compatible?	Meeting of the science and technology advisory committee (TWA) of the GfH Society of Hop Research	Wolnzach, 11.04.2018	32
Weihrauch, F.	Establishing predator mites in commercial hop production with the aid of undersown plants	Hop production educational trip	Sallingberg, Rohr in Niederbayern, 09.08.2018	50
Weihrauch, F.	Ecological issues of hop cultivation	Global Hop Summit	Hüll, 28.08.2018	45
Weihrauch, F.	Developing a package of measures to promote biodiversity in hop production: What can be done?	61st German plant protection conference	Universität Hohenheim, 12.09.2018	55
Weihrauch, F.	Research project: Hops and Biodiversity - are the two compatible?	Meeting of regional BBV delegates	Uttenhofen, 30.10.2018	80
Weihrauch, F.	Results of the German organic movement's monitoring programme of copper applications and implications of copper minimization strategy	3rd European Conference on the use of copper as a plant protection agent	Berlin, 16.11.2018	85
Weihrauch, F.	Ecological issues of hop cultivation	GfH Connecting Days	Hüll, 20.11.2018	20
Weihrauch, F., Doleschel, P.	Developing a package of measures to promote biodiversity in hop production: What can be done?	Supervisory board meeting HVG Hop Producer Group	Wolnzach, 16.01.2018	28
Weihrauch, F., Kienzle, J.	Application for funding of studies concerned with approval of Quassia amara as a basic substance as per § 23 of regulation (EC) No.1107/2009	Supervisory board meeting HVG Hop Producer Group	Wolnzach, 16.08.2018	30
Weihrauch, F., Schwab, S.	Minimizing use of copper-based fungicides in ecological and integrated hop production	Supervisory board meeting HVG Hop Producer Group	Wolnzach, 11.12.2018	25

Speaker(s)	Subject/title	Event	Venue, date	Atten-dees
Weihrauch, F., Wolf, S.	Plant protection in hop production 2018: limitations and possibilities	BayWa table talk	Bruckbach, 24.01.2018	28
Weihrauch, F., Wolf, S.	Plant protection in hop production 2018: limitations and possibilities	LfL hop production meeting	Osseltshausen, 01.02.2018	105
Weihrauch, F., Wolf, S.	Plant protection in hop production 2018: limitations and possibilities	LfL hop production meeting	Hedersdorf, 05.02.2018	25
Weihrauch, F., Wolf, S.	Plant protection in hop production 2018: limitations and possibilities	LfL hop production meeting	Spalt, 05.02.2018	42
Weihrauch, F., Wolf, S.	Plant protection in hop production 2018: limitations and possibilities	LfL hop production meeting	Marching, 09.02.2018	43
Wolf, S.	The latest on plant protection in hop 2018	Informational event for representatives of hop-trading companies	Hüll, 17.01.2018	45
Wolf, S.	Plant protection in hop production 2018: limitations and possibilities	Informational event Beiselen company	Hebrontshausen, 22.01.2018	25
Wolf, S.	Ecological hop production - new plant protection options?	Biolandwoche hop production day	Plankstetten, 06.02.2018	45
Wolf, S.	Technical discussion on plant protection in hop production 2018	Technical discussion on plant protection in hop	Bonn, 28.02.2018	23
Wolf, S., Weihrauch, F.	Plant protection in hop production 2018: limitations and possibilities	LfL hop production meeting	Biburg, 29.01.2018	50
Wolf, S., Weihrauch, F.	Plant protection in hop production 2018: limitations and possibilities	LfL hop production meeting	Oberhatzkofen, 30.01.2018	60
Wolf, S., Weihrauch, F.	Plant protection in hop production 2018: limitations and possibilities	LfL hop production meeting	Unterpindhart, 31.01.2018	120
Wolf, S., Weihrauch, F.	Plant protection in hop production 2018: limitations and possibilities	LfL hop production meeting	Mainburg, 07.02.2018	170
Wolf, S., Weihrauch, F.	Plant protection in hop production 2018: limitations and possibilities	LfL hop production meeting	Lindach, 07.02.2018	45

9.3.6 Trade fairs and exhibitions/shows

Date	Supervisor	Event	Venue	Target group
21.- 25.05.2018	Portner, J.	Regional horticultural show	Würzburg	Consumers
17.- 20.07.2018	Portner, J.	Hops at the regional horticultural show in Würzburg	Würzburg	Consumers

9.3.7 Practial work experience

Subject	Supervisor	Work experience participant	Start	Finish
Hops and analytics	Kammhuber, K.	Technical college FOS Landshut Schönbrunn	17.09.2018	15.02.2018
Hops and analytics	Kammhuber, K.	Technical college FOS Landshut Schönbrunn	02.10.2017	09.02.2018
Research concerned with hop	Lutz, A.	Student at Hochschule Weihenstephan-Triesdorf	01.10.2018	26.10.2018
Research concerned with hop	Lutz, A.	Student at TUM	30.07.2018	24.08.2018
Research concerned with hop	Lutz, A.	High school student (Gymnasium)	09.07.2018	13.07.2018
Research concerned with hop	Lutz, A.	High school student (Gymnasium)	09.07.2018	13.07.2018
Research concerned with hop	Lutz, A.	ATA trainee	02.07.2018	20.07.2018
Research concerned with hop	Lutz, A.	Technical college FOS Landshut Schönbrunn	05.03.2018	20.07.2018
About hop for instruction at vocational school	Münsterer, J.	Vocational school training activity	27.10.2017	01.10.2018

9.3.8 Guided tours

Date	Name	Subject/title	Guests	Attendees
12.07.2018	Doleschel, P. Lutz, A.	Hop research at the LfL	TOP-Management participants, summer excursion	28
03.07.2018	Kammhuber, K. Weihrauch, F.	Hop analytics, ecological hop production, hop research in general	Farmers interested in hop production, consultants, brewers and the press	50
07.03.2018	Lutz, A.	Hop research at the LfL, hop breeding, hop production	Freie Wähler (political group) Wolnzach	25
06.07.2018	Lutz, A.	Hop research at the LfL, hop breeding, hop aroma, beer tasting	People interested in hops	25
14.08.2018	Lutz, A.	Hop research at the LfL, hop breeding	HVG, US hop growers	2
16.08.2018	Lutz, A.	Hop breeding, developing varieties, maturing	Hopfenring	80
20.08.2018	Lutz, A.	Hop breeding	BayWa	2
01.09.2018	Lutz, A.	Hop research at the LfL, hop breeding and varieties	AB-InBev, craft brewers and photographic team	5
20.09.2018	Lutz, A.	Hop research at the LfL, hop breeding, hop varieties, hop production	Vocational school Munich students studying brewing science	60
26.09.2018	Lutz, A.	Hop Research at the LfL, hop breeding, hop aroma	Brauer, IGN	3
23.10.2018	Lutz, A.	Hop research at the LfL, hop breeding	US hop traders and brewers	7
24.10.2018	Lutz, A.	Grüne Woche 2019 (*Green Week)* speciality crops stand	Federal Agency for Agriculture and Food	1

Date	**Name**	**Subject/title**	**Guests**	**Attendees**
16.08.2018	Lutz, A. Seigner, E.	Hop research at the LfL, hop breeding, Tettnanger breeding programme	Journalists	2
17.09.2018	Lutz, A. Seigner, E.	Fact-finding visit, hop varieties, breeding, farming	Nateco, Dr. Wuzik	1
16.01.2018	Lutz, A. Seigner, E. Kammhuber, K.	Hop research at the LfL, hop breeding, hop analytics, GfH membership	Diageo, Innovation team; Barth Haas Group	6
29.08.2018	Lutz, A. Seigner, E. Kammhuber, K. Weihrauch, F.	Hop breeding, hop varieties, plant protection, ecological issues, hop analytics	AB-InBev, Global Hop Network	42
17.07.2018	Lutz, A. Weihrauch, F.	Hop research at the LfL, hop breeding, ecological hop production	Comptoir Agricole and French agricultural college	55
21.09.2018	Seigner, E.	Hop research at the LfL, hop breeding, hop analytics, hop breeding, harvest	AB-InBev, management	2
24.09.2018	Seigner, E.	Hop research at the LfL, hop breeding, hop aroma	AB-InBev, GPO department	40
29.09.2018	Seigner, E.	Hop research at the LfL, hop breeding, hop aroma and analytics	AB-InBev, brewers, craft brewers	20
31.10.2018	Seigner, E.	Hop farming in Germany, hop breeding, hop varieties	High school student from Gymnasium Neustadt	1
19.06.2018	Seigner, E. Euringer, S.	Hop research at the LfL, Hop production, hop breeding, *Verticillium* research	BoKu Vienna and TUM, Chair of Agricultural Systems Technology	11
17.09.2018	Seigner, E. Euringer, S.	Hop research at the LfL, hop breeding, hop farming, hop analytics	High school Burkhart-Gymnasium Mallersdorf-Pfaffenberg	23
12.04.2018	Seigner, E. Weihrauch, F.	Hop research at the LfL, hop breeding, plant protection, hop analytics, ecological issues in hop production	Students of gastronomic sciences from the University of Pollenzo	34
08.05.2018	Seigner, E. Kammhuber, K.	Hop research at the LfL	Students, Den Bosch agricultural college	30
11.05.2018	Seigner, E. Kammhuber, K.	Hop research at the LfL	AB-InBev, Global Brewmaster Class	55
30.05.2018	Seigner, E. Kammhuber, K.	Hop aroma compounds	TUM, Brewing faculty; Kirin	2
03.07.2018	Seigner, E. Kammhuber, K.	Hop research	Students, TUM, chair of beverage and brewing technology	20
09.08.2018	Seigner, E. Kammhuber, K.	Hop research at the LfL	AB-InBev, economics students (GMBA)	32
04.09.2018	Seigner, E. Kammhuber, K.	Hop research at the LfL, hop breeding, hop analytics	Polar, Heineken	4
07.09.2018	Seigner, E. Kammhuber, K.	Hop research at the LfL, hop research, plant protection, hop analytics	Kloser Group, US craft brewers, beer consultant, distributor	4
09.11.2018	Seigner, E. Kammhuber, K.	Hop research at the LfL, hop breeding, cultivars, hop analytics	US Brewers‘ Association	2

Date	Name	Subject/title	Guests	Attendees
09.11.2018	Seigner, E. Kammhuber, K.	Hop research at the LfL, hop breeding, hop analytics, Huell hop cultivars	Tsingtao Brewery	4
28.06.2018	Seigner, E. Kammhuber, K. König, W., GfH	Hop research at the der LfL, hop breeding, hop production, plant protection, hop analytics	VLB, Certified Brewmaster Course	39

9.3.9 Exhibitions/shows and posters

<table>
<tr><th>Author(s)</th><th>Title</th><th>Event/Venue</th><th>Organizer</th></tr>
<tr><td>Euringer, S.
Seigner, E.</td><td>Aubergine as an indicator plant for Verticillium-contaminated soils</td><td>Hops tour 2018, Hüll</td><td>Association of German Hop Growers</td></tr>
<tr><td>Lutz, A.
Seigner, E.</td><td>Hüll breeding line 89/02/25
with its classic noble aroma</td><td rowspan="4">Various guided tours</td><td rowspan="4">LfL, IPZ 5</td></tr>
<tr><td>Lutz, A.
Seigner, E.</td><td>Hüll breeding line 96/01/24 with its classic noble aroma</td></tr>
<tr><td>Seigner, E.
Lutz, A.</td><td>2011/02/04 - a new Huell Special Flavor Hop</td></tr>
<tr><td>Seigner, E.
Lutz, A.</td><td>Breeding line 89/02/25 with its classic noble aroma</td></tr>
</table>

9.4 Participation in Working Groups, Memberships

Member	Organization
Doleschel, P.	Bavarian Plant Breeding Society
	DLG e.V., German Agricultural Society
	DLG Committee for Plant Breeding and Seed Science
	GIL Society of Computer Science in Agriculture, Forestry and Food Science e.V.
	Society of Hop Research
	Society for Plant Cultivation Sciences e.V.
	Society of Plant Breeding
	ISIP e.V. (Information System Integrated Plant Production)
	Potato Health Service Bavaria
	LKP
	Test Team for Seed Potatoes in Bavaria
Euringer, S.	EU Commodity Expert Group Minor Uses Hops
	Young Hop Growers e.V.
Fuß, S.	Board of Examiners for Qualified Agriculturalist at Landshut authority for continuing education
Kammhuber, K.	Hop Analytics Working Group (AHA)
	European Brewery Convention (Hops Sub-committee), Analysis committee
	Society of German Chemists (GDCH)
Laupheimer, S. (née Wolf)	EU Commodity Expert Group (CEG) Minor Uses in Hops
Münsterer, J.	Board of Examiners for Qualified Agriculturalist at Landshut authority for continuing education
Portner, J.	WG Sustainability in Hop Production
	JKI Advisory Committee – equipment approval procedure for assessing plant production equipment
	JKI Federal States WG Monitoring Plant Protection Equipment
	Boards of Examiners Lower Bavaria, Upper Bavaria East, Upper Bavaria West, for Qualified Agriculturalist
Seigner, E.	Society of Hop Research
	Society of Plant Breeding
Weihrauch, F.	Consortium of Bavarian Entomologists e.V.
	British Dragonfly Society
	DGaaE, German Society for General and Applied Entomology
	DGaaE, Study Group Neuroptera
	DgaaE, Study Group Beneficial Arthropods and Entomopathogenic Nematodes
	DgfO, German Society of Orthopterology
	DPG, German Phytomedicinal Society
	EU Commodity Expert Group (CEG) Minor Uses in Hops: Chair (from 20.03.2018)
	Society of German-speaking Odonatologists e.V.
	Society of Hop Research e.V.
	Munich Entomological Society e.V.
	Red List Working Group Germany's Neuroptera
	Red List- Working Groups Bavaria's Dragonflies and Neuroptera
	Scientific-Technical Commission of the International Hop Growers' Convention: Chair
	Worldwide Dragonfly Society

10 Personnel IPZ 5 - Hops Department

The following members of staff were employed at the Bavarian State Research Center for Agriculture (LfL), Institute for Crop Science and Plant Breeding at Hüll / Wolnzach / Freising in 2018
(WG = Working Group):

IPZ 5

Coordinator: Director at LfL Dr Doleschel Peter

Hertwig Alexandra
Krenauer Birgit

IPZ 5a

AG Hopfenbau, Produktionstechnik
(WG Hop Farming/Production Techniques)
Lead: LD Portner Johann

Fischer Elke
LA Fuß Stefan
LAR Münsterer Jakob
B.Sc. Obster Regina
B.Sc. Schlagenhaufer Andreas (from 01.03.2018)
M.Sc. Stampfl Johannes

IPZ 5b

AG Pflanzenschutz im Hopfenbau
(WG Hop Plant Protection)
Lead: Dipl.-Biol. Dr Weihrauch Florian (acting lead till 30.06.2018)
M.Sc. Simon Euringer (from 01.07.2018)

M.Sc. Euringer Simon (bis 30.06.2018)
Dipl.-Ing. agr. (Univ.) Baumgartner Anna (from 15.05.2018)
Felsl Maria
M.Sc. Laupheimer, Silvana (née Wolf)
B.Sc. Lutz Kathrin (from 29.10.2018)
LI Meyr Georg
BTA Mühlbauer Marlene
Weiher Johann

IPZ 5c

AG Züchtungsforschung Hopfen
(WG Hop Breeding Research)
Lead: RD Dr Seigner Elisabeth

Brummer Brigitte
LTA Enders Renate
CTA Forster Brigitte
Graßl Herbert
Grebmair Hermann
CTA Hager Petra
LTA Haugg Brigitte
Hock Elfriede
Agr.-Techn. Ismann Daniel
LTA Kneidl Jutta
LAR Lutz Anton
Maier Margret
Mauermeier Michael (till 30.09.2018)
Ostermeier Sonja (from 01.02.2018)
Penger Leonhard (from 14.05.2018, † 07.10.2018)
Pflügl Ursula

IPZ 5d

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

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

IPZ 5e

AG Ökologische Fragen des Hopfenbaus
(*WG Ecological Issues in Hop Cultivation)*
Lead: Dipl.-Biol. Dr Weihrauch Florian

M.Sc. Obermaier Maria (from 01.05.2018)