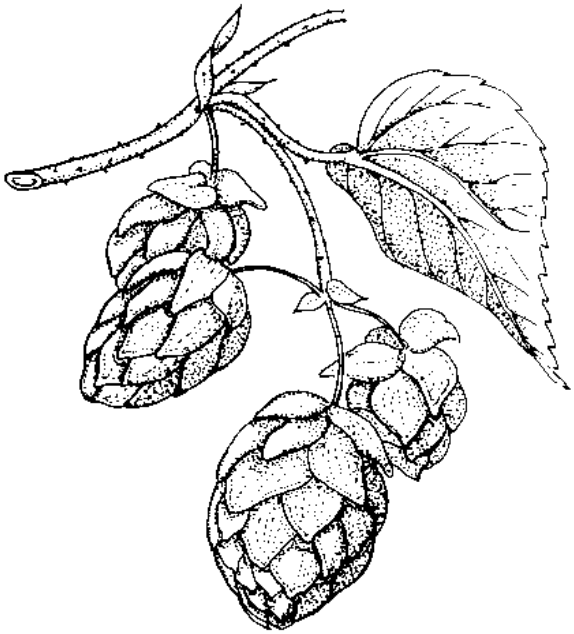
LfL

Bavarian State Research Center for

Report 2003
Special Edition for Hops



Bavarian State Research Center for Agriculture
- Institute for Crop Production and Plant Breeding -

and

Society of Hop Research

March 2004

Information

TABLE OF CONTENTS

1 Hop Research - Research projects and main research areas

1.1 Current research projects

Development of molecular selection markers for mildew resistance to support effectively breeding of quality hops (*Humulus lupulus*) (Wifö-Nr. B 80)

Bayerische Landesanstalt für Landwirtschaft,
(Bavarian State Research Center for Agriculture)
Institut für Pflanzenbau und Pflanzenzüchtung
(Institute for Crop Production and Plant Breeding)

Financed by: Hopfenverwertungsgesellschaft e.G.
Wissenschaftsförderung der Deutschen Brauwirtschaft e. V.
(Scientific Funds of the German Brewing Industry)

Project Manager: Dr. S. Seefelder; ORRin Dr. E. Seigner

Cooperation: Dr. F. Felsenstein, EpiLogic GmbH Agrarbiologische Forschung und Beratung, Freising

Working on project: Dr. S. Seefelder, LTA P. Bauer (until 30.06.03), LTA L. Logothetis, CL V. Mayer, LA A. Lutz, ORRin Dr. E. Seigner

Duration: 01.05.2002- 31.06.2005

Target: Working out molecular selection markers to speed up the breeding of mildew resistance in hops

Results:

- After artificial infection with a specific powdery mildew (PM) isolate the resistance data was ascertained from two mapping populations segregating for the resistance gene WH 25 and one mapping population with the wild hops WH 49. In addition to this plants of earlier mapping populations, where the infection tests did not allow a final assessment of their PM resistance in 2002, were retested at EpiLogic. The phenotypical data showed good compliance with the molecular data.

- The search for molecular markers for the resistance gene R2 in the 'Wye Target' variety was pushed ahead. Besides the marker R2-I-181 a further 9 DNA fragments were identified which could be found in the powdery mildew resistant seedlings of all the R2 mapping populations investigated. The verification of these DNA fragments associated with PM resistance in a spectrum of 255 male and female breeding lines is just in progress.

- A genetic map is at present being worked on, in which identified DNA markers for powdery mildew resistance are to be localised. It can be seen that the number of all fingerprint data so far for calculating a genetic map does not yet suffice. New assignments include another AFLP-enzyme system (PstI + MseI).

Analysis of QTLs for alpha-, beta-acids, cohumulone, xanthohumol and yield

Bayerische Landesanstalt für Landwirtschaft,
(Bavarian State Research Center for Agriculture)
Institut für Pflanzenbau und Pflanzenzüchtung
(Institute for Crop Production and Plant Breeding)

Financed by: Hopsteiner, Mainburg

Project Manager: Dr. S. Seefelder

Coordination: Dr. E. Seigner

Cooperation: P. Matthews, S S Steiner, USA

Working on project: Dr. S. Seefelder, LTA P. Bauer (until 30.06.03), LTA L. Logothetis, CL V. Mayer, LA A. Lutz

Target: The aim of this research project is to identify DNA markers for hop components relevant to brewing. Beyond that attempts are being made to describe in molecular terms agronomic characteristics which are valuable for breeding such as yield, internodium length and cone form**.**

Results:

- A mapping population of 139 female plants was produced from the crossing 'Spalter Select' x male Hüll breeding line 93/9/47. Female seedlings were selected according to their sex using molecular markers.
- 139 genotypes respectively were planted out in several replications in four standardised trial yards.
- The work also focused on working out a standardised picking method. It showed that for the analysis of the single hop samples it was preferable to machine-pick the individual vines rather than hand-pick single cones.
- The molecular verification of all genotypes at the various testing locations is an important precondition for the project and this has been successfully completed.
- Moreover, AFLP fingerprints of all mapping individuals using specific primer combinations have been produced which later on provide the basis for a genetic map.

Working out an effective method to produce fungus-resistant hops by means of gene transfer

Bayerische Landesanstalt für Landwirtschaft,
(Bavarian State Research Center for Agriculture)
Institut für Pflanzenbau und Pflanzenzüchtung
(Institute for Crop Production and Plant Breeding)

Financed by: Bayerisches Staatsministerium für Landwirtschaft und Forsten
(Bavarian State Ministry for Agriculture & Forestry)

Project Manager: Dr. E. Seigner

Working on project: Dr. H. Radic-Miehle, P. Hartberger

Duration: 01.11.2001-30.09.2004

Target:

The aim of this research project is to establish an efficient transformation method for gene-transfer in hops. When such a method has been established, ultimately resistance genes against fungal pathogens are to be transferred into the hops.

Results:

- It was continued to transform internodia of the Hüll hop varieties 'Hallertauer Magnum', 'Hallertauer Mittelfrüh', 'Saazer' and 'Saphir' with the GUS reporter gene system.
  For the first time the gene gun, i.e. the direct gene transfer, was used for a transient expression besides the indirect gene-transfer via an agro-bacterial infection.

- Also our first own construct with a fungal-resistant gene was used for the transformation. At the same time the work with this chitinase gene proved to be somewhat more complicated than first expected: cDNA was produced and amplified via RT-PCR and PCR. Also the further cloning of this cDNA proved to be difficult – presumably due to the pronounced secondary structures in the last section of the gene. However, the gene could meanwhile be successfully equipped and prepared with restriction sites and put into a promoter.

- This construct has meanwhile been transferred into a binary vector, which is now available for gene transfer of hop plants. First transgenic hop plants which have taken up this resistance gene in their genome are at present being tested by means of PCR, SDS-PAGE and infection test.

Wild hops – new genetic resources to breed for powdery mildew resistance

Bayerische Landesanstalt für Landwirtschaft,
(Bavarian State Research Center for Agriculture)
Institut für Pflanzenbau und Pflanzenzüchtung
(Institute for Crop Production and Plant Breeding)

Financed by: Wissenschaftliche Station für Brauerei in München e.V.

Project Manager: Dr. E. Seigner, LA A. Lutz

Cooperation: Dr. F. Felsenstein, EpiLogic GmbH Agrarbiologische Forschung und Beratung, Freising

Working on project: A. Lutz, J. Kneidl; S. Hasyn (EpiLogic)

Duration: 01.03.2003 –30.04.2006

Target: The objective set for this project is to identify new, hitherto unknown resistances in our collection of wild hops. These new, fully effective powdery mildew resistance genes are to be used for crossing and broadening the genetic base in the Huell breeding material.

Results:

- 750 wild hops were tested in the greenhouse for their powdery mildew resistance. Artificial inoculation in the greenhouse was carried out with powdery mildew isolates representing the virulence spectrum of those populations which are prevalent in the Hallertau. 144 individuals were identified to be resistant.

- In the EpiLogic laboratory 355 wild hops, which before in the greenhouse had shown no or only slight powdery mildew infection, were re-tested for their resistance to an English powdery mildew isolate. None at all or extremely little growth of the powdery mildew mycelium was observed on the young, very sensitive leaves of 90 seedlings.

- After the first testing season in the greenhouse and in the laboratory 64 wild hops were found to be resistant towards all the powdery mildew races used so far.

- In order to identify resistance genes in the wild hop germplasm, which confer resistance to all races of powdery mildew available so far screening must be continued in the laboratory in 2004 with powdery mildew isolates showing the v5-virulence type.

Evaluation of production techniques for organic hop growing

	LfL, Institut für Pflanzenbau und Pflanzenzüchtung *(Institute for Crop Production and Plant Breeding)*
Financed by:	Bayerisches Staatsministerium für Landwirtschaft und Forsten *(Bavarian State Ministry for Agriculture & Forestry)*
Project Manager:	Ltd.LD B. Engelhard
Working on project:	Dr. F. Weihrauch, M. Felsl, M. Fischer, A. Neuhauser
Duration:	01.04.2002 – 31.03.2005
Targets:	Evaluation of methods to support beneficial organisms in organic hop growing, particularly by creating overwintering shelters; testing of plant protectives which comply with the guidelines for organic hop growing

Results:

In the second year of the project, the following sub-sections have been worked on, with hereby briefly described results:

As in the previous year, for **the use and establishment of predatory mites in hop yards** a large-scale trial was set up at the Buch location on about 1 ha with four plots in four replicates each. In two plots, on June 18 predatory mites (*Typhlodromus pyri*) from a commercial breeder were released on each seventh plant punctually in paper bags, each containing about 100 mites (altogether approx. 8.000 mites). The further development of spider mites (*Tetranychus urticae*) and predatory mites in the stand was monitored every week. *T. pyri* were released punctually for the second time in the middle of the plots (approx. 8.000 mites) on June 26; so on an average there were altogether 20 predatory mites released on each plant. As in 2002 the desired controlling effect of spider mites by *T. pyri* was only reached in part, as plots with predatory mites showed less spider mite infestation levels, but could not be differentiated from untreated plots regarding yield. However, with 127 individuals considerably more *T. pyri* could be found again during monitoring compared to the previous year. Due to the extreme spider mite infestation in 2003 all plots were already so badly infested by mid- summer that 50% of the trial was sprayed with an acaricide on July 30 to control the expected damage. The left, untreated plots produced hops which could no longer be marketed after they had been harvested.

Prior to harvesting, felt bands were again put up as overwintering quarters for predatory mites on the hop poles, and one bine was left un-harvested at each pole until winter. These overwintering quarters for predatory mites are still being evaluated at the present time. However, the evaluation of felt bands from winter 2002/2003 showed the result that no predatory mites could be found at all, compared to spider mites which actually made use of these quarters.

The **further development of a method to control two-spotted spider mites by insect glue barriers** on the hop bines was carried out in the same trial as a fourth plot. With regard to spider mite infestation this grease variant again was considerably below all the other variants. However, the unusual strong spider mite population development in the extremely hot year 2003 for the first time after ten test years caused the glue not to stand up to spider mite pressure, and considerable spider mite infestation was recorded in these plots. The large-scale use of the tractor-heated applicator for glueing the bines again caused no technical problems.

The trial to **attract green lacewings for the control of hop aphids** was carried out at the Ursbach location. On 20.05., 02.06. and 11.08. the plants in four large plots were treated with a spraying of "artificial honeydew" (a mixture of honey, brewer's yeast and water with 1% Funguran to prevent the growth of black mould fungus). However, the monitoring for beneficial organisms carried out in the following weeks did not show any greater density of lacewings (eggs, larvae, pupae and imagines) than in untreated plots, so this trial hitherto cannot be regarded as successful.

The **creation of overwintering quarters for lacewings in hops** can be regarded as successful as in the previous year. On August 26 at the Ursbach location in the experimental yard 16 especially conceived "lacewing hotels" (blocks with slats made of thin chipboard with sides 30 cm long, filled with straw) and at the Buch location eight hotels were hung to hop poles before harvest. Additionally, in Ursbach another four lacewing hotels were set up at two different locations near the hop yard (outskirts of woods, little glade) on wooden poles 150 cm high. The hotels were dismantled on December 22 and stored temporarily in a cool, dark barn. The classification and counting of the overwintering arthropods had not been completed when this report was compiled but showed comparable results to 2002: The by far greatest number of overwintering lacewings with so far maximum 396 insects could be found on the hop poles. The overwintering rates at the other types of exposition were again considerably lower. The antagonistic potential of one hotel is quite amazing: With (according to data of both test years) approximately 130 to 150 overwintering lacewing females, each producing about 300 eggs in spring, from which hatch larvae, feeding on about 300 aphids each in the course of their development, this is more than twelve million aphids.

The targeted use of this potential, however, could not be investigated when the hotels were opened in the experimental yard in May 2003 as due to extremely high spring temperatures in 2003 practically all lacewings had already left the hotels although they had been stored cool and dark. This shortcoming should be corrected in 2004 by spring storage under better controlled conditions than in 2003.

To **test plant protectives, which comply with the guidelines for organic hop production,** two large-scale trials with four replicates per plot were run at the Ursbach location to control the hop aphid (*Phorodon humuli*). In one trial, the 2002 very effective quassia extract was tested, and in another experimental yard the effectiveness of three different NeemAzal formulations, incl. a granulate, was investigated. Due to the extreme weather conditions, which caused the aphid populations in all plots to collapse completely by the end of June, both tests unfortunately produced no results. In another aphid test at the Buch location (three replicates, cv. HM) "Spruzit Neu" produced extremely positive results and, with effective rates up to 98.2%, was considerably better than the comparative pesticide.

Unfortunately the testing of the plant restorative "Reacre" to control powdery mildew (*Sphaerotheca humuli*) at the Hofen location could likewise not be evaluated as, due to weather conditions in 2003, no powdery mildew infections occurred even in untreated plots.

Investigations on the influence of weather conditions on the epidemiology of powdery mildew *(Sphaerotheca humuli* Burr).

LfL, Institut für Pflanzenbau und Pflanzenzüchtung
(Institute for Crop Production and Plant Breeding)

Financed by: Busch Agricultural Resources International, Inc. (BARI), DOW AgroSciences

Project Manager: Ltd. LD B. Engelhard

Working on project: Bernhard Engelhard, Dr. Klaus Kammhuber, Herfried Hesse, Stefan Fuß, Georg Kindsmüller

Duration: 2003 – 2006

Targets:

1. Determining the time when the first infection occurs through ascospores (primary infection)
2. Knowledge about the weather conditions for further increasing (sporulation) the fungus and therefore creating the bases for optimum timing of the control measures.

Results:

1. Infection through ascospores from cleistothecia

During the period between mid-April until the end of June young hop plants out in the open were put in a mass storage of hop vines infected with powdery mildew. The young plants were exchanged each week and afterwards put into a climatic test cabinet for a week to facilitate the formation of powdery mildew pustules under controlled conditions.
Slight infection was observed on two dates. The pustules disappeared again under the influence of direct sunshine.
Therefore the time for releasing the ascospores from the cleistothecia could not be determined.

2. Comparison of weather parameters with the amount of powdery mildew infection in practice yards, 1998 – 2003

The data for this comparison is based on the agrarian meteorological measuring station of the Bavarian measuring network at the Hüll location. The weather data for the months April - June

- temperature
- rainfall
- humidity and
- sunshine intensity (watt-hours/m^2; wh/m^2)

were tiered according to various requirements and compared with the previous year's attacks.

The following factors produced the first logical connection between powdery mildew and weather parameters:

during the night (21°° - 8°°) ≥ 10°C + ≥ 1 mm rainfall
the following day (9°° - 20°°) ≥ 10°C + ≤ 3000 watt-hours/m^2
the following night (21°°- 8°°) ≥ 10°C + ≥ 1 mm rainfall or
≥ 5 mm in the last 24 hours
the following day (9°° - 20°°) ≥ 10°C + ≤ 3000 watt-hours/m^2

Provided that these requirements are fulfilled over at least two days, according to present findings there is a high likelihood for the first infection via ascospores; but also the propagation and infection through summer spores seem to have optimum preconditions under these conditions.

Development of a single bine spraying device for the Official Pesticide Test in the special crop hops

LfL, Institut für Pflanzenbau und Pflanzenzüchtung
(Institute for Crop Production and Plant Breeding)

Financed by: BASF, BayerCropScience, DOW AgroSciences, Spiess-Urania, Syngenta
Thanks to Messrs. Wallner, Wolnzach for the loan of their tractor during 2003

Cooperation: LfL, Institut für Landtechnik, Bauwesen und Umwelttechnik (ILT)
(Institute for Agricultural and Environmental Technology) – all the technical development

Project Manager: Ltd. LD B. Engelhard

Working on project: Dipl.Ing. (FH) Gerhard Rödel (ILT), LOI Renate Huber, Martin Schött, Pichlmaier (Thesis at FH Weihenstephan), LHS Georg Meyr, Johann Weiher

Duration: 2003 – 2004

Target: The trials for the Official Pesticide Test in hops are carried out with a (especially constructed) blower sprayer as used in the field. In order to rule out the disadvantages of this method, with the aid of plant protection companies a prototype was developed for treating a single bine. This should create the preconditions for testing development products, determining limits for concentrations and the addition of adjutants.

Results:

The extensive technical requirements were laid down by the Work Group Plant Protection in Hops.
The following variants were selected from the most diverse technical options:

- moving the nozzle ring to a height of 1 - 7 m on a 3-fold telescopic tower made of metal
- mounting the tower in the front (visibility!)
- tower must be moveable at 360° (vines trained diagonally)
- container with spray directly at the nozzle ring in order to ensure short wires are sprayed (cleaning!)
- spraying pressure produced via compressor (air pressure)
- container with spray is replaced via rapid closure; transportation on special construction at rear of tractor

First tests showed that the nozzles and the screening from the neighbouring vines is still not optimal. Even with bent nozzles 30° upwards, the undersides of the leaves are still not covered sufficiently.
Comparable trials must be carried out in 2004 using the hitherto spraying technique.

Differentiating between a selection of the world hop range and the Hüll breeding varieties according to alpha-acids and polyphenols and the influence of these hop-components on the bitter quality

Sponsored by: LfL, Institut für Pflanzenbau und Pflanzenzüchtung
(Institute for Crop Production and Plant Breeding)

Financed by: Wissenschaftliche Station für Brauerei in München e.V.

Project Manager: RR Dr. K. Kammhuber

Cooperation: Versuchsbrauerei St. Johann (*Experimental Brewery*) (Hopfenveredelung St. Johann GmbH & Co. KG)

Working on project: CTA B. Wyschkon, RR Dr. K. Kammhuber

Duration: 01.11.2003 – 31.03.2005

Target: Target of the project is to find out whether hop varieties with extremely different components have a noticeable effect on the beer quality in which brewing trials are also to be made.

Results: An HPLC-separation was worked out, which makes it possible to analyse all six hop bitter compounds such as xanthohumol in one go. A start has been made to analyse the world hop range with this method.

1.2 Main areas of research

1.2.1 Main areas of research in breeding

Breeding for powdery mildew resistance in aroma and bitter varieties

Project manager: Dr. E. Seigner

Working on project: A. Lutz, J. Kneidl

Cooperation: Dr. F. Felsenstein, EpiLogic GmbH Agrarbiologische Forschung und Beratung, Freising

Target: The main focus in Hüll breeding work is put on the development of quality varieties meeting the demand of the market. A good to very good resistance and/or tolerance towards the downy mildew and the *Verticillium*-wilt has already been anchored in the Hüll varieties. Now work is being focused on improving resistance towards powdery mildew.

Measures:

- 110 specific crosses with powdery mildew (PM) resistant crossing partners in the aroma and/or bitter sector were carried out in 2003.

- Tests for PM resistance in the greenhouse and in the field

  - Seedlings from the various breeding programmes were screened after being artificially inoculated with four different powdery mildew isolates for their resistance. Three Hüll varieties and 10 foreign varieties as well as 41 breeding lines were also included in this greenhouse test.

  - Only individuals classed as resistant were examined further on. After being tested in the greenhouse all resistant individuals were grown in the field under natural infection conditions and without the use of fungicides. Approximately 4000 seedlings were tested in 2004.

- Testing for powdery mildew resistance in the laboratory

  At present 13 different PM isolates with characterised virulence behaviour are available for testing in the Petri dish. Therefore nearly all the resistances used worldwide in breeding can been tested.

  5 varieties, 30 breeding lines and 355 wild hops were tested in the Petri dish for their resistance after being artificially inoculated with an English PM isolate. In this way resistance towards PM races, which have not yet occurred in Germany, could be checked.

1.2.2 Main research areas in hop cultivation, production techniques

Project Manager: LD G. Roßbauer (until 31.03.03), LOR J. Portner (since 01.07.03)

Working on project: LA E. Niedermeier, LA J. Münsterer

Nitrogen fertilization with nitrification inhibitors

Nitrogen fertilizers containing nitrate dissolve rapidly and are effective straightaway; it is suspected that the wilt risk is increased due to a high level of nitrate and that the susceptibility towards powdery mildew increases. With more heavy rainfall a nitrogen shift particularly on light locations cannot be ruled out. With nitrogen-stabilised fertilizers the nitrification of the ammonium nitrogen is inhibited; therefore the nitrogen is gradually made available to the hop-growers.
In comparison the usual ammonium-nitrate-nitrogen fertilizer is used in the test.
In addition to this it is to be examined whether the nitrogen can be reduced, to see how far the yield is affected.

Harvest-time trials

In order to determine the optimum time for harvesting, 20 training wires each are harvested from a practice stand at intervals of 3 days and this repeated four times. The evaluation is made on yield, alpha-acid content, aroma and quality of exterior (picking, colour and lustre, cone growth and deficits)

Optimum drying and conditioning

The procedure usually carried out in the practice for drying and conditioning the hops according to time and/or subjective feeling often leads to unsatisfactory results regarding the final hop moisture and maintaining the cone quality.
After evaluating extensive measuring data, the testing of various technical aids in practice facilities should provide objective set values and establish the use of suitable technical aids, which ultimately lead to automating the operating and controlling procedures. Therefore the hop-grower is relieved of stress in his monitoring function during the process of drying and conditioning and the hop quality is maintained with optimum economic performance.

1.2.3 Main areas of research in plant protection

Project Manager: Ltd. LD B. Engelhard

4 Coordinating the registration of plant protectives

Prepared by: Ltd. LD B. Engelhard, LOI`in R. Huber

Cooperation: Verband deutscher Hopfenpflanzer e.V.
Hopfenwirtschaftsverband e.V.
U.S. Hop Industry Plant Protection Committee

The production of hops for export is of great importance in almost all the hop-producing countries. When being imported into the recipient countries the regulations for the maximum permissable quantities of plant protectives in these countries have to be observed.
With the support of the plant protection industry and the whole hop industry in recent years a high standard has been successfully attained. Due to an intensive exchange of information on the planned tests for plant protectives, especially in the USA and Germany, it has been possible to work out maximum residues for the same plant protectives in both countries and translate them into legislation. From the German aspect particularly the untiring work of Mrs. Ann George, U.S. Hop Industry Plant Protection Committee, must be emphasized.
With the coordination between the USA and Germany the trade barriers for export to other importing countries will also be broken down.

Official Pesticide Test with main emphasis on controlling the alfalfa weevil (*Othiorrynchus ligustici*), the hop aphid (*Phorodon humuli*) and the two-spotted spider mite (*Tetranychus urticae*)

Prepared by: LOI`in R. Huber, LHS G. Meyr, O. Ehrenstraßer, M. Fischer, J. Weiher

Cooperation: Companies in the plant protection industry

While in the case of fungicides a relatively good range of plant protectives has been registered, at the moment or in the near future there will be certain gaps in the control of hop aphid and the two-spotted spider mite. Therefore, since 2003 the Pesticide Test has focused on insecticides and acaricides.
To control hop aphids very good results were obtained in the biological test with the chemical Flonicamid (IBE 3894) from Japan.
Very promising products to control the two-spotted spider mite in the future are Acrimide (Binfenazate), Envidor (Spirodiclofen) and Milbeknock (Milbemectin).
Several registered products are absolutely prerequisite for a promising resistance strategy by changing the active ingredients.

Closing gaps in pesticides by indicating gaps

Prepared by: Ltd. LD B. Engelhard, LOI`in R. Huber, LA J. Münsterer, LHS G. Meyr, J. Weiher

Cooperation: Unterarbeitskreis Lückenindikation Hopfen directed by LD G. Meinert,
(Sub-Work Group – gap indication – Hops)
Landesanstalt für Pflanzenschutz, Stuttgart
(State Institute for Plant Protection, Stuttgart)

For detrimental organisms which only occur to a limited extent, according to the plant protection law it is possible to have the products 'approved' by applying a simplified procedure.
Even in these cases it must be clarified as to whether there are possible residues of these chemicals.
Tests for the following products were carried out in the current year:
Lotus (Cinidon-etyl); Spotlight plus (Carfentrazone-etyl); Gallant super (Haloxyphop); Spruzid Neu (natural pyrethrum), MCPA, Runner (Methoxyfenozide), Steward (Indoxacarb), Fongonil (Metalaxyl-M); Oncol 20 EC (Benfuracarb)

For controlling powdery mildew the influence the products have on the alpha-acid content and the yield

Prepared by: LOI`in R. Huber, LHS G. Meyr, J. Weiher, M. Fischer, A. Baumgartner

Basically it must be checked whether the plant protectives used have a positive or negative effect on the yield besides their effectiveness against the respective detrimental organism.
The chemicals in the group of 'Strobilurine' to control fungal diseases is said to have a so-called 'greening-effect' in other plants; this means that the plants remain green for a longer time, store more nutrients and therefore produce higher yields.
In the first test year 2002 the direct comparison with all registered groups of chemicals showed **no** different alpha-acid contents and yields.
In the crop year 2003 the yields fluctuated considerably between the plots. It is not possible to produce statistics.

1.2.4 Main areas of research: quality, chemistry and technology of hops

Project Manager: RR Dr. K. Kammhuber

Development of a NIR calibration based on HPLC data

Cooperation: Dr. M. Biendl, Hallertauer Hopfenveredelungsgesellschaft mbH
J. Betzenbichler, Hallertauer Hopfenveredelungsgesellschaft mbH
R. Schmidt, NATECO$_2$ GmbH & Co. KG
U. Weiss, Hopfenveredelung HVG Barth, Raiser GmbH & Co. KG

Prepared by: CL E. Neuhof-Buckl, CTA B. Wyschkon, RR Dr. K. Kammhuber

Duration: The project was begun in September 2000, the end is still open.

In September 2000 work was begun on constructing a NIR calibration based on HPLC data by the laboratories of the above-mentioned firms and the Bavarian State Research Center for Agriculture in Hüll . This calibration was expanded each year and checked. Within the Work Group for Hop Analytica (AHA) the decision will be made when this calibration is suitable to be put into practice. In 2003 the alpha-acid contents were very small so that the existing calibration

to some extent even produced negative values. The calibration will be extended and validated by the next crop with the data from the 2003 crop.

2 Weather conditions 2003

Bernhard Engelhard, Dipl. Ing. agr.

Following an above-average rainy autumn 2002 the soil work had to be postponed until spring 2003.
A layer of snow with excellent winter weather from 8th February up to the end of the month provided very good conditions for hanging up training wires, for taking samples of soil to be examined for nitrogen and for the first pruning of various varieties.
The dry, sunny March produced optimum conditions for the spring work. In April there were still the after-effects from the rainy autumn in the previous year in the form of partly bad crown rot.
As shown clearly in the table, the rainfall was considerably below and the average temperatures considerably above the 10-year average from 1993 – 2002, compared with the 10-year mean average, in all the months from February until August. Even during the last big dry year 1947 there had been no successive seven months with below-average rainfall.
Hops have very strong roots, which (the soil conditions permitting), can reach down as far as four metres. Therefore the dry period in the spring up until the end of June could be overcome despite the already high temperatures. Though then all the water reserves in the soil had been used up and in the months July and August - the period with the greatest water consumption - there was still no rainfall.
The fact that the hops survived these extremes so well can be traced back to the lack of water in the spring and therefore

- the plants were encouraged to increase root growth and
- the ground had not become at all compacted by tractors being driven through the hop yards.

As early as about 10th June all the varieties had reached the top of the trellis. Hallertauer Mittelfrüher and Northern Brewer came into burr even before 20th June.
From June till August it would be ideal for the hops (but not for the brewers and not for the holiday-makers), if 100 mm of rain would fall each month; yield and alpha-contents then reach their optimum.
The rainfall was restricted to small regions where this resulted in higher yields. Altogether in a very extraordinary year the weather conditions had taken their toll even from the hops and produced

- low yields
- coupled with very low alpha-acid contents.

Harvesting began as early as 10th August with the variety Hallertauer Mittelfrüher.

Table 2.1: Weather conditions 2003 compared with the 10-year mean average

	Rainfall (mm)			Temperature (°C)		
Month	Ø 1993-2002	2003	± to Ø	Ø 1993-2002	2003	± to Ø
January	36.4	41.8	+ 15 %	minus 0.6	minus 1.3	
February	38.2	15.3	- 60 %	1.3	minus 4.7	
March	67.3	14.6	- 88 %	3.9	4.8	+ 23 %
April	53.5	21.8	- 59 %	8.3	8.3	± 0
May	77.8	67.3	- 14 %	13.9	15.1	+ 9 %
June	100.3	39.6	- 60 %	16.0	21.4	+ 34 %
July	112.7	64.3	- 43 %	17.5	18.7	+ 7 %
August	81.7	16.1	- 80 %	17.5	21.1	+ 21 %
March-August	**493.3**	**223.7**	**- 55 %**	**12.8**	**14.9**	**+16%**

Table 2.2. Weather data (monthly mean averages or monthly totals) of the year 2003 compared with the 10- and 50-year mean averages

Month		Temperature at height of 2 m Average (°C)	Min.∅ (°C)	Max.∅ (°C)	Relat.air moisture (%)	Precipi-tation (mm)	Days w. precipit. >0.2 mm	Sun-shine (hrs.)
January	2003	-1.3	-4.6	2.3	90.4	41.8	12.0	62.6
∅	10-yr.	-0.6	-3.3	2.8	86.4	36.4	11.2	63.8
	50-yr.	-2.4	-5.1	1.0	85.7	51.7	13.7	44.5
February	2003	-4.7	-10.9	2.4	84.7	15.3	6.0	136.1
∅	10-yr.	1.3	-2.8	5.8	82.9	38.2	11.8	90.4
	50-yr.	-1.2	-5.1	2.9	82.8	48.4	12.8	68.7
March	2003	4.8	-1.2	12.5	73.2	14.6	7.0	182.4
∅	10-yr.	3.9	0.1	9.4	79.0	67.3	15.2	133.1
	50-yr.	2.7	-2.3	8.2	78.8	43.5	11.3	134.4
April	2003	8.3	1.3	15.2	63.5	21.8	6.0	208.6
∅	10-yr.	8.0	2.7	13.5	74.7	63.2	11.4	158.8
	50-yr.	7.4	1.8	13.3	75.9	55.9	12.4	165.0
May	2003	15.1	8.9	22.0	75.2	67.3	15.0	205.0
∅	10-yr.	13.9	7.7	19.9	71.3	77.8	11.9	219.4
	50-yr.	11.9	5.7	17.8	75.1	86.1	14.0	207.4
June	2003	21.4	12.8	30.2	70.9	39.6	13.0	306.1
∅	10-yr.	16.0	9.9	22.0	72.6	100.3	14.5	218.5
	50-yr.	15.3	8.9	21.2	75.6	106.1	14.2	220.0
July	2003	18.7	11.7	26.1	72.4	64.3	12.0	261.1
∅	10-yr.	17.5	11.7	23.6	74.8	112.7	15.6	211.8
	50-yr.	16.9	10.6	23.1	76.3	108.4	13.9	240.3
August	2003	21.1	12.8	30.0	69.1	16.1	3.0	292.2
∅	10-yr.	17.5	11.4	24.0	75.9	81.7	12.4	219.3
	50-yr.	16.0	10.2	22.5	79.4	94.9	13.3	218.4
September	2003	13.2	6.3	21.3	76.9	47.1	6.0	215.7
∅	10-yr.	12.8	7.8	18.5	81.4	77.3	13.8	152.6
	50-yr.	12.8	7.4	19.4	81.5	65.9	11.4	174.5
October	2003	6.0	1.6	11.0	83.3	89.3	12.0	121.7
∅	10-yr.	9.1	5.1	13.8	85.2	65.7	13.7	105.4
	50-yr.	7.5	2.8	13.0	84.8	60.0	10.4	112.9
November	2003	3.9	0.4	7.8	91.7	40.4	9.0	69.5
∅	10-yr.	3.2	0.3	6.3	89.0	56.1	11.3	59.7
	50-yr.	3.2	-0.2	6.4	87.5	58.8	12.6	42.8
December	2003	0.3	-2.6	4.0	88.2	30.8	12.0	69.3
∅	10-yr.	0.4	-2.5	3.2	87.7	53.6	14.5	51.9
	50-yr.	-0.9	-4.4	1.6	88.1	49.1	13.3	34.3
Year 2003		8,9	3.0	15.4	78.3	488.4	113.0	2130.3
10-yr. mean average		8,6	4.0	13.6	80.1	830.3	157.3	1684.5
50-yr. mean average		7,4	2.5	12.5	81.0	828.8	153.0	1663.0

The 50-year mean average applies to the years 1927 up to and including 1976, the 10-year mean average applies to the years 1993 up to and including 2002.

3 Statistical Data on Hop Production

Bernhard Engelhard. Dipl.Ing.agr.

3.1 Production data

3.1.1 Structure of hop production

In the year 2003 the hop acreage in the Federal Republic of Germany decreased by 789 ha to 17,563 ha compared with 18,352 ha in the previous year (- 4.30 %).

The number of hop farms also decreased in 2003, i.e. by 155 (=7.98 %) from 1,943 to 1,788 farms. The average hop acreage per farm for the whole Federal Republic is now 9.82 ha compared with 9.45 ha in 2002.

Table 3.1: Number of hop farms and their hop acreage in the Federal Republic of Germany

Year	No. of farms	Average hop acreage per farm in ha
1953	14 631	0.58
1963	13 259	0.68
1973	8 591	2.33
1974	8 120	2.48
1975	7 654	2.64
1976	7 063	2.79
1977	6 617	2.90
1978	5 979	2.94
1979	5 772	2.99
1980	5 716	3.14
1981	5 649	3.40
1982	5 580	3.58
1983	5 408	3.66
1984	5 206	3.77
1985	5 044	3.89
1986	4 847	4.05
1987	4 613	4.18
1988	4 488	4.41
1989	4 298	4.64
1990	4 183	5.35
1991	3 957	5.70
1992	3 796	6.05
1993	3 616	6.37
1994	3 282	6.69
1995	3 122	7.01
1996	2 950	7.39
1997	2 790	7.66
1998	2 547	7.73
1999	2 324	7.87
2000	2 197	8.47
2001	2 126	8.95
2002	1 943	9.45
2003	1 788	9.82

Table 3.2: Hop acreage, number of hop farms and average hop acreage per farm in the German production areas

Production area	Hop acreage				Hop farms				Hop acreage per farm in ha	
	in ha		Increase + / Decrease - 2002 to 2003		2002	2003	Increase + / Decrease - 2002 zu 2003		2002	2003
	2002	2003	ha	%			Betriebe	%		
Hallertau	14 967	14 391	- 576	- 3.85	1 527	1 416	- 111	- 7.27	9.80	10.16
Spalt	427	395	- 32	- 7.49	118	107	- 11	- 9.32	3.62	3.69
Hersbruck	98	98	± 0	± 0	16	16	± 0	± 0	6.13	6.13
Tettnang	1 444	1 257	- 187	- 12.95	243	210	- 33	- 13.58	5.94	5.99
Bitburg &.) Rheinpfalz)	20	20	± 0	± 0	2	2	± 0	± 0	10.00	10.00
Elbe-Saale	1 396	1402	+ 6	+ 43	37	37	± 0	± 0	37.73	37.89
Fed. Republic of Germany	18 352	17 563	- 789	- 4.30	1 943	1 788	- 155	- 7.98	9.45	9.82

Diagram 3.1: Hop acreage in Germany and in the Hallertau hop-growing region

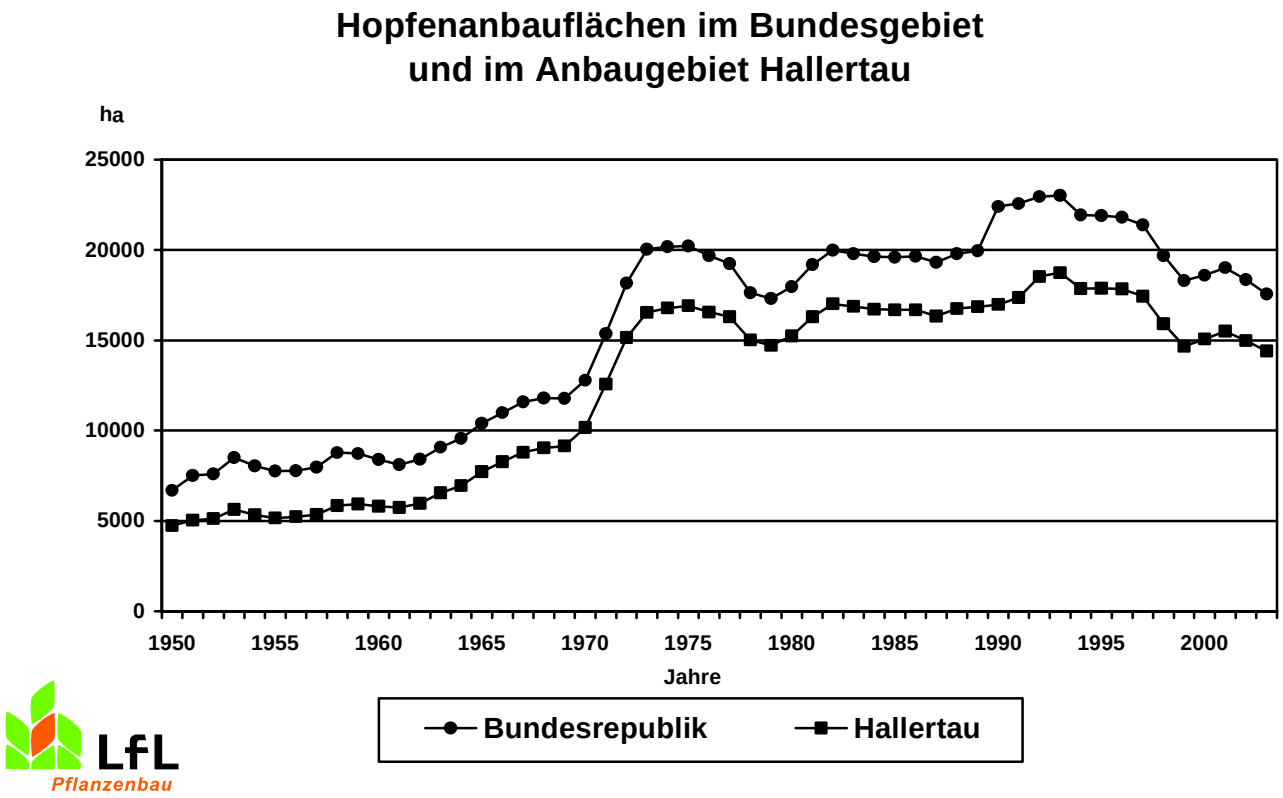


Diagram 3.2 Hop acreages in the areas Spalt, Hersbruck, Tettnang and Elbe-Saale

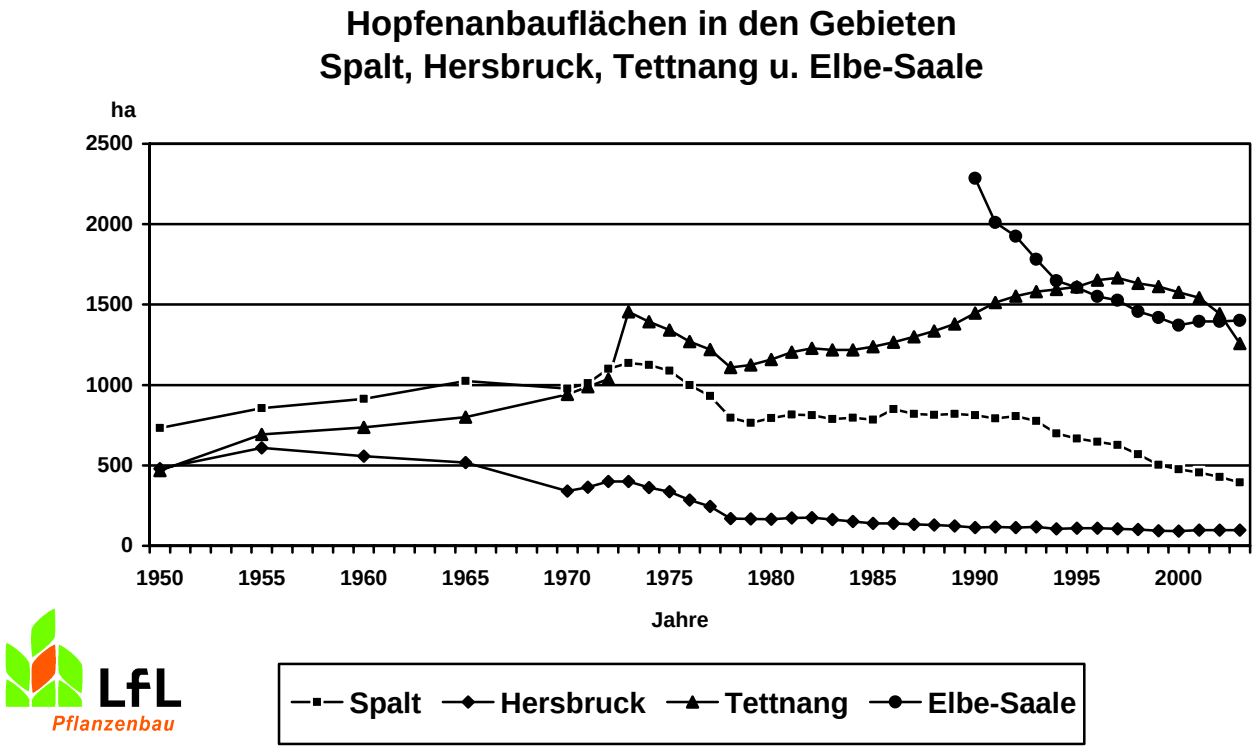


Table 3.3: Hop varieties in the German production regions in ha in 2003

Teil 2 - Bitter varieties

Anbaugebiet	Northern Brewer	Brewers Gold	Nugget	Target	Hall. Magnum	Hall. Taurus	Hall. Merkur	Colum-bus	Sonstige	Bitterstoffsorten	
Hallertau	624	41	423	36	4.059	1.242	144	9	31	6.609	45,92%
Spalt									9	9	2,28%
Hersbruck		2			11		1			14	14,29%
Tettnang					1	1				2	0,16%
Rheinpfalz } Bitburg }					2	3				5	25,00%
Elbe-Saale	246		78	4	851	39	34	4		1.256	89,59%
Bundesgebiet	870	43	501	40	4.924	1.285	179	13	40	7.895	44,95%
Anteil je Sorte in %	4,95%	0,24%	2,85%	0,23%	28,04%	7,32%	1,02%	0,07%	0,23%		

Change of varieties in the Federal Republic of Germany

2002 ha	1.237	73	545	51	4.847	1.243	135	13	32	8.176	46,55%
2003 ha	870	43	501	40	4.924	1.285	179	13	40	7.895	44,95%
Veränderung in ha	-367	-30	-44	-11	77	42	44	0	8	-281	-3,44%

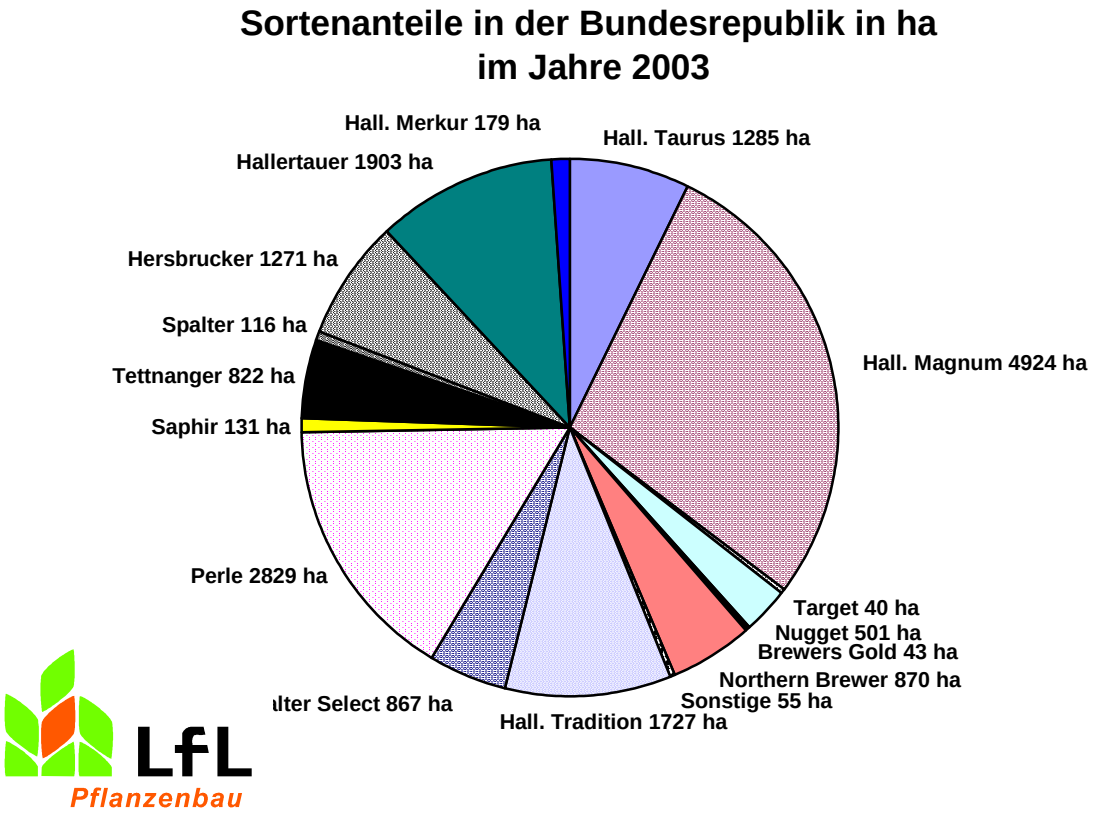
3.1.2 Hop varieties

As far as the hop varieties are concerned, in 2003 there was a slight shift in favour of the bitter varieties. The proportion of aroma varieties in 2003 was 55.05 % compared with 55.45 % in 2002. The bitter varieties make up a proportion of 44.95 % of the production area compared with 44.55 % in 2002.
The production areas for the aroma varieties, except for Hallertauer Mfr. and Saphir, were reduced without any exceptions.

The acreages for the bitter varieties Northern Brewer (-367 ha), Brewers Gold (- 30 ha), Nugget (-44 ha) and Target (- 11 ha) were also reduced. An increase in the production area was recorded for the varieties Hallertauer Magnum (+ 77 ha), Hallertauer Taurus (+ 42 ha) and Hallertauer Merkur (+44 ha).

The exact distribution of the varieties according to the production areas can be seen in Table 3.3.

Diagram 3.3: Distribution of varieties in hectares in 2003 in the Federal Republic of Germany



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3.2 Crop situation in 2003

The total crop in the Federal Republic of German yielded 25,325,768 kg (= 506,515 ztr.) compared with 32,270,635 kg (= 645,513 zentner) in 2002. The size of the crop is about 6,944,867 kg (= 138,998 zentner) below the result of the previous year; this means a decrease of around 21.53 %.

The yields per hectare and relative figures in the Federal Republic are shown in Table 3.4. The yields per hectare for the individual varieties and production areas are listed in Table 3.5 as well as the yields for the whole Federal Republic, compared with the figures for 2002.

Table 3.4: Yields per hectare and relative figures in the Federal Republic

	1996	1997	1998	1999	2000	2001	2002	2003
Yield ztr./ha	35.1	31.9	31.4	30.5	31.5	1660 kg (33.2 Ztr.)	1758 kg (35.2 Ztr.)	1442 kg 28.84 ztr.
Relative to 100% (long-term.∅ =35 ztr.)	100.3	91.1	89.7	87.1	90.0	94.9	100.6	82.40
Acreage in ha	21.813	21.381	19.683	18.299	18.598	19.020	18.352	17 563
Total crop in ztr.	766.070	681 035	617.181	558.247	585.841	31.576.465 kg (= 631.529 ztr.)	32.270.635 kg (= 645.413 ztr.)	25 325 768 kg (=506 515 ztr.)

Diagram 3.4: Average yields in the various production areas in kg/ha

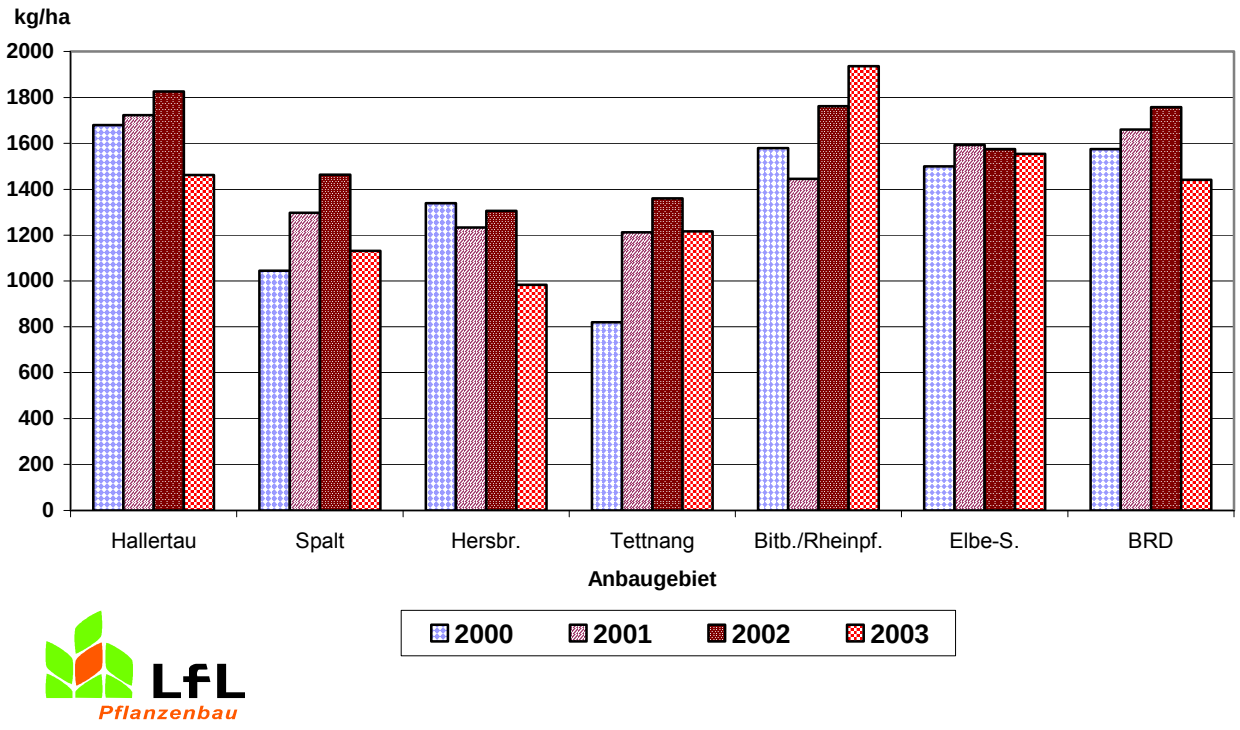

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Table 3.5: Average yields for the individual hop varieties in the German production areas in 2003 in kg per ha

Aroma varieties

Production area	Haller-tauer	Spal-ter	Hers-brucker	Hüller Bitterer	Tett-nanger	Perle	Spalter Select	Hall. Trad.	Saphir
Hallertau	499		1690			1397	1695	1568	643
Spalt	1008	925	1071			1618	1367	1473	
Hersbruck	985		1094			756	1080	915	480
Tettnang	1210				1212	2326		865	
Bitburg }	2497			1405		1930	1412	1760	
Rheinpfalz }									
Elbe-Saale						1199		1492	
Fed.Republic									
2003	697	925	1682	1405	1212	1388	1636	1563	639
2002	1276	1194	1826	1566	1291	1818	1984	1982	801
± to 2002 kg/ha	- 579	- 269	- 144	- 161	- 79	- 430	- 348	- 419	- 162
Crop in tons Fed.Republic	1326.3	107.3	2138.0	2.8	996.4	3925.8	1418.4	2699.4	83.7

Bitter varieties

Production area	Northern Brewer	Brewers Gold	Nugget	Target	Hall. Magnum	Hall. Taurus	Hall. Merkur	Colum-bus	Others	Total
Hallertau	1026	2195	1806	1818	1702	1521	1170	2017	1306	1462
Spalt									1031	1131
Hersbruck		1390			1205		1100			983
Tettnang					1660	970				1257
Bitburg }					3350	1700				1936
Rheinpfalz }										
Elbe-Saale	967		1506	1948	1776	1939	1317	1915		1555
Fed.Rep.										
2003	1010	2158	1759	1831	1714	1534	1198	1985	1244	1442
2002	1513	2459	2245	2174	1812	1925	880	2085	1648	1758
± to 2002 kg/ha	- 503	- 301	- 486	- 343	- 98	- 391	+ 318	- 100	- 404	- 316
Crop in tons Fed.Rep.	878.3	92.8	881.3	73.2	8441.6	1970.6	214.4	25.8	49.8	25325.8

Source: EU report

Diagram 3.5: **Crop volume in the Federal Republic**

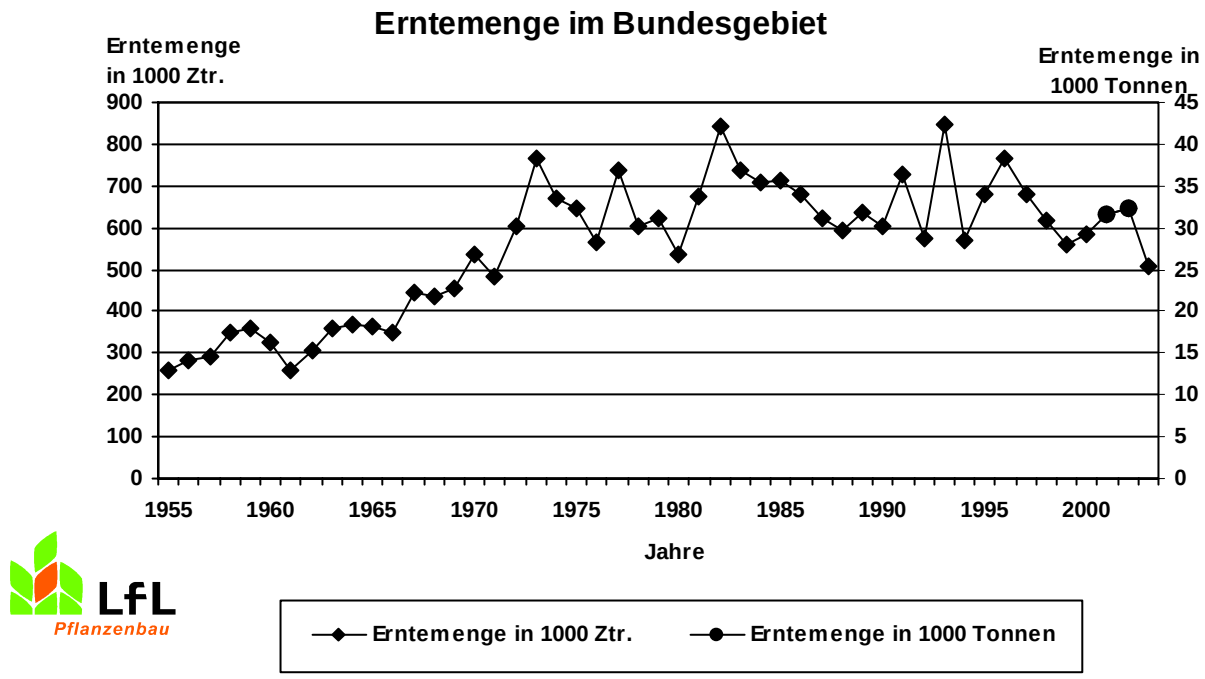


Diagram 3.6: **Average yield per ha hop acreage in the Federal Republic**

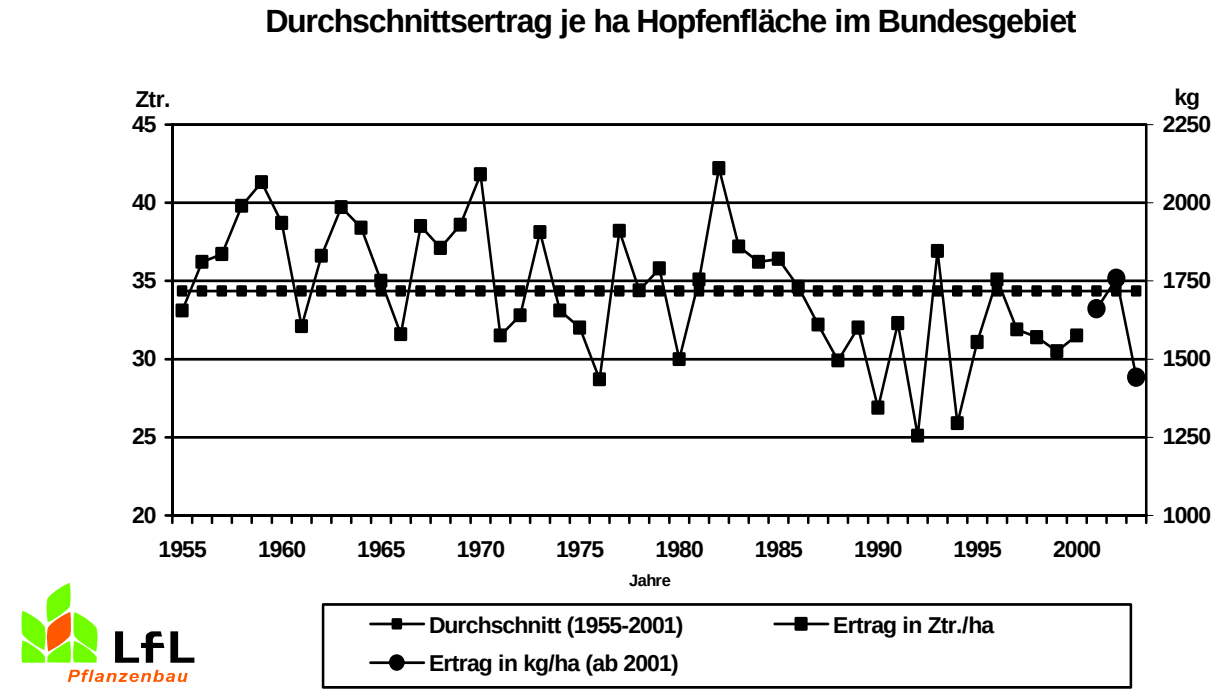


Table 3.6: Yields per hectare in the German production areas

Production area	Yields in Ztr./ha total acreage (from 2001 in kg/ha)								
	1995	1996	1997	1998	1999	2000	2001	2002	2003
Hallertau	32.3	35.1	32.8	32.5	31.2	33.6	1724	1825	1462
Spalt	26.2	32.3	26.5	22.1	28.2	20.9	1298	1464	1131
Hersbruck	23.9	27.9	28.3	28.8	23.5	26.8	1233	1306	983
Tettnang	24.1	28.9	31.2	26.8	28.3	16.4	1212	1360	1216
Bitburg } Rheinpfalz }	31.3	39.0	34.9	30.1	31.4	31.6	1445	1763	1936
Elbe-Saale	27.7	30.6	23.6	27.5	27.3	30.0	1594	1576	1555
∅ yield per ha Fed. Republic	31.1	35.1	31.9	31.4	30.5	31.5	1660 kg	1758 kg	1442 kg
Total crop Fed. Republic	681 081	766 070	681 035	617 181	558 247	585 841	31 576 to 631 529	32 271 to 645 413	25326 to 506 515
Acreage Fed. Republic	21 885	21 813	21 381	19 683	18 299	18 598	19 020	18 352	17 563

Table 3.7: Alpha-acid values for the various hop varieties

Variety	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	10-year ∅
Hallertauer	3.2	3.8	4.8	5.1	4.4	3.9	4.5	4.3	4.3		4.32
Spalter	2.6	3.3	4.8	6.0	4.5	4.1	4.5	4.5	4.7		4.29
Tettnanger	3.0	2.6	4.5	4.9	3.7	3.5	4.7	4.1	4.1		3.94
Hersbrucker	1.3	2.2	4.0	4.6	3.4	2.0	4.6	2.7	2.9		3.11
Hüller Bitterer	4.0	4.0	5.4	7.9	6.5	5.2	6.6	5.7	6.9		5.78
Perle	3.7	5.3	7.9	8.8	6.5	6.7	8.0	6.8	8.0		6.88
Spalter Select	2.2	3.7	5.4	6.6	5.3	4.3	5.8	4.6	5.4		4.84
Hall. Tradition	3.9	4.7	6.5	6.8	5.6	5.7	6.8	6.3	6.7		5.88
Saazer	2.5	3.3	3.3	3.8	4.1	3.9	-	-	-		-
Northern Brewer	5.5	7.4	9.7	10.1	8.5	8.6	9.6	8.7	9.3		8.59
Brewers Gold	4.0	4.8	7.0	8.2	7.3	5.9	7.3	6.1	6.7		6.38
Record	3.1	4.4	7.3	8.4	6.5	6.3	8.3	6.0	-		6.30
Orion	4.3	5.9	8.4	9.3	7.4	7.0	8.6	8.2	-		7.40
Nugget	9.1	9.3	10.2	12.9	10.5	9.6	11.8	10.9	11.3		10.56
Target	8.5	9.4	11.6	12.7	10.8	11.1	12.1	11.7	11.5		11.04
Hall. Magnum	10.1	11.5	13.9	15.9	13.0	12.8	14.1	13.4	13.6		13.09
Hall. Taurus	-	-	15.6	13.8	13.3	15.2	14.9	15.1	15.3		-
Hall. Merkur	-	-	-	-	-	-	-	12.1	12.4		-
Columbus	-	-	-	-	-	-	-	10.6	-		-

Source: EU report

The 10-year average applies to the years 1993 – 2002. So far we have received no data for the crop year 2003.

3.2.1 Hop marketing 2003

The hop marketing in 2003 was extremely difficult. The majority of spot hops were taken into a pool by the hop-trading firms and the producer groups. Part payments were made for certain varieties. Payments have still not been made for varieties which are difficult to market. Therefore no average price can be calculated for spot hops and neither can the total average price. The earnings per hectare hop acreage cannot be calculated for this reason either.

3.2.2 World hop market

Table 3.8: World hop market

	1994	1995	1996	1997	1998	1999	2000	2001	2002
World hop acreage in ha	86 786	81 466	76 967	70 290	60 111	57 427	58 991	58 903	57 703
Change in ha	-4 335	-5 320	- 4 499	- 6 677	-10 179	- 2 684	+ 1 564	- 88	- 1 200
World hop crop in million zentner	2.43	2.53	2.49	2.24	1.89	1.91	1.93	1.98	2.01
Change in million zentner	- 0.31	+ 0.10	- 0.04	- 0.25	- 0.35	+ 0.02	+ 0.02	+ 0.05	+ 0.03
World average yield in Ztr./ha	28.00	31.06	32.35	31.92	31.48	33.24	32.79	33.68	34.97
World alphaproduction in 1000 kg	6 907	7 831	9 300	8 782	7 248	7 393	8 294	8 646	8 745
World beer production in million hectolitrel	1 214	1 248	1 269	1 300	1 301	1 365	1 392	1 424	1 444
Increase/decrease in %	+ 2.19	+ 2.80	+ 1.68	+ 2.44	+ 0.8	+ 3.46	+ 1.98	+ 2.30	1.40
Amount of hops harvested per hl beer in grams	99	101	98	86	72	70	69	70	70
Alpha production per hl beer produced in grams	5.66	6.27	7.33	6.76	5.57	5.42	5.96	6.08	6.06

Source: Barth report

Diagram 3.7: World hop acreage

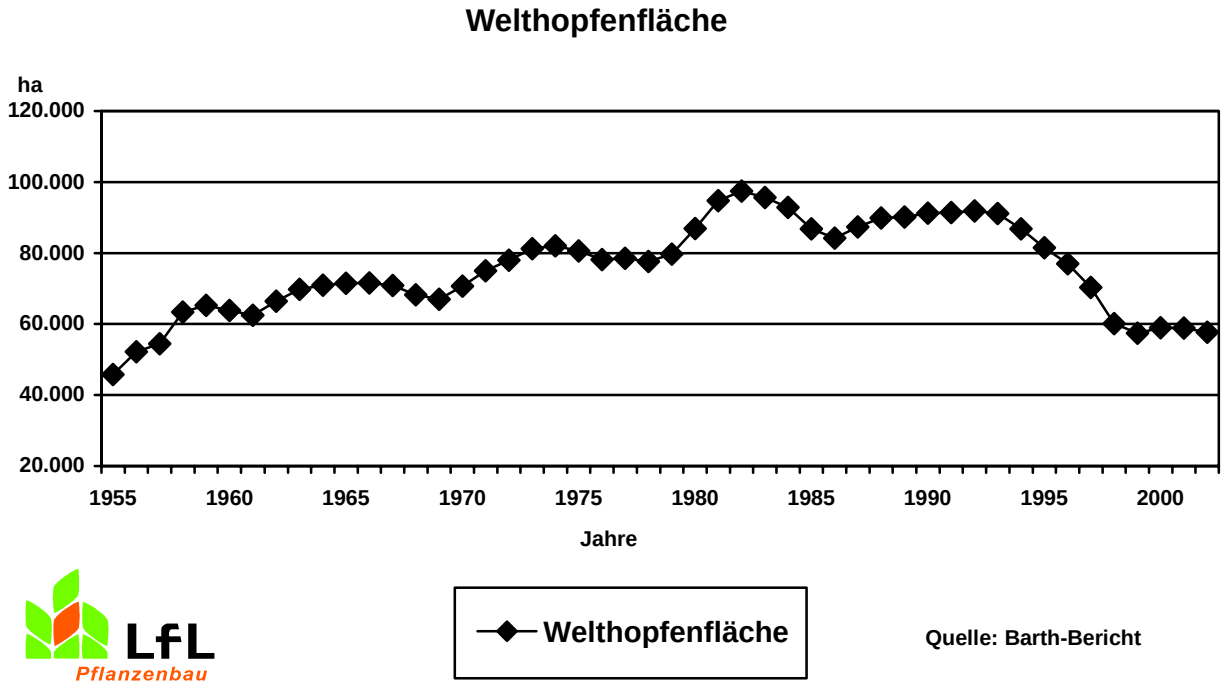


Diagram 3.8: **Hop acreage of various countries**

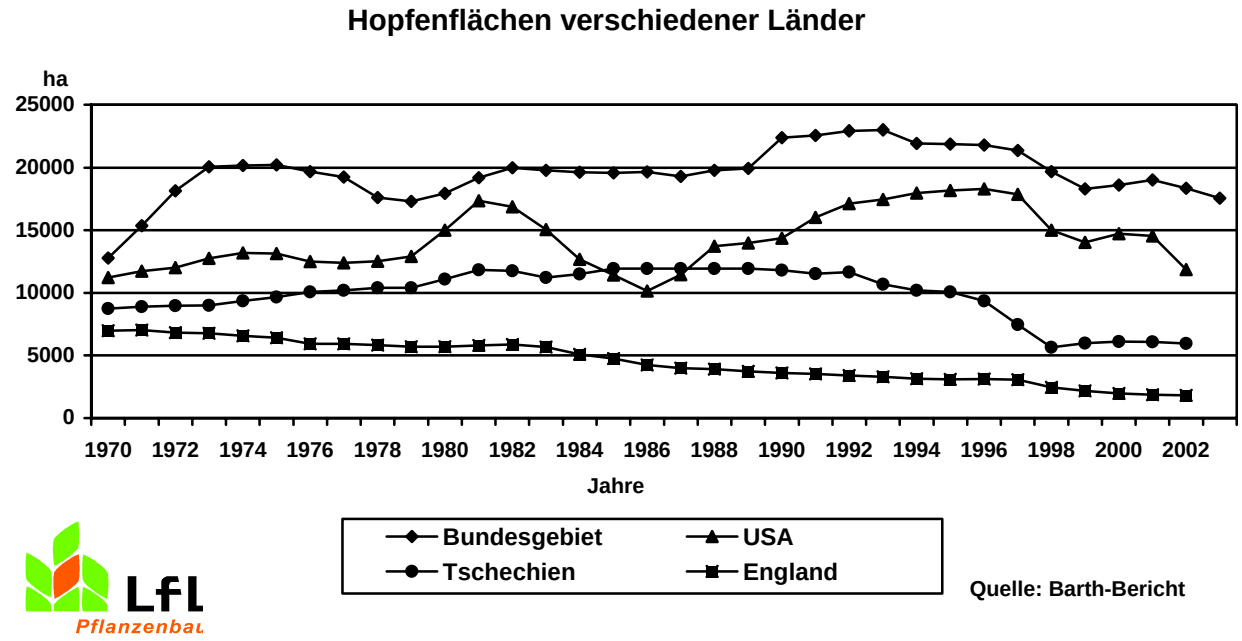


Diagram 3.9: **World hop crop**

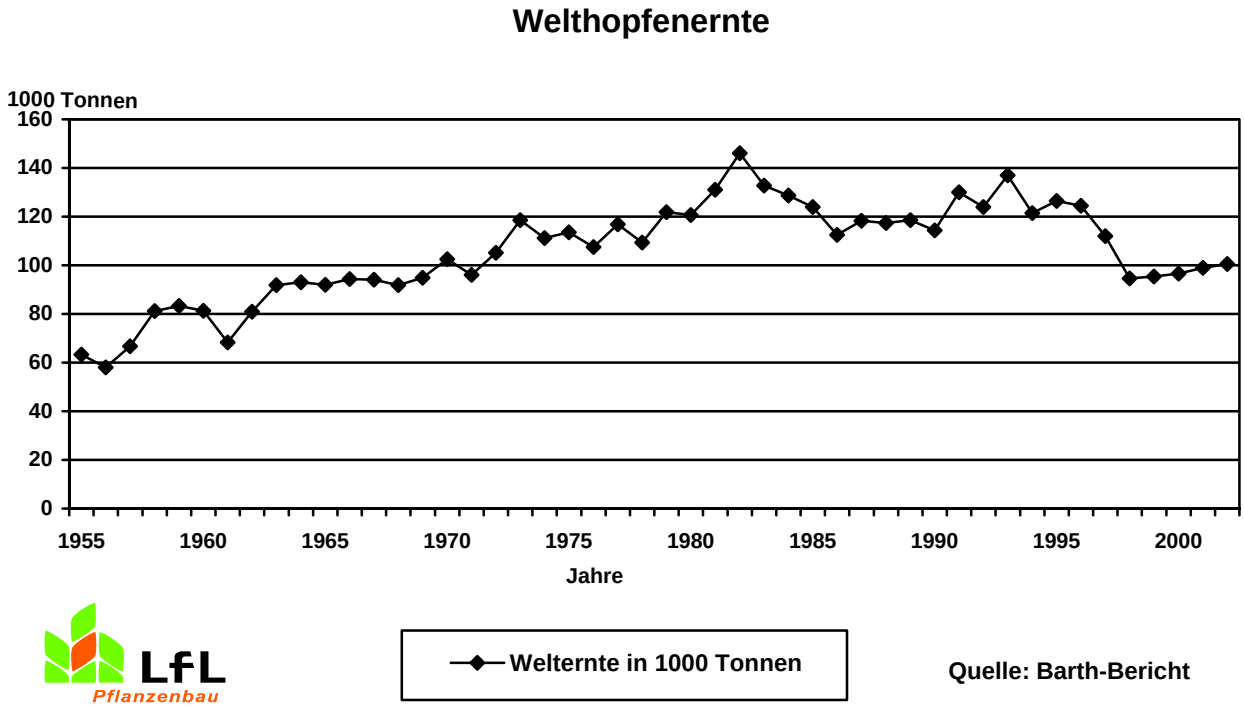
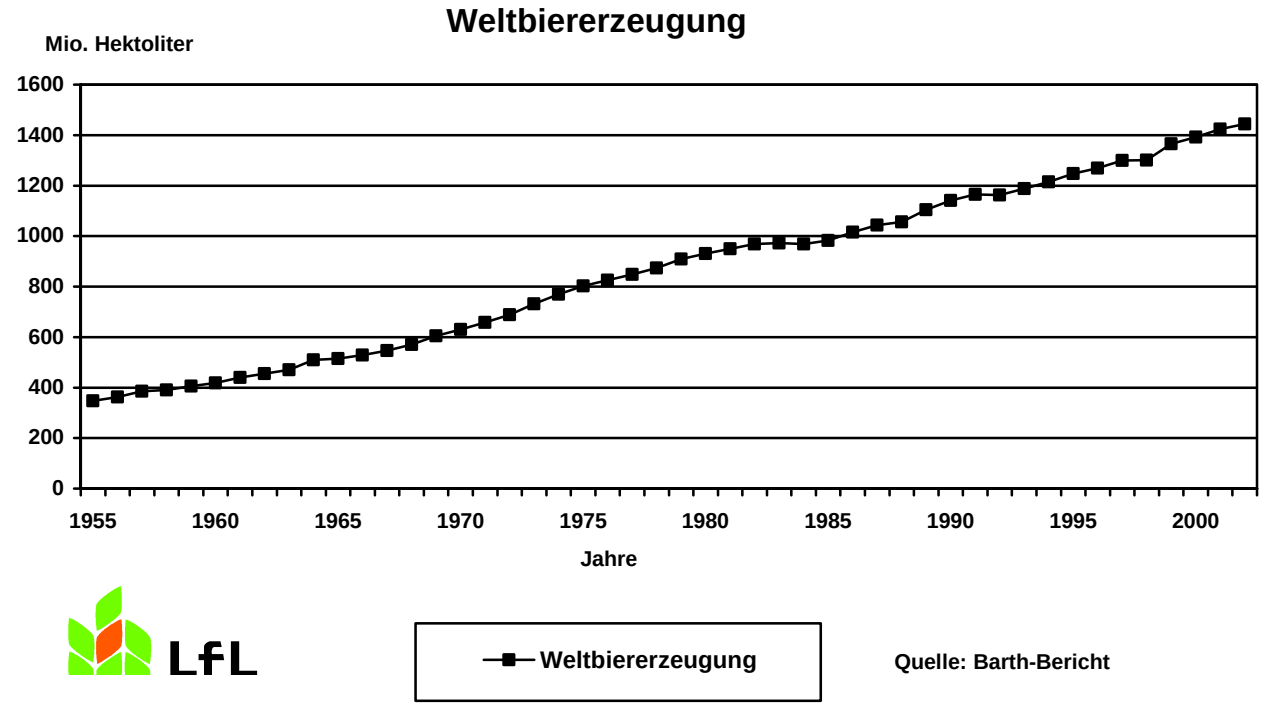


Diagram 3.10: **World beer production**



4 Breeding Research on Hops

Dr. Elisabeth Seigner, Dipl. Biol.

4.1 Practical hop breeding

4.1.1 Crossing programme 2003

110 crosses were carried out in 2003 with the following breeding aims:

No. of crosses

32 Aroma hops with good downy mildew tolerance and powdery mildew resistance
15 Low-trellis hops with downy mildew tolerance and powdery mildew resistance
63 Bitter hops with good downy mildew tolerance and powdery mildew resistance
total:110

In 2003 the number of crosses was again very high. There were some wild hops with a new kind of powdery mildew resistance which should be used as crossing partners.

4.1.2 Results of the seedling tests

The unusually hot, dry weather in the summer of 2003 also had obvious effects on the development of the seedlings.
Despite late pruning the warm weather in May resulted in rapid longitudinal growth and the first seedlings had already reached the top of the trellis by the end of May. Some very early seedlings came into burr prematurely and by mid-July some vines were fully coned.
The disease pressure from downy mildew and powdery mildew was very slight. Also as regards hop aphid despite only one treatment there was hardly any “cone-blackening” as the aphids literally died of thirst. The two-spotted spider mite enjoyed extremely favourable conditions in 2003. Two treatments had to be carried out in the breeding yards.
The water reserves were completely used up by the end of August. As far as seedlings and breeding lines medium-early in maturity are concerned the low yields were still within an acceptable range. Seedlings and breeding lines with late and above all those with very late maturity showed bad cone formation. The alpha-acid values dropped sharply with some breeding lines.
From the breeding aspect in 2003 the positive side was that after seven years with largely well-balanced weather conditions it was very good to select for drought tolerance and alpha-acid stability.

4.1.2.1 Seedlings 2000

Of the seedlings 2000 there are 3940 descendants from 40 aroma crosses and 82 bitter crosses being grown in the breeding yard at Huell. The seedlings were not treated with any chemicals to control powdery mildew during the whole vegetation period.

Hallertauer Mfr., Hallertauer Tradition, Spalter Select and Perle were grown as reference varieties in the aroma hop sector. The reference varieties in the bitter sector are Hallertauer Magnum, Hallertauer Taurus, Nugget and Wye Target.

Result of the seedlings 2000

Altogether 137 seedlings were harvested during the two years' crop testing. It was possible to select 19 seedlings with individual plant yields over 1000 g and 36 seedlings with alpha-acid values over 14 %.
Six breeding lines were already included in the new „Stammespruefung“ (trials with replications at two different locations) in 2003. Another nine breeding lines are envisaged for the „Stammespruefung“ 2004.

4.1.2.2 Seedlings 2001

Of the seedlings 2001, approx. 3800 descendants from 55 aroma crosses and 57 bitter crosses are being grown in the breeding yard at Huell.
Hallertauer Mfr., Hallertauer Tradition, Spalter Select and Perle are being grown as reference varieties in the aroma sector. The reference varieties in the bitter sector are Hallertauer Magnum, Hallertauer Taurus, Nugget and Wye Target.

Results of the seedlings 2001

The seedlings 2001 were planted in autumn 2001 in the breeding yard and developed so well up to the harvest that 118 seedlings could already be harvested in the first year. Another 112 seedlings were harvested in 2003. So far it has been possible to select 24 seedlings with alpha-acid values over 14 %.
Eight breeding lines were already included in the new „Stammespruefung“(trials with replications at two different locations) in 2003. Another eight breeding lines are envisaged for the „Stammespruefung“ 2004.

4.1.2.3 Seedlings 2002

Of the seedlings 2002 approx. 4950 descendants from 38 aroma crosses and from 40 bitter crosses are being grown in the breeding yard at Huell.
Hallertauer Mfr., Hallertauer Tradition, Spalter Select and Perle are being grown as reference varieties in the aroma sector. The reference varieties in the bitter sector are Hallertauer Magnum, Hallertauer Taurus, Nugget and Wye Target.

Results of the seedlings 2002

The seedlings 2002 were only transplanted into the breeding yard during the spring of 2003 due to the extremely damp weather in autumn 2002. Despite the very dry, hot weather conditions the seedlings developed surprisingly well and some especially drought-tolerant seedlings could even be harvested.
Five breeding lines are already envisaged for the new „Stammespruefung“ (trials with replications at two different locations).

4.1.3 New breeding lines from Huell increase the diversity of the beers

4.1.3.1 Principles on testing and applying for the registration of the breeding lines

After 16 years of intensive breeding work for two aroma lines and eight and/or ten years testing for four high-alpha lines at the Hop Research Centre in Huell of the Bavarian State Institute for Agriculture (LfL) application was made to register the promising lines.
The testing of breeding lines in breeding yards and farm trials comes solely under the Hop Department of the LfL.
Contrary to this, it is laid down in the cooperation contract between the Free State of Bavaria, represented by the LfL, and the Society for Hop Research (GfH) that decisions on applying for registration of breeding lines must be mutually agreed. The application can only be made by the GfH as government authorities may not be holders of variety rights. As a rule the testing by the Federal Plant Registration Office (BSA) takes two years; in justified exceptions the test can be speeded up to one year.
Furthermore in the cooperation contract it is laid down that varieties newly bred at the hop research institute are to be solely surrendered to the GfH for sale to the farmers. As holders of variety rights the Society for Hop Research has the right i.a. to lay down and call for licences.
Due to financing the hop-breeding in Huell, it is out of the question that breeding lines can be solely supplied to one purchaser, i.e. anybody interested has access to the breeding lines and varieties released for hop-growing by the LfL and GfH.
The breeding lines already mentioned were created by conventional cross-breeding followed by selection and are therefore not affected by changes through genetic engineering.
Detailed information on the breeding lines including the results of brewing trials will be presented at the 2nd Seminar on Raw Materials on 30 March 2004 in Weihenstephan.

4.1.3.2 Aroma breeding lines 87/24/55 ("Smaragd") and 87/24/56 ("Opal")

Hops, especially aroma hops, provide the brewers with an opportunity to make their beers differ from other brands. These two newly bred lines are marked by an outstanding aroma which differs considerably from the varieties available at the present time. By using these newly bred lines the brewers have the chance to create new beers. Both breeding lines have been tested for several years by several breweries and are now to be tested and used to a greater extent. They produced good results in the brewing trials so far with all the beer types tested, beginning with a typical Pils via the Bavarian lager and the lesser hopped types of American beer. In the brewing trials the beers were also marked by a good foam and storage stability. The new varieties should not replace the present varieties of the Hop Research Centre in Huell but supplement them.

The two newly bred aroma lines are siblings and come from the following cross:

Huell breeding variety Hallertauer Gold x male wild hop Ku II/18.

The "old" Huell cultivar Hallertauer Gold is marked by favourable agronomic characteristics, an average alpha-acid content and an excellent aroma, which is very similar to the traditional variety Hallertauer Mfr. A disadvantage is only the incomplete wilt tolerance and bad susceptibility to powdery mildew.
The wild hop Ku II/18 comes from the Kulmbach area and was found during a wild hop collection in the 1980s. It is marked by a very low cohumulone content, slight susceptibility to powdery mildew and a good healthy crown. Using Ku II/18 as crossing partner was mainly to introduce low cohumulone contents into the existing Huell breeding material. Afterwards it proved to be excellent in passing these characteristics on in numerous crosses.
This is extremely unusual. Normally as well as the desired characteristics wild hops also pass on many negative qualities, such as unfavourable appearance, low alpha-acid contents and high susceptibility to disease. As a rule this makes several re-crosses necessary in order to suppress the negative characteristics.

Aroma breeding line 87/24/55 ("Smaragd")

Registration for this aroma breeding line was applied for at the Federal Plant Registration Office in December. The name **"Smaragd" (SD)** was proposed for the variety.
As well as the plot trials in the breeding yards this breeding line is in six farm trials, of which there are two areas with approx. 0.7 ha respectively. It is planned to extend the test on an area of 5-6 hectares in spring 2004.
So that sufficient hops are available for the breweries for brewing trials in the next few years, the big hop-trading firms will already receive up to 1000 plants for trial growing in spring 2004. The other interested hop-trading firms can obtain pellets of this breeding line via the HVG.

Table 4.1: Average results of the aroma breeding line 87/24/55 ("Smaragd") in the "Stammespruefung" and in farm trials so far

crop years	yield in ztr./ha	alpha-acids in %	beta-acids in %	cohumulone in % of alpha-acids
2003	35.6	3.2	2.7	15.2
2002	42.7	6.3	5.4	13.8
1991 – 2002	39.0	5.7	4.8	14.4
1991 – 2003	38.6	5.6	4.7	14.4

Brief description :

- yields about 40 ztr./ha (30 - 50)
- alpha-acid contents about 5,5 % (3,0 – 7,0)
- beta-acid contents about 4,5 % (3,0 – 6,0)
- cohumulone about 15 % (13 - 16)
- average storage stability
- aroma points 24 – 26 (own special aroma)
- favourable oil pattern (e.g. linalool 20 – 30)
- good, healthy crown
- homogenous shoots
- cylindrical vine with good cone set
- somewhat susceptible for late powdery mildew
- good downy mildew tolerance
- good wilt tolerance
- medium-late maturity (4th September)

Aroma breeding line 87/24/56 ("Opal")

This aroma breeding line was already registered by the Federal Plant Registration Office on 26.03.2001 under the cultivar name **("Opal") (OL)**. Re the decision passed on 11.12.2003 this variety was released for commercial growing. This means that the propagation will begin in spring 2004.
Besides the plot trials in the breeding yards the variety Opal is being tested in eight farm trials, one of which has an area of approx. 0.8 ha. An extended production on an area of approx. 2.5 ha is planned for spring 2004.
So that sufficient hops are available for the breweries for brewing trials over the next few years, the big hop-trading firms will already receive up to 1000 plants for trial growing in spring 2004. The other interested hop-trading firms can obtain pellets of the breeding line via the HVG.
In the meantime it has come to light that a hop variety with the name Opal has also been registered in Australia and is also being grown in the field. In this case it is a high-alpha variety with a cohumulone content of more than 30%. Since this variety came onto the market at the end of the 1990s and was only listed later on in international reports, it so happened that the name Opal was registered twice for hop varieties. The production area of the Australian high-alpha variety is clearly decreasing but at the moment it is being discussed whether it would make sense to replace the name Opal for the breeding line 87/24/56 with another cultivar name.

Table 4.2: Average results of the aroma variety Opal in the "Stammespruefung" and in farm trials

crop years	yield in ztr./ha	alpha-acids in %	beta-acids in %	cohumulone in % of alpha-acids
2003	32,1	4,7	3,9	14,1
2002	40,9	8,4	5,8	14,0
1991 – 2002	43,8	8,0	5,5	14,3
1991 – 2003	42,9	7,6	5,3	14,4

Brief description :

- yields about 40 ztr./ha (30 - 50)
- alpha-acid contents about 7.5 % (4,5 – 10)
- beta-acid contents about 5 % (3,5 – 6)
- cohumulone about 15 % (13 - 16)
- average storage stability
- aroma points 24 – 26 (own, special aroma, freshly harvested somewhat fruity and pungent)
- favourable oil pattern (e.g. linalool 25-40)
- good, healthy crown
- homogenous shoots
- cylindrical vines
- nice cones
- little susceptibility to powdery mildew
- good downy mildew tolerance
- good wilt tolerance
- medium-early maturity (end of August)

4.1.3.3 High-alpha breeding lines 93/10/34, 93/10/36 and 93/10/63

In December 2003 application was made to the Federal Plant Registration Office to register the high-alpha breeding lines 93/10/34, 93/10/36 and 93/10/63.
No variety names have yet been proposed for these breeding lines, as presumably not all the lines will be registered or certain lines will be withdrawn after they have been tested.

The three high-alpha breeding lines are siblings and originate from the following cross:

Huell-bred cultivar Hallertauer Magnum x male breeding line 81/8/13

The powdery mildew (PM) resistant cultivar Hallertauer Merkur, which was released for commercial growing in 2000, also originated from this cross.
A lot of interesting breeding lines could be selected as regards this cross. They are all marked by good growth and a healthy crown. The mother of the male breeding line 81/8/13 is the PM resistant English variety Wye Target. Although the cv. Hallertauer Merkur and the three high-alpha breeding lines awaiting registration do not appear to possess the major gene of Wye Target which is responsible for the resistance, they proved to be resistant in all powdery mildew tests.
While Hallertauer Merkur with its poor winding ability and its high susceptibility to *Botrytis* has two serious agronomic disadvantages. There are no problems in this respect with the siblings awaiting registration. What is more, in recent years it could be seen that the newly registered lines produce more stable alpha-acid contents than Hallertauer Merkur.
Hallertauer Merkur was released for cultivation under the impression of the problem year 1999 with a disease pressure which had not been known before. While Hallertauer Merkur already stood out at the young hop stage as being a very interesting breeding line, the siblings only produced outstanding results in the subsequent years. For this reason the high-alpha breeding lines 93/10/34, 93/10/36 and 93/10/63 were only admitted to the „Stammespruefung“ (advances trials in several replications at two different locations) two years later. At the time the decision was made in 2000 only six plants of these breeding lines respectively were in the test at two locations. Compared with the variety Hallertauer Merkur there had not yet been any results from storage and brewing trials. Therefore the risk for introducing one of these siblings would have been too big.
In the meantime new “Stammespruefung” tests and farm trials, as well as storage studies, were made with these breeding lines and the respective performance potential can now be considerably better assessed. So far a brewing trial has only been made with the breeding line 93/10/36 (refer to Point 4.1.4). The results obtained here can be compared with the reference varieties Hallertauer Magnum and Hallertauer Taurus.
The results of the three high-alpha breeding lines under comparable conditions are shown in Table 4.3. It is quite obvious that the breeding lines 93/10/36 and 93/10/63 which are late in maturity show a higher yield potential. As the breeding line 93/10/34 is interesting for many farms due to early maturity, in order to extend the harvesting period the registration of these varieties was applied for despite the somewhat lower yield of alpha-acids per ha.
Also as far as these breeding lines are concerned, the big hop-trading firms can already obtain up to 1000 plants for trial growing in spring 2004 so that sufficient hops are available to the breweries for brewing trials during the next few years. Any other interested hop-trading firms can obtain pellets via the HVG.

Table 4.3: Results of the high-alpha breeding lines 93/10/34, 93/10/36 and 93/10/63 in a direct comparison

Breeding line	Yield in ztr./ha	kgα/ ha	Alpha-acids in %	Beta-acids in %	Cohumulone in % of alpha-acids
93/010/034	52.2	374	14.3	4.5	21.4
93/010/036	55.3	405	14.7	5.3	27.2
93/010/063	57.4	401	14.0	5.6	31.3

High- alpha breeding line 93/10/34

Table 4.4: Average results of the high alpha-breeding line 93/10/34 in the "Stammespruefung" and in farm trials

Crop years	Yield in ztr./ha	Alpha-acids in %	Beta-acids in %	Cohumulone in % of alpha-acids
2003	36.3	10.6	4.6	19.8
2002	47.9	13.4	4.5	22.5
1995 - 2002	51.9	14.5	4.5	22.2
1995 -2003	48.6	13.9	4.5	21.8

Brief description :

- yields about 40 ztr./ha (30 - 55, like Hallertauer Magnum)
- alpha-acid contents about 14 % (10 – 16)
- beta-acid contents about 4.5 % (3.5 – 5.5)
- cohumulone about 22 % (20 – 25)
- average storage stability
- aroma points 20 - 22
- linalool about 20; farnesene 0
- somewhat heterogenous growth with few shoots
- slight cone set
- open vine
- long, slim cones
- average resistance to powdery mildew
- average downy mildew tolerance
- some *Botrytis* and cones dying off
- early maturity (picking 3 - 5 days before Hallertauer Magnum)

High-alpha breeding line 93/10/36

Table 4.5: Average results des high-alpha breeding line 93/10/36 in the "Stammespruefung" and in farm trials

Crop years	Yield in ztr./ha	Alpha-acids in %	Beta-acids in %	Cohumulone in % of alpha-acids
2003	42.8	11.3	4.8	24.4
2002	64.9	15.4	5.9	27.7
1995 - 2002	56.8	14.7	5.3	27.4
1995 - 2003	52.6	13.9	5.2	26.6

Brief description :

- yields about 45 Ztr./ha (30 - 60, like Hallertauer Magnum)
- alpha-acid contents about 14 % (11 – 15.5)
- beta-acid contents about 5 % (4.5 – 5.7)
- cohumulone about 27 % (25 - 28)
- average storage stability
- aroma points 20 - 23
- linalool about 20; farnesene 0
- relatively homogenous growth
- good cone set
- vine relatively dense at the top
- cones similar to Hallert. Magnum with dark-green colour
- good powdery mildew resistance
- average downy mildew tolerance
- some *Botrytis* and cones dying off
- medium late maturity (picking like Hallertauer Magnum)

High-alpha breeding line 93/10/63

Table 4.6: Average results of the high-alpha breeding line 93/10/63 in the "Stammespruefung" and in farm trials

Crop years	Yield in ztr./ha	alpha-acids in %	beta-acids in %	Cohumulone in % of alpha-acids
2003	44.4	10.5	4.3	28.6
2002	54.3	14.1	6.5	30.9
1995 - 2002	56.9	14.0	5.7	31.4
1995 - 2003	54.4	13.4	5.5	31.0

Brief description :

- yields about 48 ztr./ha (35 - 60, via Hallertauer Magnum)
- alpha-acid contents about 13.5 % (10 - 15)
- beta-acid contents about 5.5 % (4.9 – 6.1)
- cohumulone about 32 % (30 - 34)
- aroma points 20 - 22
- linalool 15 - 20, farnesene 0
- strong root formation (runners) and few shoots at the centre of the crown
- rapid development in youth
- strong wide-spreading vine
- very robust hops (yield stable)
- very big, firm cones with a light colour
- good powdery mildew resistance
- average to good downy mildew tolerance
- some *Botrytis* and cones dying off
- high susceptibility to aphids
- late maturity (when picking Hallertauer Magnum finishes)

4.1.3.4 High-alpha breeding line 95/94/816

According to the results so far the high-alpha breeding line 95/94/816 seems to be the most promising. If the progress in alpha-acid yield determined so far is confirmed in further tests, this breeding line can contribute to maintaining competitiveness on the global market. For this reason in December 2003 not only the national variety registration but also European registration was applied for at the Community Variety Registration Office of the European Union in Angers/France. The testing costs are in fact considerably higher but following the EU expansion in May 2004 the registration at the EU level guarantees full variety protection rights in the most important European production regions.

The high-alpha breeding line originates from the following cross:

Huell-bred variety Hallertauer Taurus x male breeding line 93/9/41

In the course of a three-year seedling test, it was possible to select numerous interesting siblings and include them in advanced trials („Stammespruefung“). The descendants of this cross stand out by a combination of high yields and high alpha-acid values. Unfortunately as far as most descendants are concerned the cohumulone contents are over 30%.
Besides the good yield results, the breeding line 95/94/816 has above all favourable agronomic characteristics. Compared with most of the high-alpha breeding lines and varieties its vine is cylindrical with a very good cone set right down to the bottom. As a rule the cone is somewhat smaller than with Hallertauer Taurus and has finely overlapping bracteoles as well as being firmly closed. The only negative point noted so far is an average susceptibility for crown rot, which can be rated less than in the case of Hallertauer Taurus. In the next few years this characteristic will be observed in order to avoid adverse surprises for the farmers after the variety has been registered.
The storage studies and the brewing trials carried out so far were totally positive. The storage stability reaches at least the level of Hallertauer Magnum and Hallertauer Taurus.
Also as far as these breeding lines are concerned the big hop-trading firms can obtain up to 1000 plants for trial growing as early as spring 2004 so that sufficient hops are available to the breweries for brewing trials during the next few years. Any other interested hop-trading firms can obtain pellets via the HVG.

Table 4.7: Average results of the high-alpha breeding lines 95/94/816 in the “Stammespruefung” and in farm trials

Averages	Yield in ztr./ha	Alpha-acids in %	Beta-acids in %	Cohumulone in % of alpha-acids
2003	49.5	11.4	3.6	29.5
2002	62.1	15.9	5.3	36.0
1997 - 2002	64.0	16.7	5.2	35.6
1997 - 2003	58.2	14.9	4.7	33.7

Brief description :

- yields about 50 ztr./ha (35 - 70, via Hallertauer Magnum)
- alpha-acid contents about 14.5 % (10 - 18)
- beta-acid contents about 5 % (4.3 – 5.5)
- cohumulone about 35 % (30 - 37)
- good storage stability
- aroma points 20 - 22
- linalool 10, farnesene 0
- very nice cylindrical vine
- very good cone set right down to bottom
- somewhat susceptible for crown rot
- medium-size cones
- good powdery mildew resistance
- average downy mildew tolerance
- very late maturity (similar to Nugget)

4.1.3.5 Performance potential of the high-alpha breeding lines

Table 4.8 gives an overview on the yields and analysis results of the high-alpha breeding lines awaiting registration compared with the reference varieties Hallertauer Magnum and Hallertauer Taurus in the tests so far. As the lines and varieties are not adjacent to each other at all the testing locations under similar conditions, these values have been adjusted accordingly.

Tab 4.8: Performance potential of the varieties and high-alpha breeding lines

Breeding line	Yield in ztr./ha	kgα/ ha	Alpha-acids in %	Beta-acids in %	Cohumulone in % of alpha-acids
Hall. Magnum	45	315	14.0	6.4	26
Hall. Taurus	42	315	15.0	5.0	22
93/010/034	45	315	14.0	4.5	22
93/010/036	50	350	14.0	5.3	27
93/010/063	52	350	13.5	5.5	31
95/094/816	55	400	15.0	4.8	35

Notes:

- As far as all the crop results are concerned these are average values from plot trials! The field values to be expected are about 15-20 % lower (refer to Hall. Magnum and Hall. Taurus).
- Analysis results for the hop components are determined in accordance with EBC 7.7 (HPLC, air-dried cones)

4.1.4 Brewing trials with new breeding lines from Huell at the experimental brewery St. Johann

4.1.4.1 Hop analysis

As there were no analysis results from Huell available at the beginning of the trials, the hop samples were analysed (mid-November 2002) in St. Johann.
These values served as a basis for the hop dosing.

Table 4.9: Analysis results for the varieties and breeding lines

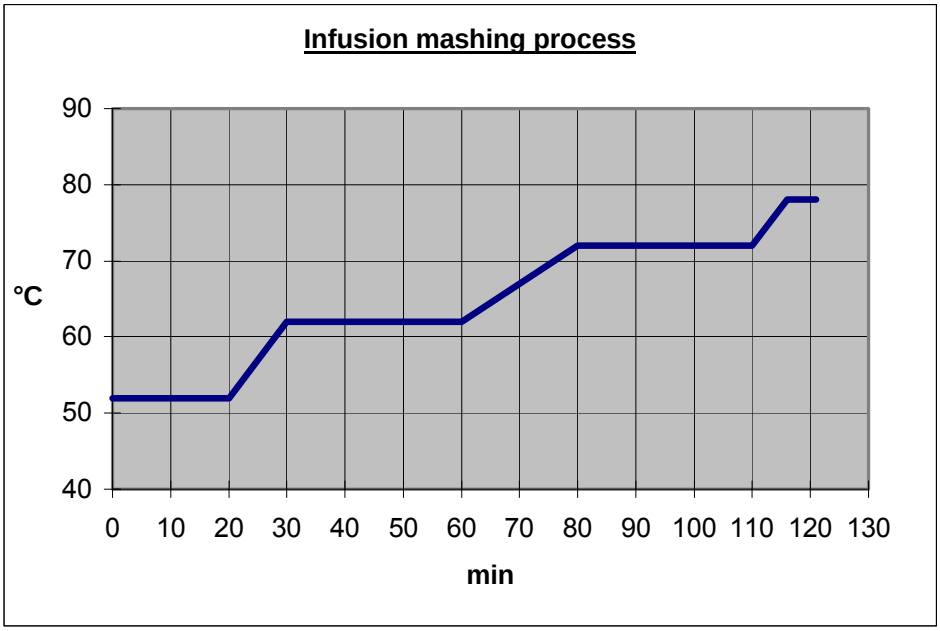
Designation of brew	Line/ variety	Alpha-acids in %	Beta-acids in %	Cohumulone in % alpha-acids
A 1	**HHA**	5.1	5.3	21.6
A 2	**HSR**	5.0	7.9	16.0
A 3	**87/024/055**	5.7	5.2	14.0
A 4	**87/024/056**	7.9	5.4	17.7
B 1	**HHM**	15.2	7.3	27.6
B 2	**HTU**	16.1	4.9	24.2
B 3	**93/010/036**	13.4	5.4	28.4
B 4	**95/094/721**	14.5	6.3	33.1
B 5	**95/094/816**	18.2	5.9	37.4

4.1.4.2 Brewing report

At the variety trials for the Bavarian State Institute for Agronomy, Hop Research Centre in Huell, milled samples of green hops from five bitter and four aroma varieties were brewed according to the standard brewing process. The purpose of these trials was to determine the brewing value of the breeding lines compared with the successful varieties.

34 kilos of a Pils malt in a dry state were milled on a two-roll mill and mashed in with four times as much water at 52°C. This was followed by an infusion mashing process (refer to Diagram 4.1).

5 Diagram 4.1: Temperature and variation in time with the infusion mashing process



In the lauter tun first of all 90 litres of first wort were gained from the mash. Together with 7 toppings up at 20 litres this made 230 litres of full tun wort with approx. 11.2 GG%.

The only difference between the bitter and aroma brews were the hop doses (refer to following table) and the boiling time. Efforts were made to obtain a bitterness of 25-30 BE, but this was not quite reached as far as the aroma brews were concerned.

Table 4.10: Hop dosage in the individual brews

	Hop dosing			
Trials	**Boil begins**	**Mid-boil**	**Whirlpool**	**Boil time**
B 1-5	**17 g α–acid**	**-**	**-**	**75 min**
A 1-4	**8 g α–acid**	**8 g α–acid**	**8 g α–acid**	**80 min**

The wort was boiled 75 or 80 mins. with the internal boiler. When the wort was cast (approx. 195 litres with approx. 12.7 GG%) the pH-value was corrected with 30 ml lactic acid (90%) to approx. 5.10. After a whirlpool rest lasting 20 mins. the wort was cooled down to approx. 6°C with a plate cooler, aired over a sintering candle with sterile air and pitched in a starting vessel at approx. 8-9°C with yeast crop (1st cultivation from a Munich brewery) with a cell count of approx. 25 million cells/ml.

The primary fermentation took a week at 9°C. The green beer was piped with remaining extract (E_S = 4 – 5 GG%) into the storage tank. There it was matured at 14°C until it was fermented completely and the diacetyl content was below the taste threshold.

Afterwards it was stored for 3-4 weeks at 1°C and under 0,7 bar pressure, before being filtered with a kieselgur horizontal filter and two candle filters (polypropylene membranes with 1.2µm and 0.45µm) without stabilising. The total quantity of beer was filled into bottles (0.5l Obus) and kept in a cool store until it was delivered, tasted and/or analysed

.

4.1.4.3 Results of tastings

Several tastings were carried out by the St. Johann taster panel according to the St. Johann tasting scheme (Table 4.11), which is based on a grading from 1 (worst) – 5 (best assessment), not only in the individual criteria but also in the sum total. The results as well as a short characterising of the beers is shown in Table 4.12.

Table 4.11: Taster form for beer at the experimental brewery St. Johann

Verkostungsformblatt für Bier (klare Biere) Probenbezeichnung						
Prüfkriterien						
Aussehen	**Farbe**	1 deutlich zu hell	9	9	9	9	9
		2 zu hell	8	8	8	8	8
		3 etwas zu hell	7	7	7	7	7
		4 Spur zu hell	6	6	6	6	6
		5 typgerecht	5	5	5	5	5
		4 Spur zu dunkel	4	4	4	4	4
		3 etwas zu dunkel	3	3	3	3	3
		2 zu dunkel	2	2	2	2	2
		1 deutlich zu dunkel	1	1	1	1	1
	Glanz / Trübung	5 klar, leuchtend	5	5	5	5	5
		4 klar	4	4	4	4	4
		3 opalisierend	3	3	3	3	3
		2 opal	2	2	2	2	2
		1 trüb, Bodensatz	1	1	1	1	1
Schaum	**Poren-größe**	5 durchgehend fein	5	5	5	5	5
		4 fein bis mittel	4	4	4	4	4
		3 mittel	3	3	3	3	3
		2 mittel bis grob	2	2	2	2	2
		1 grobe Blasen	1	1	1	1	1
	Haft-vermögen	5 sehr gut anhaftend	5	5	5	5	5
		4 gut anhaftend	4	4	4	4	4
		3 befriedigend anhaftend	3	3	3	3	3
		2 wenig anhaftend	2	2	2	2	2
		1 schlecht, kein Anhaften	1	1	1	1	1
Geruch		5 typisch, ausgeprägter Charakter	5	5	5	5	5
		4 rein, noch typisch	4	4	4	4	4
		3 leichte Fehler	3	3	3	3	3
		2 deutliche Geruchsfehler	2	2	2	2	2
		1 starke Fehler, ungenießbar	1	1	1	1	1
Ge-schmack		5 typisch, ausgeprägter Charakter	5	5	5	5	5
		4 rein, noch typisch	4	4	4	4	4
		3 leichte Fehler	3	3	3	3	3
		2 deutliche Geschmacksfehler	2	2	2	2	2
		1 starke Fehler, ungenießbar	1	1	1	1	1
Trunk	**Vollmundigkeit**	1 deutlich zu voll, mastig	9	9	9	9	9
		2 zu voll	8	8	8	8	8
		3 etwas zu voll	7	7	7	7	7
		4 Spur zu voll	6	6	6	6	6
		5 typgerecht	5	5	5	5	5
		4 Spur zu leer	4	4	4	4	4
		3 etwas zu leer	3	3	3	3	3
		2 leer	2	2	2	2	2
		1 deutlich zu leer, wässrig	1	1	1	1	1
	Weichheit	5 sehr weich	5	5	5	5	5
		4 weich	4	4	4	4	4
		3 nicht ganz abgerundet	3	3	3	3	3
		2 unharmonisch	2	2	2	2	2
		1 hart	1	1	1	1	1
Rezenz		1 adstringierend	9	9	9	9	9
		2 zu rezent	8	8	8	8	8
		3 etwas zu rezent	7	7	7	7	7
		4 Spur zu rezent	6	6	6	6	6
		5 angenehm rezent	5	5	5	5	5
		4 genügend rezent	4	4	4	4	4
		3 mäßig rezent	3	3	3	3	3
		2 wenig rezent	2	2	2	2	2
		1 schal, abgestanden	1	1	1	1	1
Bittere	**Intensität**	1 deutlich zu bitter	9	9	9	9	9
		2 zu bitter	8	8	8	8	8
		3 etwas zu bitter	7	7	7	7	7
		4 Spur zu bitter	6	6	6	6	6
		5 typgerecht bitter	5	5	5	5	5
		4 Spur zu wenig bitter	4	4	4	4	4
		3 etwas zu wenig bitter	3	3	3	3	3
		2 zu wenig bitter	2	2	2	2	2
		1 deutlich zu wenig bitter	1	1	1	1	1
	Qualität	5 sehr fein	5	5	5	5	5
		4 fein	4	4	4	4	4
		3 etwas nachhängend	3	3	3	3	3
		2 nachhängend/breit	2	2	2	2	2
		1 deutlich nachhängend/breit	1	1	1	1	1

Table 4.12: Characterising the test beers at the tastings

6	Smell and flavour pure, somewhat fruity Full-bodied, not quite rounded off Bitters clear, a trace hangs on
B2	Smell and flavour pure, a trace fruity Full-bodied, soft Bitters appropriate to type, fine
B3	Smell and flavour pure, a trace sweetish Full-bodied, soft Bitters appropriate to type, still fine
B4	Smell and flavour neutral Full-bodied, not quite rounded off Bitters clear, a trace hangs on
B5	Smell and flavour somewhat fruity Full-bodied, soft Bitters appropriate to type, fine
A1	Smell and flavour somewhat fruit-sweet hop aromatic Full-bodied, soft Bitters appropriate to type, fine
A2	Smell pure, hop aromatic Flavour pure Full-bodied, soft Bitters appropriate to type, fine
A3	Smell and flavour somewhat fruity-estery, hop aromatic Full-bodied, very soft Bitters appropriate to type, very fine
A4	Smell a trace fruity-sulphidic, hop aromatic Flavour somewhat fruity Full-bodied, soft Bitters appropriate to type, still fine

4.1.4.4: Closing remarks and outlook

The hop samples made available by the LfL, Hop Research Centre in Huell for the brewing trials varied somewhat in their quality. Furthermore as far as the brews were concerned, they were individual brews. This should be taken into account when assessing the results of these trials.
The quality of the beers produced and therefore the brewing value of all the hop varieties used was very high in the whole series. When tasting the fresh beers not one of the beers was below the overall mark 4.0.
Neither with the brewed aroma varieties nor with the bitter varieties were there significantly differing results. The complete analysis results can be obtained from the experimental brewery St. Johann or from the Hop Research Centre in Huell.
A uniform procedure should be laid down for future variety tests, how hop samples, which are envisaged for brewing trials should be treated. We propose the following:
As far as possible the hops should be dried immediately after harvesting and a sufficient quantity for the brewing trials (min. 150 g alpha) should be filled into a Zewathener directly in St. Johann, this should be gassed, sealed and put into cold storage at –35°C until the beginning of the trials. In this way the same initial quality of the hops used in the trials can be guaranteed.
In order to make it possible to differentiate between the hop varieties in the beers, for future trials it is recommended that the level of bitter compounds in the finished beer should be raised to 30 BE.

Diagram 4.2: Result of the tasting with regard to the bitter varieties

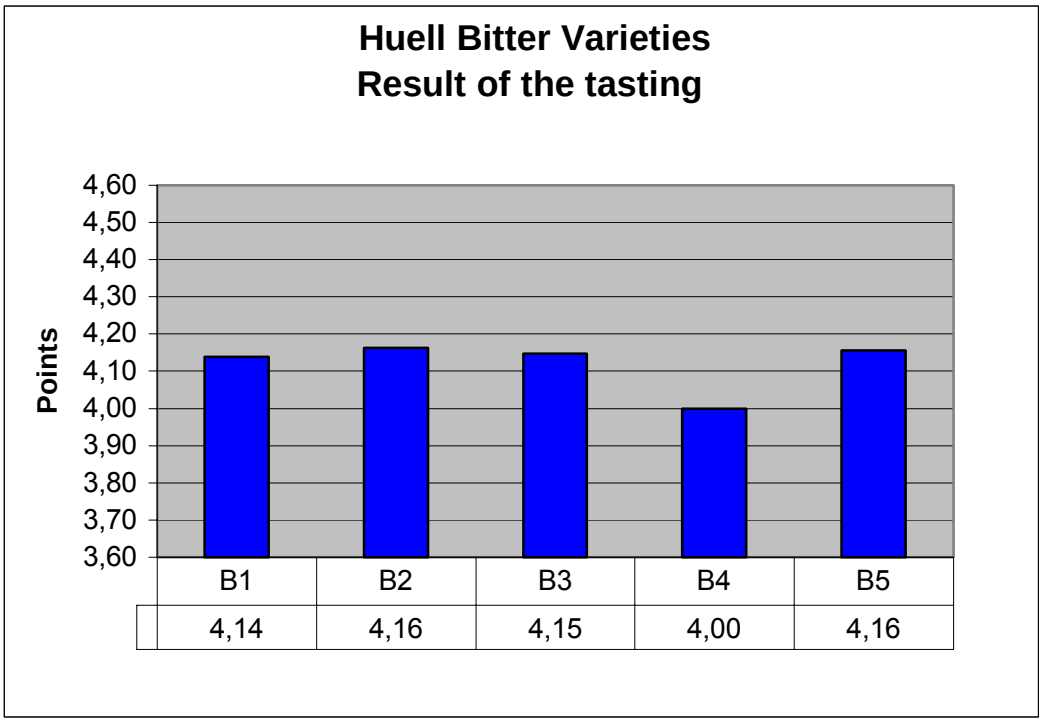
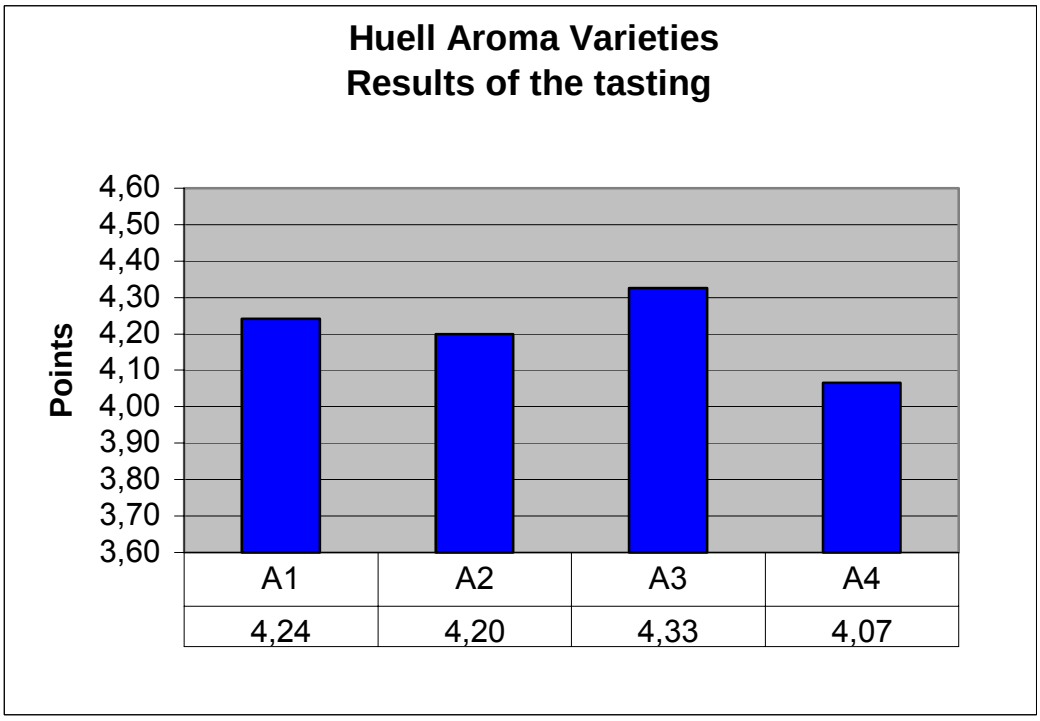


Diagram 4.3: Result of the tasting with regard to the aroma varieties



4.1.5 Breeding for powdery mildew resistance – wild hops as a promising resource for new resistances

A very extensive collection of wild hops has been built up in recent years. Due to a wide geographic origin (Europe, USA, Japan) these wild hops are regarded as an important new genetic resource. In 2003 with the support of the Scientific Station for Brewing in Munich it was possible to continue and intensify the work already begun to identify new kinds of resistance genes so far unknown in this wild hop germplasm. Wild hops with new fully effective powdery mildew (PM) resistances could ultimately be used as crossing partners to enlarge the genetic basis in the Huell breeding material.

In spring 2001 approx. 8000 wild hops from more than 58 different locations in Germany, Italy, Austria, Hungary and the USA were already checked in the greenhouse for their resistance after being artificially infected with PM spores. With more than 780 individuals no mildew pustules were found on the leaves, this is why they were assessed as resistant.

In spring 2003 at the beginning of the project the hops rated as resistant in previous tests were again subject to a resistance assay in the greenhouse. In order to make this screening in the greenhouse more reliable compared with previous years, powdery mildew races with the prevalent virulence spectrum (v3, v4, v6 and vB) of the Hallertau were provided by EpiLogic, our cooperation partner, as inoculation material. By using these PM isolates with their specific virulence types it could be assured that on the one hand the spread of infection with fungal spores was high enough and on the other hand that it was really tested with races which occur in the Hallertau hop-growing region. This test reliability had not been guaranteed in earlier tests, which is why the number of the wild hops rated as PM resistant was reduced from 750 to 144 after the 2nd test series for powdery mildew resistance in the greenhouse.

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Diagram 4.4: Testing for powdery mildew resistance in the greenhouse and in the laboratory

355 wild hops, part of which had already been rated as resistant in the greenhouse-screening, were inoculated in the laboratory with powdery mildew races as they occur in England. Thus, resistance towards others PM races that do not occur in the Hallertau could be checked.

A special PM infection test system in combination with monosporic fungal isolates was used for this resistance test in the laboratory. This test system was established by the LfL and their cooperation partner EpiLogic in a project financed by the Scientific Fund of the German Brewing Industry. A set of 13 single spore isolates of *Sphaerotheca humuli*, which reflect the virulence spectrum of the PM populations in England, France, the USA and in the Hallertauer hop-growing region, is available for the resistance tests. With this range of pathotypes it is possible to test for all the resistance genes so far used and known in hop-breeding.

As the powdery mildew isolates had already been produced in 1999 or 2000 respectively, at the beginning of the project the virulence behaviour of the 13 mildew isolates was checked again. This was to make sure that in the meantime the virulence genes had not been changed by mutations. With a set of differential hop varieties virulence analyses of all PM isolates were carried out which ultimately confirmed the virulence types of the various isolates.

In the laboratory a fungal isolate from England was used for the resistance testing, which shows the virulence type v1 and v2. Of 355 wild hops, which were tested in Petri dishes, none or extremely little growth of mycelium was seen on the young, highly sensitive leaves of 90 seedlings.

In this way after the first testing season in the greenhouse and in the laboratory (Diagram 4.4) 64 wild hops could be selected, which were identified to be resistant to all the powdery mildew races tested so far.

Next year all the wild hops, which remained uninfected after the greenhouse and laboratory testing, are to be tested in the laboratory for resistance to PM isolates with the v5 virulence type. Wild hops which are then still free from infections could be regarded as carriers of promising new resistances.

4.2. Genome analysis

4.2.1 Identifying molecular markers for powdery mildew resistance

The aim of the project sponsored by the Scientific Fund of the German Brewing Industry "Development of molecular selection markers for powdery mildew resistance as an effective aid to breeding quality hops" (Wifö-Nr. B 80) is to push ahead breeding for resistance via gene diagnosis. Selection procedures using molecular markers can be carried out very quickly and in a very reliable manner. Assessment of resistance is not influenced by the environment or the developmental stage of the plants to be investigated and above all not dependent on the infection pressure of the pathogens. In this way PM resistant plants can be selected using DNA-markers even in years when there are no infections of powdery mildew. In addition to this it is an obvious advantage that the successful combination of several resistance genes in the breeding material (pyramiding of genes) can be proved very quickly with molecular markers.

The identification of resistance markers is always based on the production of mapping populations from crosses of a plant carrying the resistance gene with a highly susceptible parent. As resistance donors so far the following varieties are available: "Wye Target" with its still effective *R2* resistance, the variety "Buket" with the *Rbu* gene and wild hops with newly characterised R genes.
The marker search last year focused upon the search for *R2*-markers. The spectrum could be extended to a total of 9 selection markers (refer to Diag. 4.5).

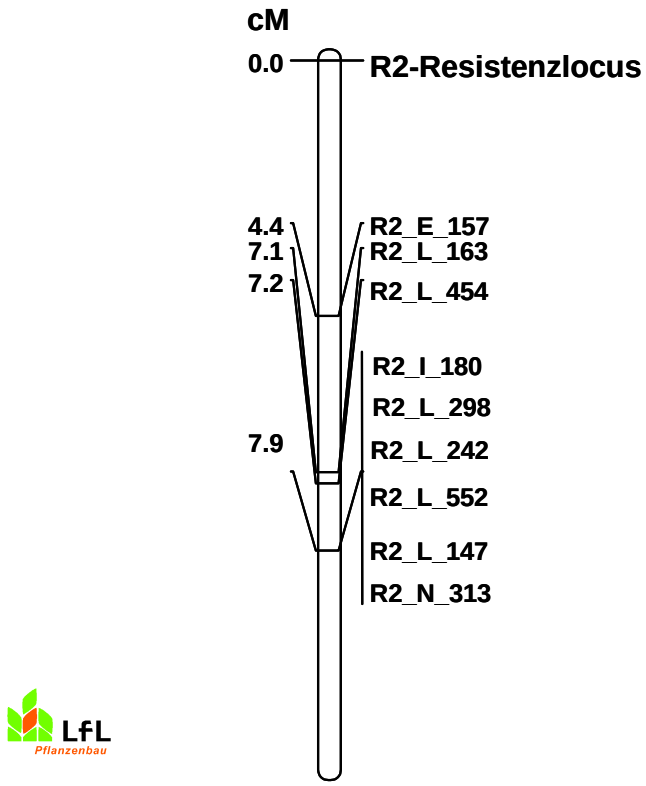


Diagram 4.5: Markers around the resistance locus *R2*

The quality of the *R2* resistance markers could so far be confirmed in 4 different mapping populations. The verification of these PM resistance fragments in a spectrum of 255 male and female breeding lines could not yet be completed.
Work is being done at the moment to work out a genetic map where identified DNA-markers for PM resistance should be localised. It can be seen that the number of all fingerprint data produced so far for calculating a genetic map does not suffice yet. New assignments therefore include a further AFLP enzyme system (PstI + MseI).

Besides markers for the *R2* resistance of "Wye Target" last year work should have begun on developing markers for the resistances of two wild hops from Thuringia, which were still effective in 2002. After artificial infection with a specific PM isolate the resistance data was determined from two mapping populations segregating for the WH25 gene and one mapping population with the wild hop WH 49. Using the PM isolate Huell ZG it was possible to differentiate 360 mapping individuals in the laboratory between resistant and susceptible. Shortly after these tests it was seen that PM infections occurred for the first time in the Huell greenhouse as far as the wild hops WH25 and WH49 were concerned. As the mixture of fungal races in the Huell greenhouse can be regarded as representative for the Hallertau hop-growing region, the molecular work on these resistance genes was stopped. Presumably this resistance is now broken in the Hallertau.

Outlook

For pyramiding several resistances in the Huell breeding material, there are mapping populations from the Eifel area available for molecular analyses. In a screening with international PM races their resistance even exceeded the resistance of "Wye Target". Shortly work will start on analysing the expression of the *R2* gene from "Wye Target" via cDNA-AFLPs.

4.2.2 Analysis of QTLs for alpha-, beta-acid, cohumulone, xanthohumol & yield

The aim of this research project is to identify DNA markers for genes of hop-components relevant to brewing beer. What is more, for the first time there is the chance in this research project to describe in molecular terms agronomic characteristics valuable for breeding such as yield, internodium length and cone form. Using a segregating population for the first time the influence of the respective location on these important parameters will be described through this project.

The basis for this QTL (quantitative trait loci) mapping project is a segregating population of 139 hop seedlings. Creating a genetic map, gene sections interesting for breeding are to be described and identified with molecular markers after recording chemical-analytical as well as phenotypical data. As a safe basis for this project a total of approx. 500 hop plants from the 4 locations were harvested at random and analysed via AFLP fingerprints to verify their genotype. Later on this molecular data can be used for producing a genetic map. From approx. 3000 cone samples at the moment alpha-, beta-acid, cohumulone and xanthohumol contents are being determined via the HPLC analysis. In three other populations with approx. 60 plants respectively, which were chemically analysed in Huell for the second year running, several very promising molecular markers could be identified. These markers only occur in seedlings with a cohumulone value over 25 (in % of alpha-acids). These markers can now be verified in the mapping population of this project.

4.2.3 Further molecular analyses in hops

Molecular assignments were carried out in preparing a potential project. The parents of a mapping population (hop-aphid resistance) were examined via fingerprint analyses for a sufficient degree of polymorphism. In these assignments a high degree of polymorphism was found which is of crucial importance for the success of the project.

In the late autumn the sex was determined via DNA analyses of important hop seedlings from various crosses of the year 2002, when there was still no indication of their sex. With two DNA markers (1 STS and 1 RAPD) it was possible to identify 58 male and 172 female seedlings.

Within the scope of wide-scale propagation of root cuttings of "Hallertauer mfr.“, "Hersbrucker" and "Hallertauer Taurus" in advance approx. 1200 data points were produced from 154 plants. Based on this data the respective genotype of these root-cuttings could be verified. These analyses are tremendously important for the Hop Research

Centre in Huell, in order to make sure that the hop-growers are supplied with the desired plants. As from only one single “wrong-typed” root-cutting later several thousand "wrong" genotypes would be propagated.

In an analysis for the hop industry also one wrong genotype could definitely be identified from 50 alleged genotypes of one variety with the aid of the AFLP and microsatellite markers. Also in the past year the enormous benefits of molecular markers could be seen in the hop research when analysing samples from the practice.

The following result could be obtained via a „trueness-to-type“ analysis of various hop samples. Diagram 4.6 shows the accuracy of the AFLP method applied when the purity of a variety should be investigated. Of 3 hop samples (A,B,C) only A and B were known. It had to be clarified whether the hop sample C was representative of the variety A or B. The DNA of some frequently used hop varieties was included as a reference for the following fingerprint analysis. In the analysis it could be clarified that as regards sample C it was neither a pure variety A nor the variety B. Also C could not be allocated to any of the reference varieties. Some fragments of A and some of B could definitely be proven in the sample C (refer to Diag. 4.6). Presumably sample C is a mixture of A and B. The enormous efficiency of this AFLP technique could be proved as the varieties A and B are very closely related hop varieties which are difficult to distinguish analytically.

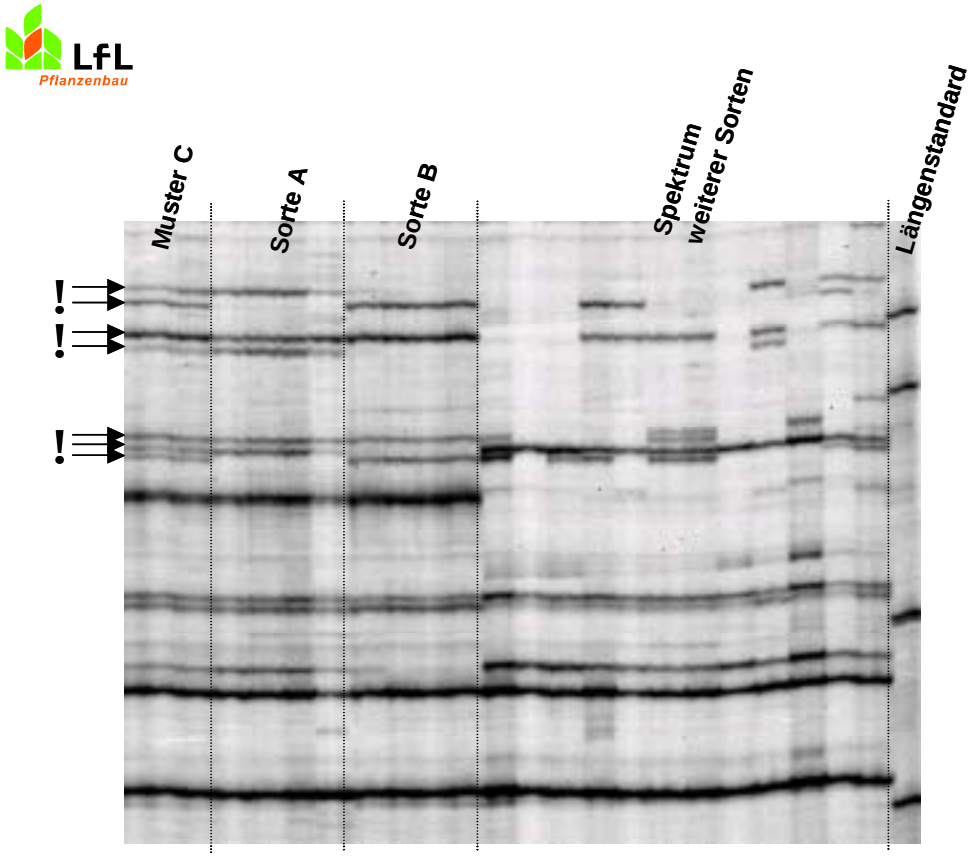


Diagram 4.6: DNA analysis for purity of variety

4.3 Working out an effective method to produce fungal-resistant hops via gene transfer

The aim of this research project is to establish an efficient transformation method for gene transfer in hops. After establishing such a method resistance genes against fungal pathogens should ultimately be transferred into the hops.

Transformation

Transformation of the internodia of the Huell hop varieties 'Hallertauer Magnum', 'Hallertauer Mittelfrüh', 'Saazer' and 'Saphir' was continued with the GUS reporter-gene system. Besides the indirect gene transfer via the agrobacteria infection for the first time the gene gun, i.e. the direct gene transfer, was also used for a transient expression. Also our first, own chitinous construct was used for the transformation.

Regeneration and proof of transgene plants

It was possible to select and regenerate more plants from internodia. However, only in the case of the 'Saazer' hop variety were several of the plants selected for Kanamycin tested positive, i.e. transgene by means of GUS colouring. Since February 2003 nine trans-gene 'Saazer' plants of the first test series were cultivated successfully in the greenhouse. They proved to be as uniformly and stably transgene – just like the transgenes in vitro plants. Gene 'silencing' or chimera formation was not observed. For the first time it was possible to regenerate plants of the variety 'Hallertauer Mittelfrüh' after agrobacteria transformation. However these in-vitro plants died off – probably due to endogenous infections – up to now always with a size of approx. 1-2 cm. Therefore it was impossible to check for a stable, uniform transformation success.
First transformation tests by means of a gene gun brought an intensive, transient expression in the case of all the varieties used, but due to lack of regeneration there could be no check on a stable gene insertion. To continue this kind of test series a separate regeneration protocol would have to be compiled and optimised in advance.

Optimising the transformation-regeneration systems

Further phytohormones (GA_3 / BAP / Spermidine; 2-iP) and series of antibiotics were tested in regeneration tests.
Test started with the variety 'Saphir' were dropped due to lack of regeneration. Instead of this the varieties 'Hallertauer Taurus' (high-alpha variety, highly susceptible to powdery mildew) and 'Phoenix' (resistant/tolerant to *Verticillium*) were put in culture and will shortly be available for regeneration and transformation tests.
Endogenous contaminations with fungal and bacterial pathogens as well as exogenous pathogens and pests in the greenhouse are still causing big problems in the hop tissue culture. Therefore detailed studies on combating this kind of contamination were continued. At the same time diverse treatments with antibiotics, fungicides, biocides were carried out.

Producing own constructs

Constructs with resistance genes are to be compiled parallel to optimising the methods.
At the same time the work with a chitinase gene proved to be more time-consuming than first expected: cDNA was produced and amplified via RT-PCR and PCR.
The further cloning of this cDNA also proved to be difficult – probably due to pronounced secondary structures in the last section of the gene. However, meanwhile the gene could be successfully equipped with restriction sites and inserted into a promoter. In the

meantime this construct was transferred into a binary vector which is now available for gene-transfer tests in hop plants. First transgene hop plants which have taken up this resistance gene into their genome are at present being checked by means of PCR, SDS-PAGE and infection test.

Outlook

An optimising of the regeneration and transformation protocols for Huell breeding varieties should be continued. Information on genes, which can convey resistance to fungal pathogens, will be brought in and evaluated. More plasmids (vectors) will be checked to see if they are suitable for transferring resistance genes into the hops. The production of more of our own constructs for the gene-transfer is to be made shortly.

In addition to this methods for checking the chitinase activity under laboratory conditions (SDS-PAGE, chitinase isolation and assays will be further established. An infection system for testing the powdery mildew resistance can be used in Petri dishes in vitro.

5 Hop Cultivation, Production Techniques

Johann Portner, Dipl. Ing. agr.

5.1 Fertilization

5.1.1 Nmin tests 2003

Nitrogen fertilization according to DSN (Nmin) was introduced into the practice and has become an integral part of the fertilizer planning. In Bavaria 3809 hop yards were tested in 2003 for their Nmin content and a fertilizer was recommended.
The development of a number of the samples for the Nmin test has been drawn up in Table 5.1. It can be seen that the Nmin contents from 1999 - 2003 are considerably lower than in the previous years.

Table 5.1: Number of Nmin tests and average Nmin contents as well as fertilizer recommended in hop yards in the Bavarian production areas

Year	Number of samples	Nmin kg N/ha	Fertilizer recommended kg N/ha
1983	66	131	
1984	86	151	
1985	281	275	
1986	602	152	
1987	620	93	
1988	1031	95	
1989	2523	119	
1990	3000	102	
1991	2633	121	
1992	3166	141	130.0
1993	3149	124	146.0
1994	4532	88	171.3
1995	4403	148	126.6
1996	4682	139	123.3
1997	4624	104	146.7
1998	4728	148	118.5
1999	4056	62	166.6
2000	3954	73	157.7
2001	4082	59	162.6
2002	3993	70	169.0
2003	3809	52	171.0

With the aid of a computer a detailed recommendation for nitrogen fertilizer based on the Nmin content was compiled for the hop-growers for every hop yard tested.
The soil samples for the Nmin test were taken from a depth of 0-90 cm between the end of February up until the beginning of April. The N-test was carried out with RQflex test strips by Messrs. Fritzmeier in the laboratory of the Hop Ring in Hüll. The content of NO_3-N is measured in the soil filtrate. According to the questionnaire, if an organic fertilization is made then the proportion of ammonium is ascertained in addition.
Starting at a specific set value, an EDP programme calculates the remaining nitrogen requirements less the nitrogen present in the soil. In order to refine the system increases or decreases are made for certain parameters and the fertilizer dosed at various dates according to the variety. The calculation for the N-fertilizer recommendation can be seen in the following Table 5.2.

Table 5.2: Calculating the required amount of N-fertilizer in Bavaria

Set value		**240 kg N/ha**
Plus and minus		
Yield		
< 1500 kg/ha	- 10	
- 2000 kg/ha	0	
- 2500 kg/ha	+ 10	
> 2500 kg/ha	+ 20	_____kg N/ha
without ground cover [1)]	+ 10	_____**kg N/ha**
organic fertilizer [2)]		
vine choppings, compost	- 10	
manure, liquid manure	- 20	_____**kg N/ha**
Type of soil S, IS [3)]	+ 10	_____**kg N/ha**
corrected set value		_____**kg N/ha**
less Nmin-Gehalt (90 cm depth)		_____kg N/ha
Limit: [4)]		
Yield		
< 1500 kg/ha	max. 150 kg N/ha	
- 2000 kg/ha	max. 165 kg N/ha	
- 2500 kg/ha	max. 180 kg N/ha	
> 2500 kg/ha	max. 195 kg N/ha	
Nitrogen fertilizer (mineral and organic)		_____**kg N/ha**

Explanations on plus and minus to the set value when calculating the fertilizer needed:

1) When the ground cover rots, additional nitrogen is released during the growing period therefore there is a greater need for fertilizer when there is no ground cover.
2) Organic fertilization over many years likewise increases the supply of nitrogen, therefore less fertilizer is required.
3) Light, sandy soils contain less nitrogen, therefore the fertilizer requirement is increased, it has to be split up into several small doses.
4) The nitrogen limit prevents over-fertilization when there are low Nmin values.

In Table 5.3 the number of hop yards tested, the average Nmin value as well as the recommended average nitrogen fertilizer calculated from this has been compiled for the Bavarian production areas on the basis of administrative districts.

Table 5.3: Number, average Nmin contents and fertilizer recommended in the hop yards of the admin. districts and production areas in Bavaria 2003

Production area	District	Number of samples	Nmin kg N/ha	Fertilizer recommended kg N/ha
Hallertau	Pfaffenhofen	1169	46,3	173
	Freising	393	60,5	169
	Eichstätt	252	40,8	175
	Kelheim	1603	54,3	172
	Landshut	261	54,8	171
Average	**Hallertau**	**3678**	**51,6**	**172**
Spalt	Roth	105	74,1	146
	Weißenburg-Gunzenhausen	0	0	
Average	**Spalt**	**105**	**74,1**	**146**
Hersbruck	Hersbruck	26	56,9	147
Bavaria		**3809**	**52,2**	**171**

In Table 5.4 the values are listed according to varieties.
What is striking is that hop varieties with a high yield level have lower Nmin values and higher extraction.

Table 5.4: Number, average Nmin contents and fertilizer recommended for various hop varieties in Bavaria 2003

Variety	Number of samples	Nmin kg N/ha	Fertilizer recommended kg N/ha
Columbus	2	32.7	188
Others	5	44.0	179
Nugget	118	47.4	177
Hallertauer Taurus	385	46.1	176
Hallertauer Magnum	978	48.8	175
Target	15	61.4	173
Brewers Gold	8	46.7	173
Hallertauer Merkur	31	51.8	173
Hallertauer Tradition	461	54.8	173
Spalter Select	235	52.4	172
Perle	667	55.0	171
Saphir	16	49.1	171
Hersbrucker Spät	293	53.5	169
Northern Brewer	173	57.8	164
Hallertauer Mfr.	374	55.0	159
Spalter	48	69.8	145

5.1.2 Nitrogen requirement test according to Nmin in Biburg

The nitrogen tests over many years according to Nmin were continued in a comparison of broadcasting with fertilizing by band placement. In broadcasting the mineral N-fertilizer was widely scattered over the area. By band placement one-third of the area between the rows of poles were not fertilized with nitrogen so that the amount distributed was reduced by one-third. The aim of this test was to clarify whether the nitrogen fertilization can be reduced without affecting the yield in order to improve the N-balance in hops.
A location in Biburg was chosen to carry out this test, which with relatively similar soil conditions and average soil testing values enabled two varieties to be compared alongside each other.

Test data:

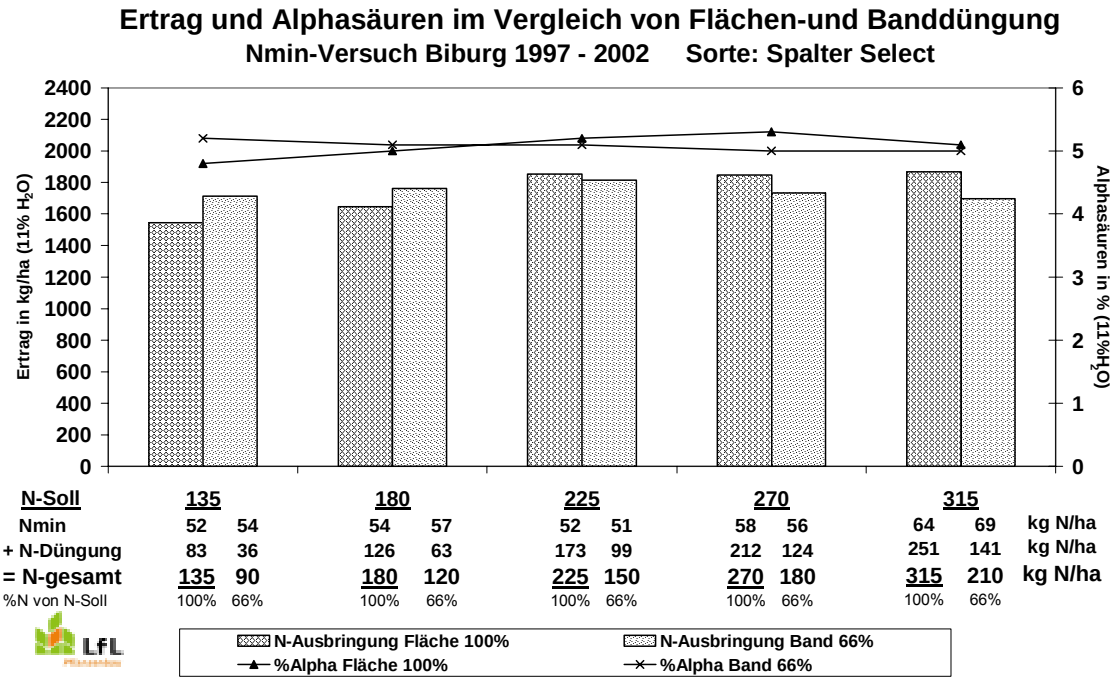
1. Extensive facility: Distance between rows 3.2 m, between hops in the row 1.65 m
2. Varieties: Spalter Select (SE) and Hallertauer Magnum (HM)
3. N set values: from 135 up to 315, in 5 steps
4. N-fertilizer: - widely scattered (100 % of the area)
   - band placement ($^2/_3$ of the area, saves $^1/_3$ of N-fertilizer)
5. Type of fertilizer: only mineral fertilizer (no org. fertilizer)

Location data:

1. Soil typology: Brown earth made up of fine and medium-sandy molasse material
2. Soil type: very clay sand
3. Soil test results: (beginning of test)
   Variety SE: pH 5.7; P_2O_5 27; K_2O 12; Mg 5
   Variety HM: pH 5.5; P_2O_5 32; K_2O 15; Mg 5

In Diag. 5.1 the yields and the alpha-acid contents are outlined in % for the variety Spalter Select. The attached table shows the average amount of Nmin contents in stages and the respective average N-fertilizer.

Diag. 5.1: Yield and alpha-acids comparing broadcasting with band placement



The yields and alpha-acid contents ascertained show that the peak yield at this location was already reached by the N set-value 225. The differences in yields between broadcasting and band placement compared with the N set-value 270 are minimal and cannot be assured statistically.
Also by checking the kilogram alpha-acid produced per hectare (Diag. 5.12) the result is unchanged.

Diagram 5.2: Alpha-acid yield in kg/ha comparing broadcasting with band placement

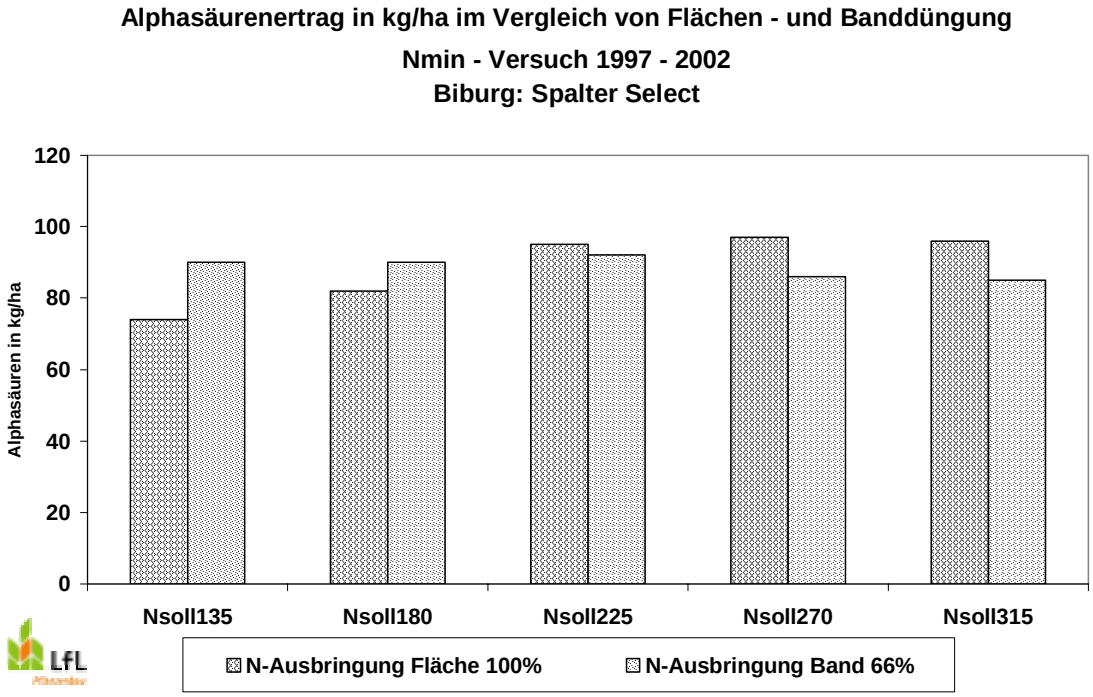
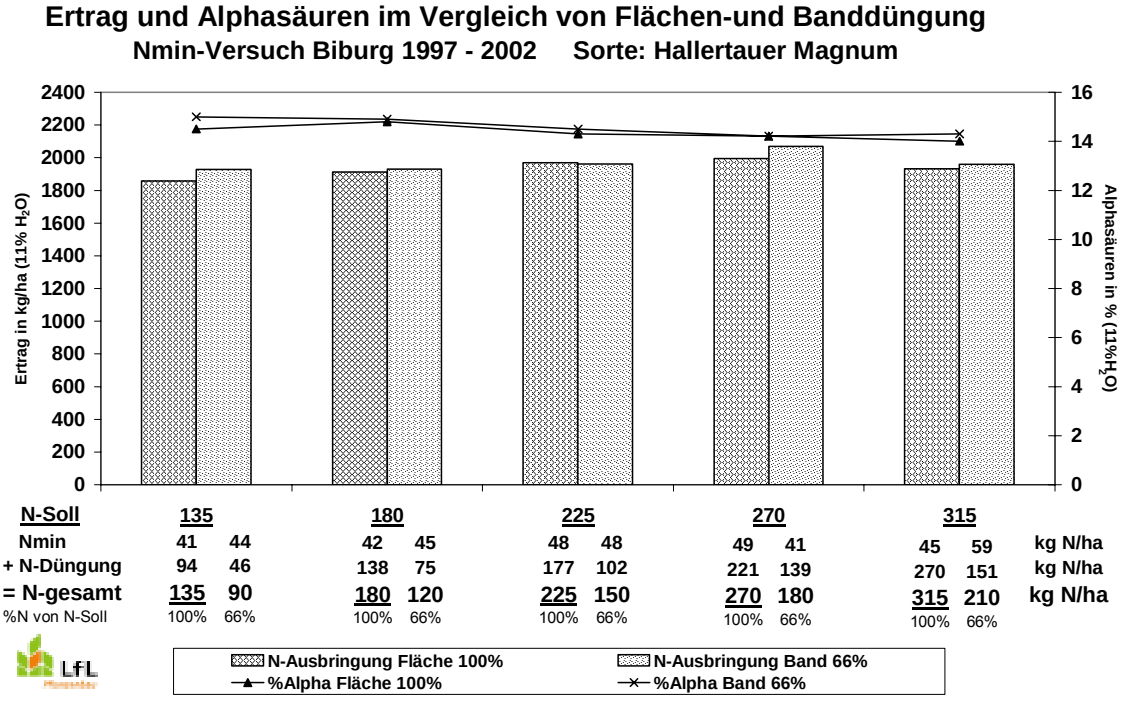


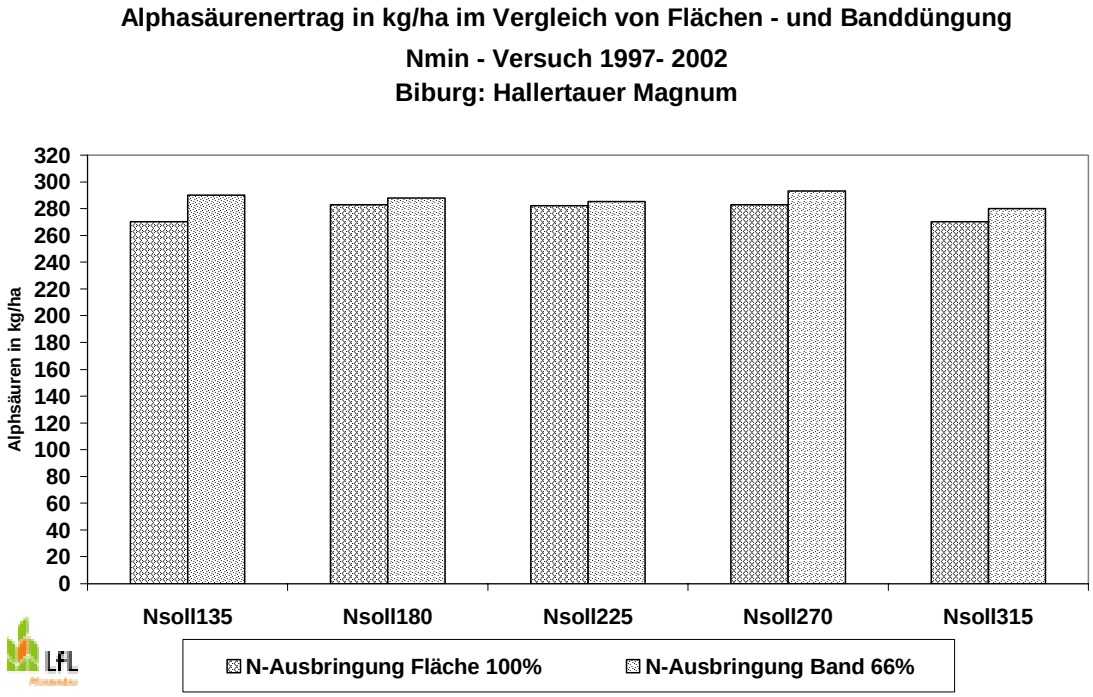
Diagram 5.3: Yield and alpha-acids comparing broadcasting with band placement



In Diag. 5.3 the yield and alpha-acid contents are shown in % for the variety Hallertauer Magnum. The average Nmin contents and the average N-fertilizer is also integrated in this diagram.

The crop result, again ascertained over 6 years, shows the peak yield at the N set-value 270. A comparison of the yield between broadcasting and band placement is more balanced here than with the variety Spalter Select. When observing the kilogram alpha-acids produced per hectare (Diag. 5.4) the variant band placement even slightly prevails and shows that no statistically guaranteed reductions or increases in yield can be shown over all the N-fertilization stages.

Diagram 5.4: Alpha-acid yield in kg/ha comparing broadcasting with band placement



With the two varieties tested the alpha-acid contents in % verify the results of all the Nmin tests over many varieties and over more than two decades; the alpha-acids cannot be affected in % with the amount of N-fertilizer!
The alpha-acid contents shown in Diag. 5.1 and Diag. 5.3 are within the range of analytic spreading and must be assessed the same.

5.1.3 Trial with green compost – improving the soil -

The effects the application of green compost had on the nutrient loading of the soil and the crop development were shown in the Annual Research Report 2002.
After finishing the trial held over many years (1993-2002) with the 2002 crop, soil samples from the plots were analysed in the early spring of 2003 to determine important chemical and physical soil values.

Test and location data:
- applying green compost amounting to 20 m^3/ha annually ($\approx P_2 0_5$-extracted by the whole plant)
- 3 stages : 1 = N-set value 270 without compost
  2 = N-set value 270 with compost
  3 = N-set value 180 with compost
- Soil type: sand

Extent of analysis :
- Humus content (Corg)
- Total nitrogen (Nt)
- Aggregate stability (AS)
- Ratio C : N (C/N)

The findings of the analysis are listed in Table 5.5.

Table 5.5: Chemical and physical soil parameters including the mean values (MW) of the stages

Stage	Repeat	Corg mg C/g	Corg-MW mg C/g	Nt mg N/g	Nt-MW mg N/g	AS %	AS-MW %	C/N	C/N-MW
1	1	11.2	12.9	1.09	1.23	0.20	0.43	10.3	10.5
	2	13.6	-	1.28	-	0.54	-	10.7	-
	3	12.2	-	1.15	-	0.51	-	10.6	-
	4	14.7	-	1.40	-	0.49	-	10.5	-
2	1	16.7	14.9	1.60	1.37	0.50	0.46	10.5	10.8
	2	14.8	-	1.34	-	0.54	-	11.1	-
	3	12.3	-	1.16	-	0.26	-	10.6	-
	4	15.6	-	1.41	-	0.52	-	11.0	-
3	1	18.8	16.4	1.75	1.52	0.58	0.47	10.8	10.8
	2	16.5	-	1.53	-	0.46	-	10.8	-
	3	15.4	-	1.40	-	0.51	-	11.0	-
	4	14.9	-	1.42	-	0.34	-	10.5	-

The organic carbon (Corg) is a suitable criterion to analyse the humus content.
The C/N-result e.g. 10.5 must be evaluated as ratio C : N. i.e. 10.5 : 1. This is a criterion for the humus quality. In both cases an increase can be seen in the plots with green compost. The amounts are typical for the soil type: sand.
As in comparable field trials the application of organic substance via green compost does not lead to high N-mineralisation in the short-term or in the long run. The content of total nitrogen (Nt) therefore rises more than the proportion of nitrogen present in the plant. The amount of which was recorded each spring via the Nmin soil test.
The aggregate stability (AS) provides a criterion for the resistance of the soil clods.

5.2 Corn borer in hops

Following the damage which occurred in 2002 in the Jura area the development of the corn borer population in 2003 was observed in various stands. The corn borer questionnaire in Bavaria shows that the whole Hallertau is mapped as an infected area.

5.2.1 Overwintering in vine stalks

The assessments by hand on 16.04.2003 showed corn borer larvae alive in vine stalks which had been cut off instead of burnt. The inspection once the hop plants had been pruned mechanically showed no infection of the cut rhizomes or no penetration into the hop plants by corn borer larvae.

5.2.2 Pheromone traps

In collaboration with the Ingolstadt Agricultural Office pheromone traps were hung up in three stands of winter wheat with the previous crop of maize (bad infection in 2002). Attention was paid to placing them in the vicinity of hop plants.
Bait was used from the firm Andermatt Biocontrol AG. Switzerland and Biotrap, Temmen GmbH.

Table 5.6: Inspection results

Location / Race / Firm	04.06. Flown	10.06. Flown	12.06. Flown	16.06. Flown	18.06. Flown	23.06. Flown	30.06. Flown	Total Z	Total E	Total E+Z
Ried										
Z - Biocontrol	1	4	0	1	0	3	0	9	0	0
- Biotrap	0	0	0	0	0	0	0	0	0	0
E - Biocontrol	0	0	0	1	1	1	0	0	3	0
- Biotrap	0	0	0	0	1	0	0	0	1	0
E+Z - Biocontrol	0	0	0	0	0	0	0	0	0	0
- Biotrap	0	0	0	0	0	0	0	0	0	0
Laimerstadt										
Z - Biocontrol	1	2	1	2	1	0	0	7	0	0
- Biotrap	0	0	0	0	0	0	0	0	0	0
E - Biocontrol	0	0	0	0	0	0	0	0	0	0
- Biotrap	0	0	0	0	0	0	0	0	0	0
E+Z - Biocontrol	0	0	0	0	0	0	0	0	0	0
- Biotrap	0	0	0	0	0	0	0	0	0	0
Tettenwang										
Z - Biocontrol	0	0	0	0	0	0	0	0	0	0
- Biotrap	0	1	0	0	0	0	0	1	0	0
E - Biocontrol	0	0	0	0	0	0	0	0	0	0
- Biotrap	0	0	0	0	0	0	0	0	0	0
E+Z - Biocontrol	0	0	0	0	0	0	0	0	0	0
- Biotrap	0	0	0	0	0	0	0	0	0	0
Total	**2**	**7**	**1**	**4**	**3**	**4**	**0**	**17**	**4**	**0**

Six traps were hung up in each clearing, two each for the Z-race, E-race and hybrids (E + Z).
The traps were hung up on 13.05.2003:
Two traps for the same race (Biocontrol and Biotrap) were place in the main wind direction at intervals of approx. 50 m. In each case the distance from Z to E or E + Z was approx. 100 m.

The traps were hung up approx. 50 cm over the ground and nothing was changed during the monitoring period.
A summary of the larvae caught in the pheromone traps shows that:

- the number of insects caught was small
- the dispensers from the firm Biocontrol brought better results
- 17 male moths could be allotted to the Z-race
- 4 male moths could be allotted to the E-race

5.2.3 Note on warning service

The peak of migration, i.e. according to the temperature model, was laid down by the LwA Ingolstadt as on 21st June.
On Monday, 23rd June the hop-growers from the LfL were alerted by the Ring fax and advised to use Baythroid 50 to control aphids with a side-effect on corn borer larvae.

5.2.4 Monitoring the eggs laid on 30.06. and 01.07.2003

In three hop-yards in the Jura area, close to where infected fields of maize stood in 2002, monitoring was carried out with a hop crow's nest in the hop varieties Hersbrucker Spät, Perle and Spalter Select to find eggs laid by the corn borer. One oviposition was found at a height of about 5 metres in the variety Perle and 5 ovipositions were found in the variety Hersbrucker at a height of 5-6 metres.
The eggs which were still closed were blackish, slightly wavy on the surface and no longer contained any living larvae. The majority were egg skins left after hatching. Holes bored into the base of the vines or living larvae could not be discovered.

5.2.5 Course of the weather in June

The data of the weather station in Hüll (Baumannshof) show extremely high temperatures and little humidity in June, which certainly did not have a positive effect on the development of the corn borer larvae.

- Average temperatures at a height of 2 metres 11-16 °C
- Maximum temperature at a height of 2 metres 38 °C on 6 Tagen
- Humidity Ø 59-86 % (Baumannshof 54-83 %)
- Minimum humidity 24 % (Baumannshof 20 %)

5.2.6 Monitoring corn borer larvae from 28.07. – 14.08.2003

According to the warning service inspections were carried out for the varieties Perle, Hallertauer Tradition, Hallertauer Taurus, Hallertauer Magnum in four farms (Ilmendorf, Niederlauterbach, Oberlauterbach, Nietenhausen) and 5 hop-stands where no insecticides were used. The maize fields in the direct vicinity showed 7-12 % were infested with the corn borer in the form of bent ears.
The hops all showed few attacks at a height of 3-6 metres of growth. 2-3 infested wires were monitored with on an average 160 training wires. The vitality and development of the larvae was below average, which could be traced back to the hot summer 2003. 1-3 larvae could be found on each wire affected.

5.2.7 Monitoring on the remaining stalks after harvesting on 17.09.2003

1 larva was found in a very long remaining stalk (1.3 m) behind a pole at only one of the six locations.

5.2.8 Resumé

The number of moths caught in the pheromone traps was small compared to the moths observed in the fields of winter wheat. Not only the Z-race but also the E-race were found.

The timing for the migration peak and the warning service was quite correct.

The success of the Baythroid sprayings was very satisfactory.
Presumably the high temperatures and the little humidity had adverse effects on the hatching rate and the larva development, however this cannot be quantified.

The whole Hallertau is mapped as an infected corn borer area.

Compared with 2002 there was a delay in the moths eatring their way from top to bottom. At the time of harvesting the larvae could still be found above 3 m plant growth (2002 at a height of 0.5 - 3 m).

Except for one exception this year no larvae could be found in the remaining stalks.

5.3 Trials with various harvesting times with Hallertauer Mfr. in Hüll (Busch-Farm)

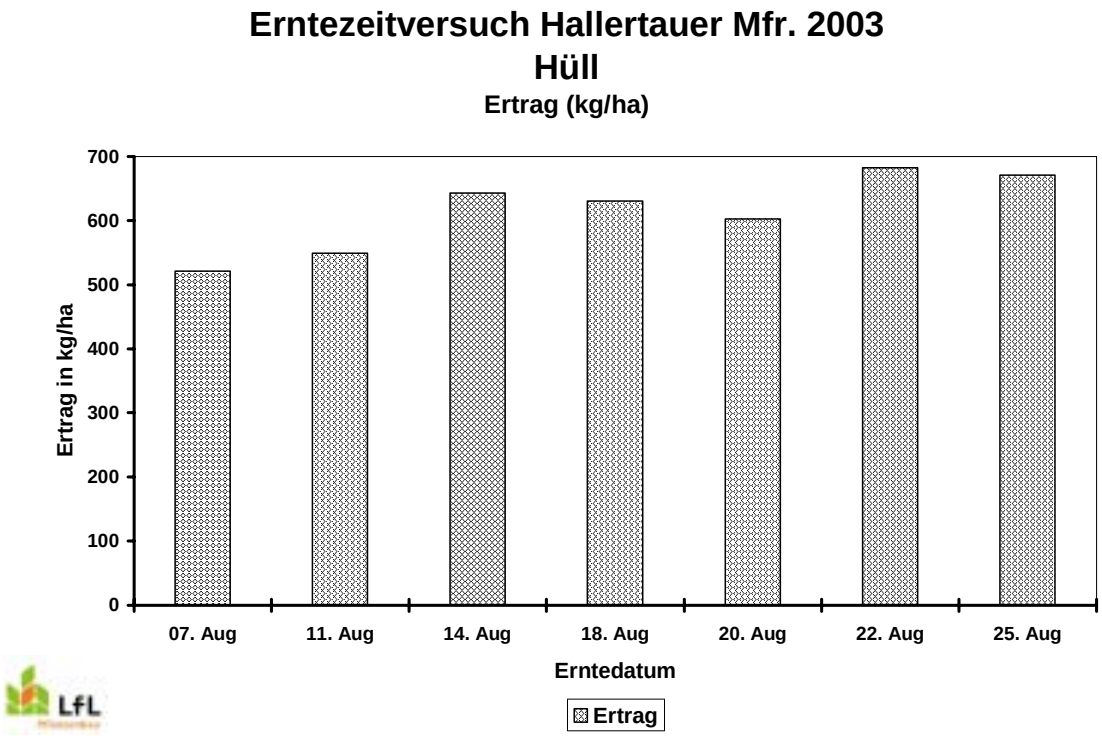
The optimum time for harvesting is important for a high yield and a good quality. While the bitter content reaches its peak early on, above all the yield is wasted if the hops are harvested too soon. In addition to this, the hops can react the following year with weaker growth and lower yield due to their being cut too early. If the hops are harvested too late the external quality and the aroma suffers. But above all, as far as the variety Hallertauer Mittelfrüher is concerned, the greatest importance is placed on these characteristics. Therefore the trend in the practice is towards earlier harvesting times for this variety.
The trials to ascertain the optimum time for harvesting the variety Hallertauer Mittelfrüher have been carried out since 2002. At intervals of 3-4 days twenty wires are harvested and evaluated at seven times and this is repeated four times.

Table 5.7: Tests carried out and methods applied

Yield	Weighing the green weight of the plot. With the aid of a dried sample converting it into dry weight in kg/ha with 11 % water content
Alpha-acid content	Measuring the alpha-acid content with HPLC. Converting it to % alpha-acids with 11 % water content of the hops
Aroma	Monitoring according to the standard method of the Scientific Commission of the International Hop Growers Convention (IHGC) by specialists in the LfL Hops Section
Hop-picking	
Cone growth	
Colour and lustre	
Defects	
Infested with pathogens	

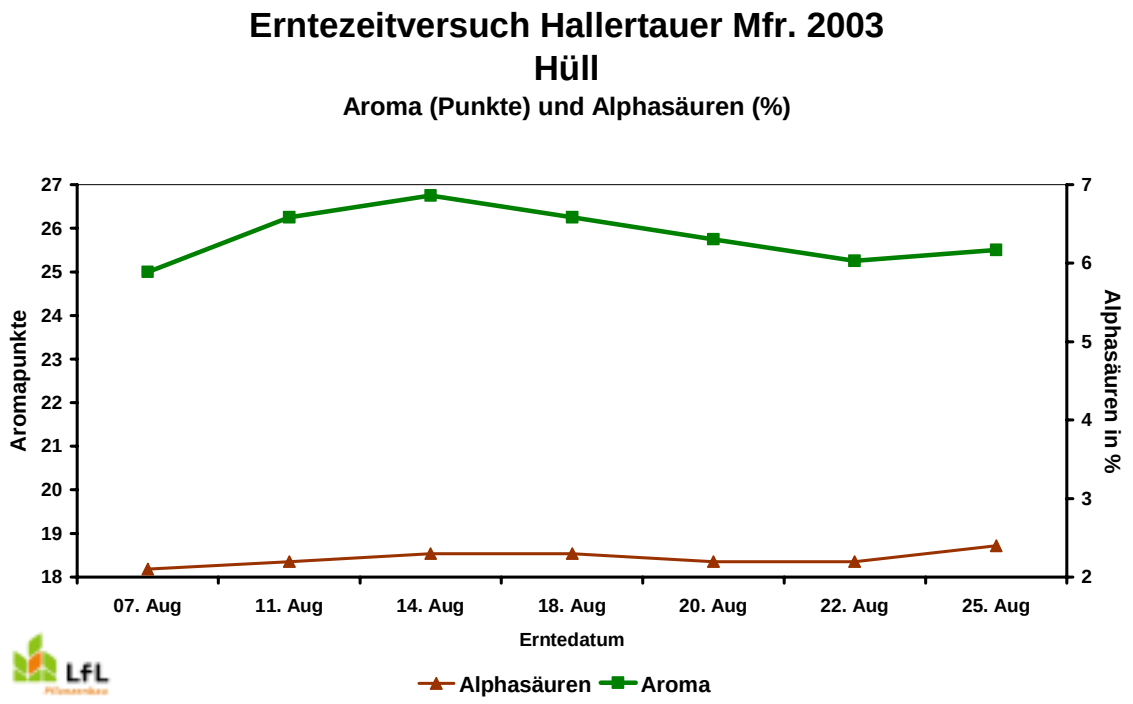
The results of the test year 2003 with the variety Hallertauer Mfr. are shown in the following charts (Diags.. 5.5 up to 5.7).

Diagram 5.5: Harvest-time trial Hallertauer Mfr. 2003, Hüll



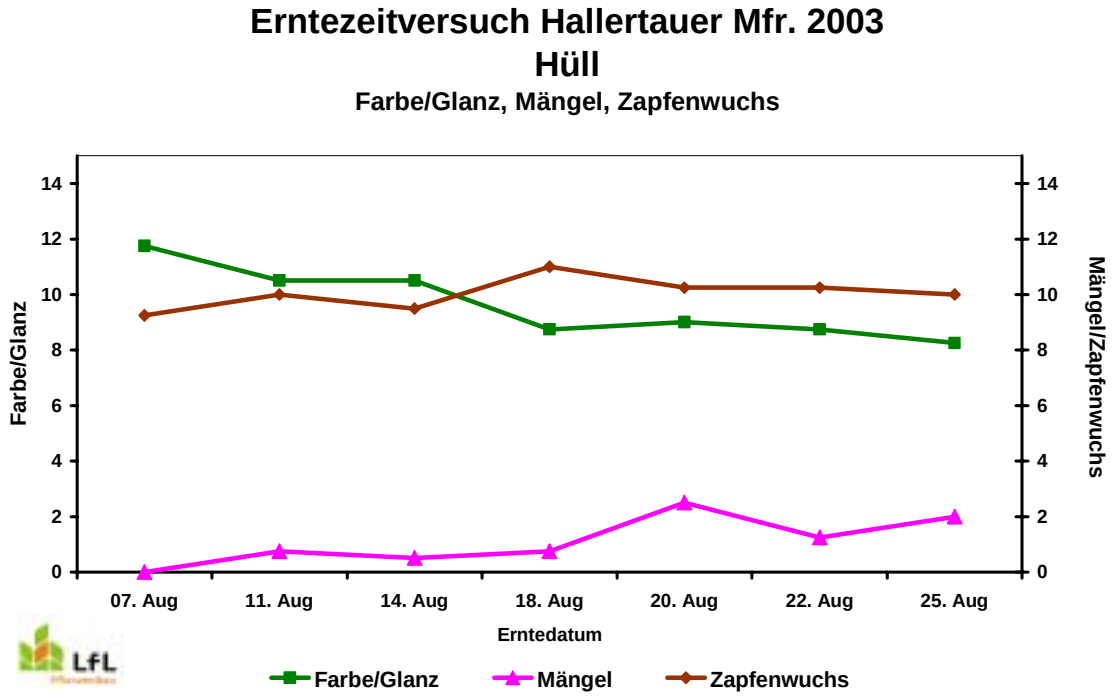
The premature burr and the extreme drought accelerated the maturing of Hallertauer Mittelfrüher and resulted in too early harvesting times. An increase in the yield can be seen up until 14th August.

Diagram 5.6: Harvest-time trial Hallertauer Mfr. 2003, Hüll



From 14th August onwards no increase in the alpha-acid content was recorded. The aroma decreased from this date onwards.

Diagram 5.7: Harvest-time trial Hallertauer Mfr. 2003, Hüll
Colour/lustre, defects, cone development – green, pink, brown lines

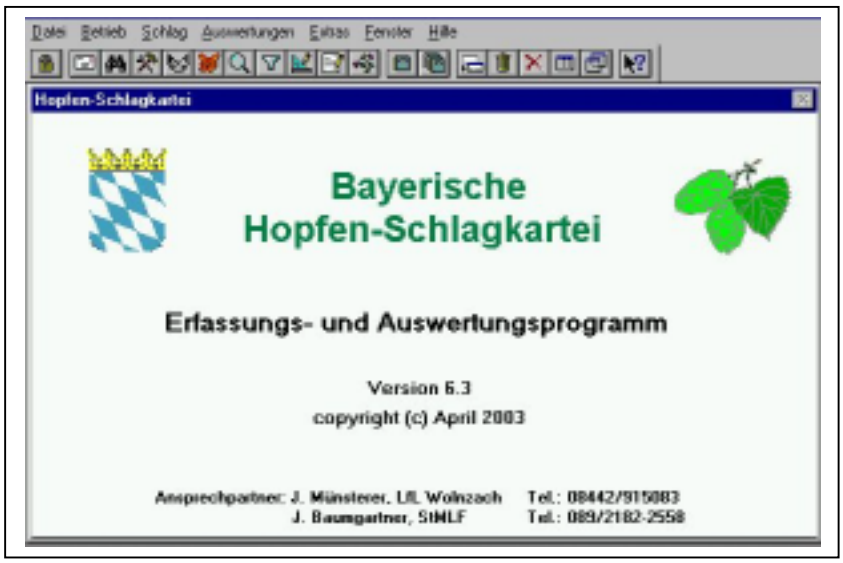


The later the harvesting time the more the colour and lustre of the hops decreases and the defects increase. A bigger drop in colour and lustre can be seen after the 14th August.

5.4 Documentation and weak-point analysis with the Bavarian Hop Index (HSK)

The hop card index (HSK) has been available in box form since 1991, where the hop-growers can document all the production techniques. The Bavarian State Ministry for Agriculture and Forestry has prepared the PC programme HSK for determining and evaluating the hop-yard records according to the requirements of the Work Group Hop Cultivation, Production Method (IPZ 5a) in collaboration with the Agricultural Offices. Box form and PC programme HSK have been further developed over the years. Besides general operating and hop field data, plant protection and fertilization techniques, harvesting data and quality diagnosis, all variable costs as well as the labour costs can be ascertained and evaluated. For many farms the hop card index has already become an integral part for analysing their production.

Diagram 5.8:



Clear, user-friendly programme design

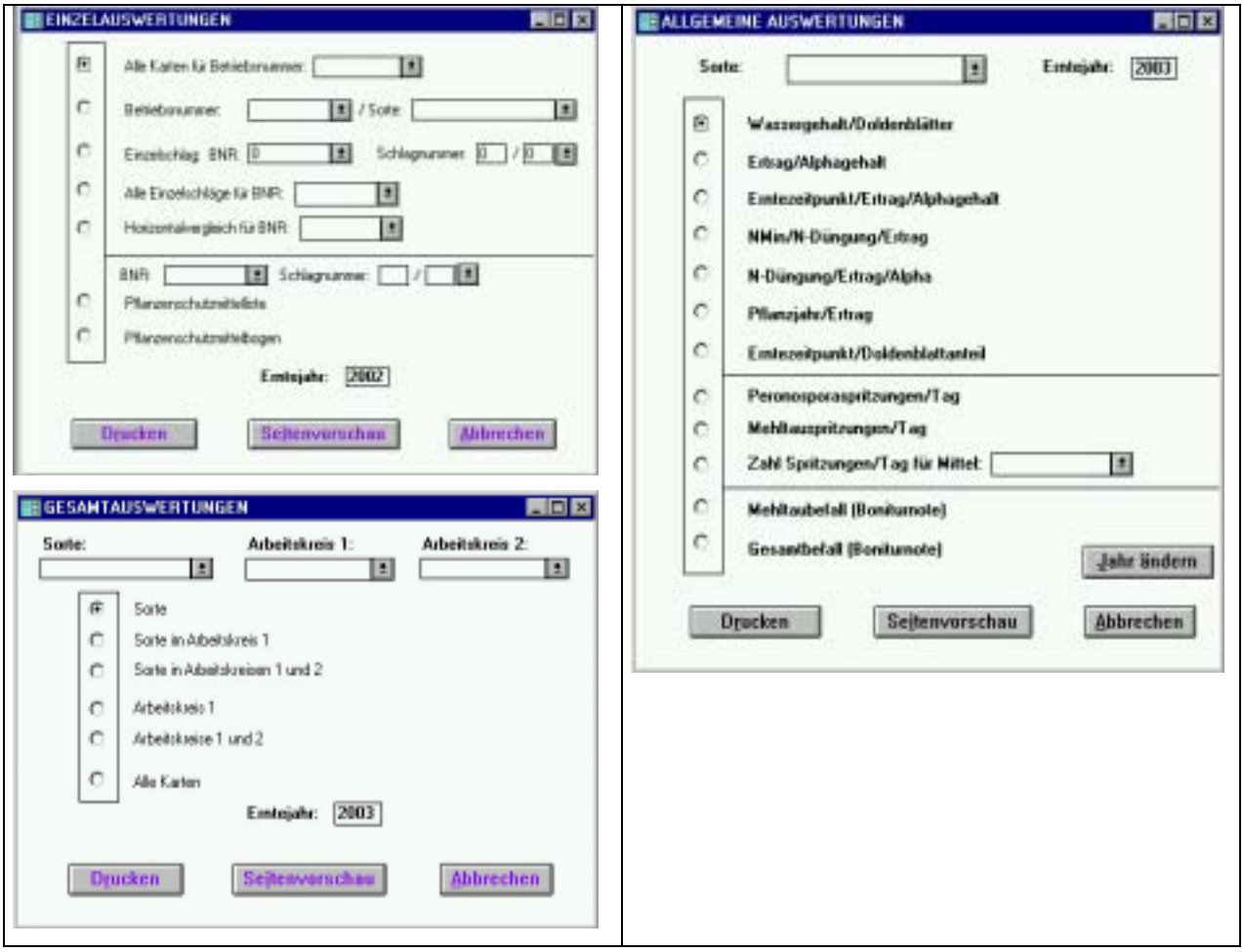
The PC programme HSK was originally prepared to ascertain and evaluate the hop card index in box form presented to the Agricultural Offices (LwÄ) as well as in the Work Group Hop Cultivation, Production Methods (IPZ 5a). Due to the clear, user-friendly programme design the hop-growers frequently enquired if they could purchase the HSK programme. Therefore it can now be obtained through the Landtechnischen Verein in Bavaria e.V.

Evaluation possibilities determine the value of an index programme

Farms which want to take part in the inter-farm evaluation present their hop index records on a floppy disc or in box form. They are put into the ascertaining and evaluating programme HSK by temporary staff or colleagues at the LwÄ.

The HSK programme provides an index-related, individual field evaluation, a total evaluation for the inter-farm comparison and a general evaluation in which stratification can be carried out regarding production-related factors. The variety- or region-specific evaluation of this data forms an important basis for giving advice.

Diagram 5.9:



Each year more than 1000 card indexes are evaluated

The total evaluation with special stratifications and advice notes is made by the Work Group Hop Cultivation, Production Methods and is introduced to the participating hop-growers at several regional evaluation meetings. At the same time the farmer is given his field-related, individual farm evaluation and the total evaluation in the form of a graph.

Only those who know their costs can plan economically

Economically you differentiate between fixed costs and variable costs. Depreciation, building maintenance, insurances etc. are fixed costs which are separate from the production.

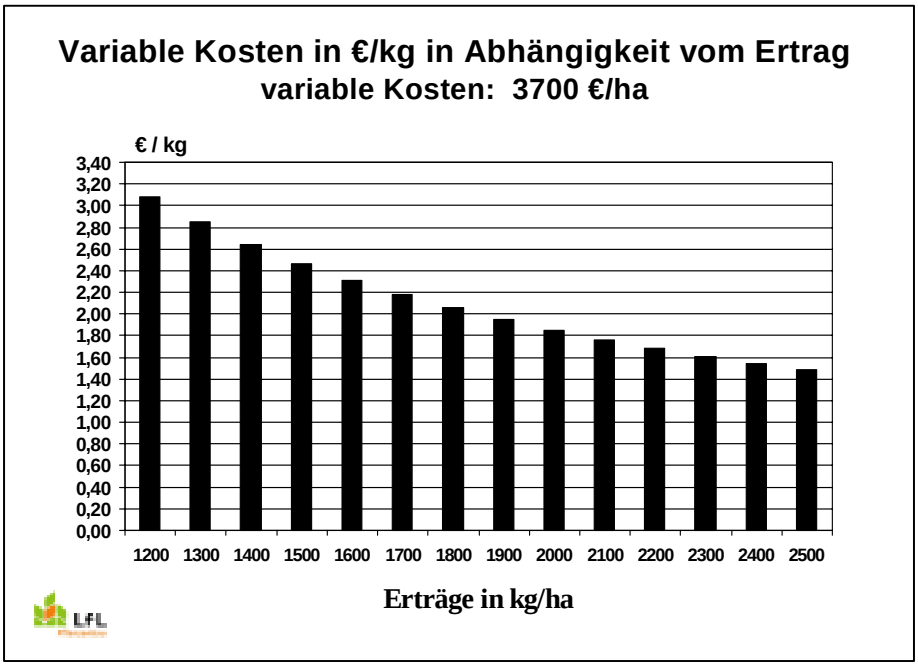
Variable costs are all costs which are incurred in hop-growing. These are also termed production costs.

An overview on the production costs and the labour is only possible by means of exact accounting and a detailed evaluation. With the HSK hop card index the total variable costs can be recorded and weak-points can be analysed.

Variable costs in €/kg depending on the yield

If you compare the total variable costs in €/ha of various varieties and hop fields, you find there are only slight differences. If you calculate the variable costs depending on the yield in €/kg (costs/yield) there are obvious differences between the hop varieties and even between individual fields with the same variety.

Diagram 5.10: Variable costs in €/kg depending on the yield



Advantages of keeping and evaluating a hop card index

- Documenting the hop data and production techniques
- Recording all the variable costs
- Comparing hop fields within the farm
- Comparing with other hop farms
- Looking for weak points through individual and inter-farm evaluation
- Discussing the results at evaluation meetings
- Confirming test results and advice given

Diagram 5.11:

HSK-Hop Card Index
Individual Evaluation
Crop Year 2003

Facility No::	1781160111	**Name:**	Hopfenbauer
Index name:	Hofgarten:	**Index No.:**	10/1
Variety:	H.Taurus	**Size of field (ha**	1,5
Yield (kg/ha):	**1850**		

Quality diagnosis (in %)

Water content:	9,2	**Hop waste**	0,2		
Leaf/stem proportion	0,2	**Bracteoles:**	12	**Alpha-content**	14,5

Plant protection	**No. of sprayings**	**l,kg/ha per spraying**	**Costs in €/ha**
Peronospora	**5**		**332**
Ridomil granulat	1	8,00	138
Forum	1	2,25	45
Ortiva	1	1,50	86
Funguran	2	7,60	63
Mildew	**6**		**290**
Bayfidan	3	1,20	160
Systhane 20 EW	2	1,00	130
Aphids	**2**		**171**
Confidor WG 70	1	0,166	90
Plenum 25 WP	1	1,50	81
Spider mites	**2**		**463**
Kiron	1	5,0	251
Mitac	1	10,5	212
Hop stripping	**1**		**29**
Reglone	1	1,8	29
Total plant protection			**1285**

Soil analysis (mg/100g)

pH-value	5,6	**Nmin kg/ha:**	45		
$P_2 0_5$	18	**$K_2 0$**	22	**MgO**:	9

Fertilization

	Nutrients in kg/ha				
	N	**$P_2 0_5$**	**$k_2 0$**	**Mg0**	**CaO**
Recommended fertilizer	170	25	80	80	15
Organic fertilizer	0	0	0	0	0
Mineral fertilizer	185	22	105	15	9
Total fertilizer	175	22	105	15	0
Fertilizer +/-	5	-3	25	-65	-15
Total fertilization costs €/ha	**155**		**liming** 0		
			trace of nutrients	0	

HSK-Hop Card Index
Individual Evaluation
Crop Year 2003

Facility No.:	1781160111	**Name:**	Hopfenbauer
Hop-yard name:	Hofgarten:	**Index No:**	10/1
Variety:	H.Taurus	**Size of field (ha)**	1,5

Required labour and variable machinery costs

		Labour/hr.	Tractor-hrs.	var. cost. €/ha
Trending hops	**Total**	**70,3**	**7,7**	**27,00**
Ploughing		2,2	2,2	7,5
Uncovering/pruning		2,0	2,0	12,00
Circular cultivating		3,5	3,5	7,50
Stripping vines/training		47,5	0,0	0,0
Cleaning		10,8	0,0	0,0
Retraining		4,5	0,0	0,0
Wire work	**Total**	**23,8**	**3,2**	**2,30**
Hanging up wires		12,5	3,2	2,30
Inserting wires		11,0	0,0	0,0
Reworking wires		0,3	0,0	0,0
Soil work	**Total**	**8,22**	**8,2**	**33,5**
Ploughing		2,3	2,3	11,50
Working soil		5,1	5,1	20,50
Sowing in green compost		0,8	0,8	1,50
Fertilizing	**Total**	**2,3**	**2,3**	**4,30**
Plant protection	**Total**	**9,6**	**9,6**	**60,80**
Inspecting hops	**Total**	**1,5**	**0,5**	**1,50**
Harvest	**Total**	**48,0**	**7,0**	**170,0**
Preparing harvest		2,0	0,0	0,0
Harvesting and weighing		46,0	7,0	70,0
Other tasks	**Total**	**3,0**	**0,0**	**0,0**
Hanging up wind sticks		1,0	0,0	0,0
Repairs to trellis		2,0	0,0	0,0
	Altogether	**175,4**	**38,5**	**299,40**
	Variable tractor costs: 38,5 Sh x 8 €/Sh =			**308,00**
	Total variable machinery costs			**607,40**

Variable costs

	Euro/ha
Green compost seed	**21**
Fertilizer	**155**
Pesticides/insecticides	**1285**
Training wire	**248**
Variable machinery costs	**607**
Fuel oil	**282**
Electricity	**84**
Outside labour costs (wages, applications, catering, insurance)	**615**
Insurances (hail, storm, fire)	**245**
Trellis repairs (material)	**80**
Contributions (Hop-Growers, Assn., Hop Ring, Machinery Co-op)	**39**
Special taxes	**25**
Soil analysis	**9**
Total	**3695**

5.5 Advisory and Training activities

Besides the applied research in the area of hop cultivation, the Work Group Hops, Production Techniques (IPZ 5a) has the task of preparing the test results for the practice and advising the Agricultural Offices (LwÄ) as well as the hop farmers directly through special consultations, training facilities, talks as well as being available via the internet. The organisation of the peronospora warning service and updating the warning instructions belong to their tasks just as much as the specialist service for the hop producer groups.
The training and advisory activities are summarized as follows:

5.5.1 Information in written form

- The "Green Pamphlet" Hops 2003 – Cultivation, Fertilization, Plant Protection, Varieties – was updated together with the Work Group Plant Protection in agreement with the Advisory Bureaus of the Federal States of Baden-Wurttemberg, Thuringia, Saxony, and Saxony-Anhalt and distributed with a circulation of 3200 pamphlets by the LfL to the LwÄ and by the producer rings to the hop-growers.
- Up-to-date hop-growing tips and warning service advice was sent to the hop-growers via the Hopfenring fax (2003: 48 faxes per 914 participants) in 32 faxes.
- Likewise up-to-date information was made available at weekly intervals for the weather fax.
- The programme data for the nitrogen fertilizer (DSN-hops) was taken care of, the soil analyses checked and 3809 DSN-fertilizer recommendations despatched.
- Advisory notes and specialist articles were published for the hop-growers in the ER-circular of the Hopfenring and in 9 issues of the Hopfen Rundschau.

5.5.2 Internet and Intranet

Warnings and advisory notes, specialist articles and talks were made available via Internet and Intranet for the hop-growers and for advisory purposes.

5.5.3 Telephone advice and announcement services

- The peronospora warning service was compiled during the period 08.05.–19.08.2003 by the Work Group Hop Cultivation, Production Techniques in Wolnzach in collaboration with the Work Group Plant Protection in Hüll and updated daily so that it can be obtained via the answer-phone (Tel. 08442/4041).
- Tips on hop cultivation with up-to-date notes on pests and diseases as well as fertilizer and soil-working measures can be heard over the answer-phone in Wolnzach (Tel. 08442/957-401).
- Regarding special questions on hop cultivation the trade consultants of the Work Group Hop Cultivation, Production Techniques gave advice per telephone or consultations in individual discussions or on the spot in 4,021 cases.

5.5.4 Tours, training facilities and meetings

- Two work discussions and a test inspection for the consultants of the LwÄ
- 4-day training courses for the Hopfenring consultants
- 9 hop cultivation meetings in collaboration with the LwÄ (850 participants)
- 30 specialist talks at meetings held by other organizers
- 20 test tours for the hop-growers and the hop industry
- Taking part in the training of 35 hop-growers within the farming education programme at the Agricultural College in Pfaffenhofen
- EDP-training on hop card index with 45 participants.

Table 5.8: Overview of the advisory and training activities in 2003

	No.	Calls/Participants
Consultations	4.021	-
Ring-fax	48 altog./32 LfL	914
Peronospora warning – answer-phone	69	11,943
DSN (Nmin)	3,809	-
Hop meetings / talks	48	2,495
Tours and training days	20	1,069

6 Plant protection in hops 2003

Bernhard Engelhard, Dipl.Ing.agr.

6.1 Trials carried out to determine the maximum amounts of residue in compliance with GLP (Good Laboratory Practice) directives

The field trials carried out in compliance with GLP directives are prerequisite for determining the maximum amounts of residue from plant protectives within the bounds of registration according to the § 15 of the law on plant protection.
The Bavarian State Research Centre for Agronomy (LPB) supervised the certification in compliance with the directives.
Job changes in the registered personnel and staff cuts made it necessary to relinquish the certification as it could no longer be guaranteed that it could be properly executed according to the stipulations.
Altogether 33 trials were run on payment in the Hops Dept. during the period 1994 -2002. From the season 2004 onwards residue trials could no longer be carried out in compliance with GLP directives by the Hops Dept. Now the work had to be handed out to private firms.
Trials to determine the maximum residues within the limits of indicating gaps according to § 18 of the plant protection law, can still be carried out as in these cases when carried out in compliance with GEP (Good Experimental Practice) the directives are recognised for the field part.

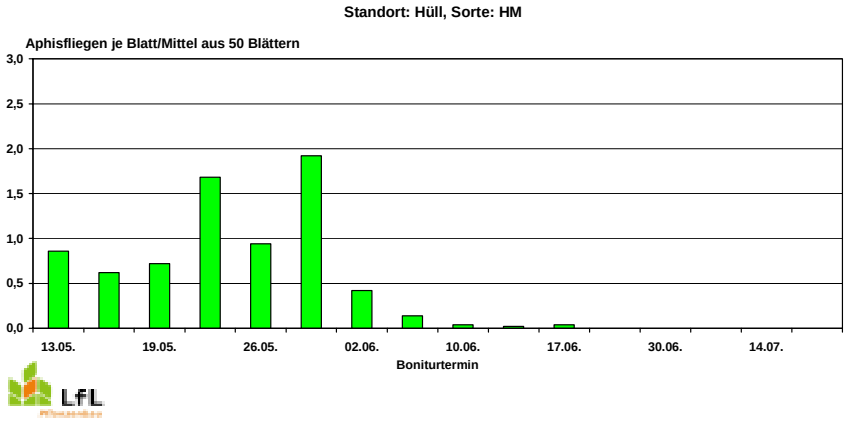
6.2. Pests and diseases in hops

6.2.1 Alfalfa weevil *(Othiorrhynchus ligustici L.)*

The occurrence and therefore the attacks of this pest were relatively slight in the vegetation year 2003. The very varied attacks in the hop yards made it difficult to target it accurately as well as to find good areas for the trials.
As described under Main Research Areas "Indication of gaps" various insecticides are being urgently tested. Though a comparable effect as with the phosphor acid ester and carbamates could not yet be found any product.

6.2.2 Hop aphid

Diagram 6.1: Migration of aphids 2003



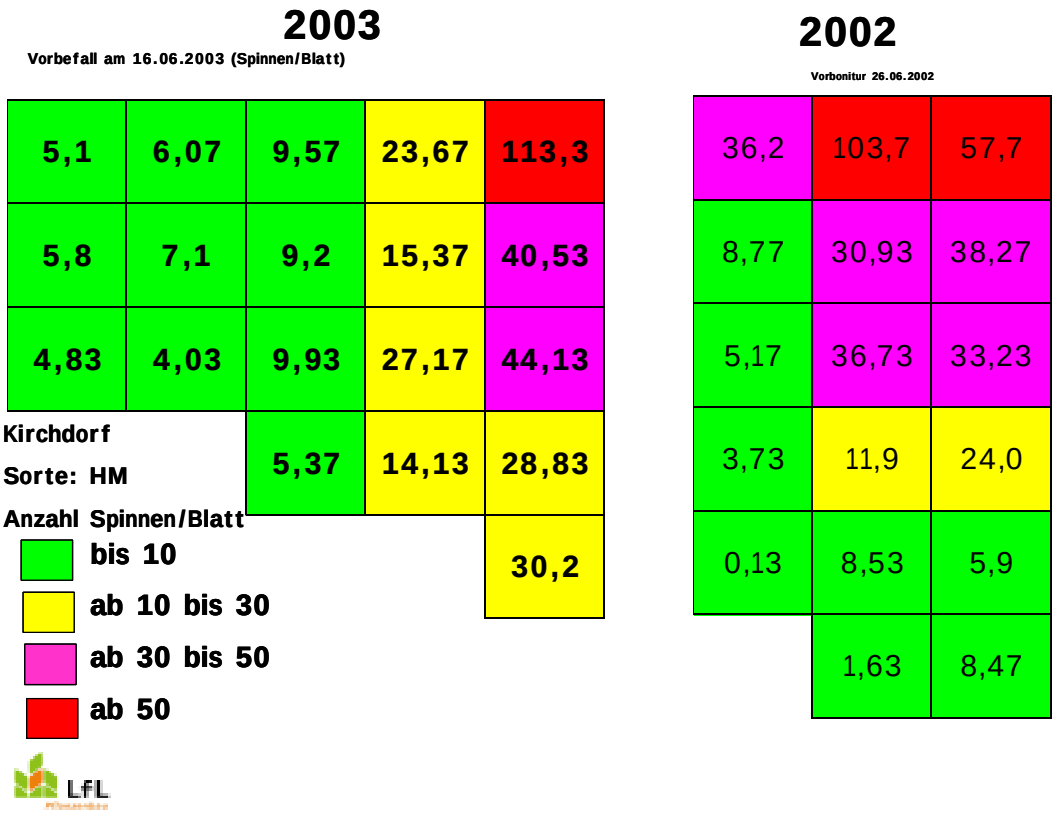
This summer was marked by aphids starting to migrate very early at an extremely low level and by an early end to the migration. Due to the high temperatures and the low humidity the flow of

sap in the plant and the nourishment of the aphids was therefore restricted. In many hop stands (including trial plots) the population constantly decreased even without control measures.
The effectiveness of the insecticides in this season must be made under these preconditions! In many cases the demands on the products were relatively slight.

6.2.3 Two-spotted spider mite *(Tetranychus urticae* KOCH)

Only the exact control of the attacks in every single hop yard makes it possible to specifically target and successfully control this pest. The spread of attacks as seen in the Kirchdorf location is not unusual. If partial areas are treated early enough the above-average attacks can be prevented in certain corners of the hop yard as well as above-average infestation on single leaves.
The control threshold developed at the Hop Research Centre in Hüll assures that the sprayings are well-timed.

Diagram 6.2: Example for differing spider mite attacks in a hop yard



6.2.4 Minor pests

Flea beatles in the first and second generation appeared in scattered places to an extent which needed control. The corn borer caused considerably less damage than in the previous year.

6.2.5 Peronospora [*Pseudoperonospora humuli* (MIY. et TAK.) WILSON]

The peronospora forecast for hops – a tried and tested instrument to optimise the use of fungicide

Aim

Before the development of the forecast model altogether 15 – 17 sprayings were carried out throughout the season to control the disease *pseudoperonospora humuli.*. With the findings on the biological prerequisite for a potential infection the amount of fungicides could be reduced considerably. Besides the ecological advantages the financial savings by saving one treatment can be reduced by approx. € 0.5 million. In addition to this it is necessary to use the genetically present tolerance in the breeding varieties from the Hop Research Centre in Hüll and introduce into the practice a separate control threshold for these varieties.

Method

With the aid of spore traps the zoosporangia in the air are drawn in and counted under the microscope. Years ago they were counted at seven points in the Hallertau, nowadays this biological data (particularly for capacity reasons) is only collected at four locations. In addition the data is put into two weather models, which serve as extra information for any spray warning which might be necessary. The data is collected, evaluated and made available to the hop-growers every day via answer-phone, Ringfax and internet. A special service for the hop-growers is that within the scope of this model there is concrete information which day a spraying is necessary and when it is not. In addition to this the warning is differentiated according to varieties.

Results

Following completion of the essential plot trials, since 1998 there has been a separate spray recommendation for tolerant Hüll breeding lines, susceptible varieties and towards the end of the season a recommendation for late-ripening varieties. The spray warnings during the period 1998 – 2003 (Table 6.1) allows the following conclusions:

- When the spray warnings were followed it was possible to produce hops in all varieties which were free of peronospora every year,
- the differentiation in tolerant varieties and susceptible varieties brings further savings in fungicides; Hüll breeding varieties are already being grown on three-quarters of the hop acreage in Bavaria.
- very susceptible varieties such as Hallertauer Mittelfrüher and Northern Brewer need additional treatments according to the amount of infection,
- the same applies to late-ripening varieties as they are exposed to the infection for a longer time,
- the timing and the frequency of the sprayings required varies from year to year; regular surveys must be made each year anew.

The forecasting model combined with resistance breeding brings a not quantifiable ecological advantage and savings of several million euros. The staff required for the forecast are very few compared with the yearly benefit and must therefore be maintained.

Table: 6.1: Dates for combating peronospora according to the forecast model depending on the year and varieties

Year	1998			1999			2000			2001			2002			2003		
Variety	**tolerant**	**suscept.**	**late**	**tolerant**	**suscept.**	**late**	**tolerant**	**suscept.**	**late**	**tolerant**	**suscept.**	**late**	**tolerant**	**suscept.**	**late**	**tolerant**	**suscept.**	**late**
May					25.05		15.05.	15.05.			29.05.			22.05.				
June	22.06.	02.06. 22.06.		07.06.	07.06. 15.06. 29.06. HA,NB			05.06.		20.06.	20.06.		11.06.	11.06. 27.06. HA		27.06.	02.06. 20.06. HA,NB 27.06.	
July	24.07.	10.07. . 24.07.		14.07.	14.07. 23.07.		17.07. 25.07.	17.07. 25.07.		12.07. .	02.07. 12.07. . 23.07. HA,NB HE,NU		05.07. 15.07.	05.07. 15.07. 27.07.		08.07.	08.07. 28.07..	
Aug.		03.08.		09.09.	09.08.	19.08.	04.08.	04.08. 16.08.	16.08.		06.08.	. HM,TU, HE,NU, 17.08. TA, BG	06.08. 14.08. HM,TU,MR	06.08. 14.08.	23.08. .			
Total	**2**	**5**		**3**	**6(+1)**	**+1**	**4**	**6**	**+1**	**2**	**6**	**+1**	**4(+1)**	**7(HA8)**	**+1**	**2**	**4(+1)**	

HA= Hallertauer Mittelfrüh; NB = Northern Brewer; HE = Hersbrucker Spät; NU = Nugget; HM = Hallertauer Magnum; TU = Hall. Taurus; TA= Target; BG = Brewers-Gold

6.2.6 Powdery mildew *(Sphaerotheca humuli* BURR.)

7 Attacks of cleistothecia on hop cones

From a peronospora trial for the Official Fungicide Test 2002 at the Barthof on 22.10. approx. 15 vines (variety Nugget), which were simultaneously very badly infested with peronospora and powdery mildew, were taken from the untreated plot and stored in Hüll at the north-east end of the vegetation hall out in the open air on a tarpaulin until April 2003.
To record the amount of infestation with cleistothecia, 80 cones were taken from the vines at random in the months January and February 2003 and the number of cleistothecia determined under a reflected light microscope (50 x magnification).
At the same time the bracts and bracteoles of the cones were removed individually and examined inside and out for cleistothecia. In order to record the distribution on the cones for the first time, the data was evaluated separately.

Table 6.2: Number and distribution of cleistothecia on hop cones, variety Nugget, trial at the Barthof 2002 – counted on the individual bracteoles

	bracteoles	cleistothecia Ø	cleistothecia from – up to
Top of cone to mid-cone	inside	85	0 – 890
	outside	176	0 - 1090
Mid-cone to stalk	inside	243	0 – 1860
	outside	441	0 – 2930
Whole cone	inside	328	0 – 1860
	outside	617	0 – 2930
Total	per cone	945	0 - 2930

The cleistothecia were spread out all over the cone, whereby surprisingly twice as many overwintering organs were found on the outside of the bracteoles as on the inside. In the tests by Seigner et.al it was considerably more difficult to infect the outsides of the bracteoles than the insides.
Altogether it can be assumed that in the material there is a high infection potential for the field trial.

Comparison of weather parameters with the attacks of powdery mildew during the period 1998 – 2003

As already described in the chapter "research projects", a logical connection could be found between weather and the state of infestation. In den tables "periods with a probably high infection risk of powdery mildew in hops“

April – July 1999
April – July 2003 and
May 1998 – 2003

are the years or the months listed with extremely varied conditions.
In the year 1999 with so far the worst attacks of mildew the requirements of the model had already been fulfilled twice in May. Another presumably bad infection period is in the first half of July. The 1999 course of epidemiology produces a logical correlation as infections in the trial hop stands could be determined as early as in May.
Practically no attacks of mildew were found in the hop yards in 2003. Also at the Hofen location (Official Fungicide Test) normally a "definite mildew hop-yard“, no attacks were found in the untreated plots. This model at no time showed it necessary to control mildew from May - July.

Table 6. 3: Periods with probably high infection risk due to powdery mildew in hops
Weather data at the Hüll location, April - July 1999

	8-19 Uhr			20 - 7 Uhr			8-19 Uhr			20 - 7 Uhr			8-19 Uhr			20 - 7 Uhr			8-19 Uhr			20 - 7 Uhr	
	°C	mm	Wh/m²	°C	mm		°C	mm	Wh/m²	°C	mm		°C	mm	Wh/m²	°C	mm		°C	mm	Wh/m²	°C	mm
1. Apr.						**1. Mai.**						**1. Jun.**						**1. Jul.**					
2. Apr.						2. Mai.						2. Jun.				**16,3**	**16,7**	2. Jul.					
3. Apr.						3. Mai.						3. Jun.						3. Jul.					
4. Apr.						4. Mai.						4. Jun.				**13,0**	**10,6**	4. Jul.					
5. Apr.						5. Mai.						5. Jun.						5. Jul.				**18,8**	**35,5**
6. Apr.						6. Mai.						6. Jun.				**10,9**	**2,4**	6. Jul.	**17,7**	**3,5**	**1459,1**	**16,4**	**0,0**
7. Apr.						7. Mai.						7. Jun.						7. Jul.	**17,6**	**0,2**	**3037,0**		
8. Apr.						8. Mai.						8. Jun.	**11,7**	**11,1**	**948,5**			8. Jul.	**16,4**	**4,2**	**1581,5**		
9. Apr.						9. Mai.						9. Jun.						9. Jul.	**16,5**	**8,7**	**1453,2**	**14,2**	**3,9**
10. Apr.						10. Mai.						10. Jun.						10. Jul.	**18,8**	**18,7**	**1348,3**	**16,8**	**1,9**
11. Apr.						11. Mai.	**13,8**	**5,8**	**1837,4**	**12,5**	**3,8**	11. Jun.						11. Jul.	**19,4**	**17,9**	**2036,6**	**16,5**	**0,1**
12. Apr.						12. Mai.	**14,7**	**2,4**	**2250,1**	**11,8**	**6,3**	12. Jun.						12. Jul.	**19,9**	**1,4**	**2950,9**		
13. Apr.						13. Mai.				**11,3**	**1,0**	13. Jun.						13. Jul.					
14. Apr.						14. Mai.	**12,5**	**1,0**	**1658,9**	**10,9**	**10,5**	14. Jun.						14. Jul.				**15,7**	**4,1**
15. Apr.						15. Mai.						15. Jun.						15. Jul.				**13,7**	**1,4**
16. Apr.						16. Mai.						16. Jun.						16. Jul.					
17. Apr.						17. Mai.						17. Jun.						17. Jul.					
18. Apr.						18. Mai.						18. Jun.				**12,6**	**11,0**	18. Jul.					
19. Apr.						19. Mai.						19. Jun.						19. Jul.					
20. Apr.						20. Mai.	**16,0**	**1,2**	**2671,1**	**11,8**	**2,8**	20. Jun.						20. Jul.					
21. Apr.						21. Mai.	**12,8**	**17,5**	**247,0**	**11,6**	**23,6**	21. Jun.	**13,6**	**0,9**	**2649,8**	**11,8**	**6,5**	21. Jul.	**22,9**	**2,5**	**3265,5**		
22. Apr.						22. Mai.	**12,5**	**2,0**	**1006,2**	**11,7**	**6,7**	22. Jun.						22. Jul.					
23. Apr.						23. Mai.						23. Jun.						23. Jul.	**14,8**	**4,3**	**2644,5**		
24. Apr.						24. Mai.						24. Jun.						24. Jul.					
25. Apr.						25. Mai.						25. Jun.	Blattbefall					25. Jul.					
26. Apr.						26. Mai.						26. Jun.				**12,3**	**1,4**	26. Jul.					
27. Apr.						27. Mai.						27. Jun.						27. Jul.					
28. Apr.						28. Mai.						28. Jun.	**15,8**	**3,6**	**2232,4**	**13,3**	**2,6**	28. Jul.					
29. Apr.						29. Mai.						29. Jun.						29. Jul.					
30. Apr.						30. Mai.						30. Jun.				**14,7**	**6,6**	30. Jul.					
						31. Mai.												31. Jul.					

Table 6.4: Periods with probably high infection risk due to powdery mildew in hops
Weather data at the Hüll location, April - July 2003

	8-19 Uhr			20 - 7 Uhr	
	°C	mm	Wh/m²	°C	mm
1. Apr.					
2. Apr.					
3. Apr.					
4. Apr.					
5. Apr.					
6. Apr.					
7. Apr.					
8. Apr.					
9. Apr.					
10. Apr.					
11. Apr.					
12. Apr.					
13. Apr.					
14. Apr.					
15. Apr.					
16. Apr.					
17. Apr.					
18. Apr.					
19. Apr.					
20. Apr.					
21. Apr.					
22. Apr.					
23. Apr.					
24. Apr.					
25. Apr.					
26. Apr.					
27. Apr.					
28. Apr.					
29. Apr.					
30. Apr.	**19,5**	**1,2**	**2742,0**	**11,3**	**2,8**

	8-19 Uhr			20 - 7 Uhr	
	°C	mm	Wh/m²	°C	mm
1. Mai.					
2. Mai.				**9,2**	**2,3**
3. Mai.				**9,0**	**4,4**
4. Mai.					
5. Mai.					
6. Mai.					
7. Mai.					
8. Mai.				**15,8**	**2,3**
9. Mai.	**17,9**	**0,8**	**3229,0**	**14,3**	**3,5**
10. Mai.					
11. Mai.	**15,9**	**3,1**	**2344,0**	**13,0**	**5,8**
12. Mai.					
13. Mai.	**11,5**	**3,8**	**1151,0**		
14. Mai.					
15. Mai.					
16. Mai.					
17. Mai.					
18. Mai.					
19. Mai.					
20. Mai.	**11,2**	**7,9**	**2113,0**		
21. Mai.					
22. Mai.				**9,6**	**1,1**
23. Mai.					
24. Mai.					
25. Mai.					
26. Mai.					
27. Mai.					
28. Mai.					
29. Mai.					
30. Mai.					
31. Mai.					

	8-19 Uhr			20 - 7 Uhr	
	°C	mm	Wh/m²	°C	mm
1. Jun.					
2. Jun.					
3. Jun.					
4. Jun.					
5. Jun.					
6. Jun.				**18,6**	**1,7**
7. Jun.					
8. Jun.					
9. Jun.					
10. Jun.					
11. Jun.					
12. Jun.				**19,7**	**1,2**
13. Jun.	**22,8**	**2,3**	**3205,0**		
14. Jun.					
15. Jun.					
16. Jun.					
17. Jun.				**14,4**	**4,5**
18. Jun.				**16,5**	**4,9**
19. Jun.					
20. Jun.	**20,5**	**1,8**	**3321,0**		
21. Jun.					
22. Jun.					
23. Jun.					
24. Jun.	**22,9**	**0,9**	**3257,0**	**18,8**	**4,4**
25. Jun.					
26. Jun.					
27. Jun.				**15,2**	**3,7**
28. Jun.				**16,2**	**2,1**
29. Jun.					
30. Jun.					

	8-19 Uhr			20 - 7 Uhr	
	°C	mm	Wh/m²	°C	mm
1. Jul.	**14,6**	**6,5**	**793,6**	**16,3**	**1,9**
2. Jul.					
3. Jul.	**16,5**	**4,2**	**3109,0**	**12,5**	**0,7**
4. Jul.					
5. Jul.	**17,1**	**2,4**	**3085,0**		
6. Jul.					
7. Jul.					
8. Jul.					
9. Jul.					
10. Jul.					
11. Jul.					
12. Jul.					
13. Jul.					
14. Jul.					
15. Jul.					
16. Jul.				**16,1**	**2,0**
17. Jul.	**18,7**	**7,8**	**1735,0**		
18. Jul.					
19. Jul.					
20. Jul.					
21. Jul.					
22. Jul.					
23. Jul.				**17,5**	**1,7**
24. Jul.				**15,3**	**3,8**
25. Jul.					
26. Jul.					
27. Jul.				**19,2**	**3,2**
28. Jul.				**16,3**	**2,5**
29. Jul.					
30. Jul.					
31. Jul.					

Table 6.5: Schedule of weather data (Hüll location) May; 1998 2003

1998						1999					2000				
	8-19 Uhr			20 - 7 Uhr		8-19 Uhr			20 - 7 Uhr		8-19 Uhr			20 - 7 Uhr	
	°C	mm	Wh/m²	°C	mm	°C	mm	Wh/m²	°C	mm	°C	mm	Wh/m²	°C	mm
1. Mai.															
2. Mai.															
3. Mai.															
4. Mai.															
5. Mai.															
6. Mai.	**11,9**	**1,4**	**2617,8**											10,6	3,7
7. Mai.															
8. Mai.															
9. Mai.															
10. Mai.															
11. Mai.						**13,8**	**5,8**	**1837,4**	**12,5**	**3,8**					
12. Mai.						**14,7**	**2,4**	**2250,1**	**11,8**	**6,3**	16,7	40,1	1909,6	14,2	0,1
13. Mai.									**11,3**	**1,0**	17,3	0,0	3545,3		
14. Mai.						**12,5**	**1,0**	**1658,9**	**10,9**	**10,5**					
15. Mai.															
16. Mai.															
17. Mai.														14,0	6,1
18. Mai.											12,4	3,9	1104,5	11,5	5,3
19. Mai.															
20. Mai.						**16,0**	**1,2**	**2671,1**	**11,8**	**2,8**					
21. Mai.						**12,8**	**17,5**	**247,0**	**11,6**	**23,6**					
22. Mai.						**12,5**	**2,0**	**1006,2**	**11,7**	**6,7**	10,7	1,5	1672,4		
23. Mai.															
24. Mai.															
25. Mai.	14,3	1,0	3159,7												
26. Mai.															
27. Mai.															
28. Mai.											16,2	8,0	2877,4	10,7	0,6
29. Mai.				14,0	9,9										
30. Mai.															
31. Mai.				11,8	15,9										

2001						2002					2003				
	9-20 Uhr			21 - 8 Uhr		9-20 Uhr			21 - 8 Uhr		8-19 Uhr			20 - 7 Uhr	
	°C	mm	Wh/m²	°C	mm	°C	mm	Wh/m²	°C	mm	°C	mm	Wh/m²	°C	mm
1. Mai.															
2. Mai.														9,2	2,3
3. Mai.														9,0	4,4
4. Mai.						10,0	3,7	1031,2							
5. Mai.	15,6	20,1	3139,1	11,3	0,6										
6. Mai.															
7. Mai.															
8. Mai.														15,8	2,3
9. Mai.											17,9	0,8	3229,0	14,3	3,5
10. Mai.						15,9	5,4	2718,1	13,2	14,5					
11. Mai.									10,4	6,2	15,9	3,1	2344,0	13,0	5,8
12. Mai.						14,4	0,3	2748,4	11,2	1,5					
13. Mai.											11,5	3,8	1151,0		
14. Mai.				10,4	4,4										
15. Mai.	16,6	2,3	3294,7												
16. Mai.				11,4	2,2										
17. Mai.				12,5	4,7										
18. Mai.				9,9	4,0				**13,8**	**21,0**					
19. Mai.						**12,7**	**0,0**	**1724,3**	**11,3**	**17,0**					
20. Mai.						**14,7**	**0,1**	**2499,0**			11,2	7,9	2113,0		
21. Mai.															
22. Mai.														9,6	1,1
23. Mai.									**13,2**	**4,9**					
24. Mai.						**13,2**	**0,0**	**1893,3**	**10,0**	**2,4**					
25. Mai.						**15,5**	**12,3**	**3127,3**							
26. Mai.															
27. Mai.						12,9	2,0	1478,2							
28. Mai.															
29. Mai.															
30. Mai.															
31. Mai.															

The time for the first treatment probably has the greatest significance. If the infection has taken place, it can no longer be effectively stopped with the range of fungicides available at the present time. By comparing the weather data with probable infection in May again there is a logical connection with the bad attacks in 1999 and 2002. In these years the attacks could definitely have been prevented by sprayings in May.

Evaluation of weather data in the periods with probably high likelihood of infection

For assessing the individual hour values, basically the following common points can be derived for the periods when mildew infection is possible:

- with regard to night temperatures, only few hourly average temperatures just below 10 °C
- the maximum temperatures during the day are below 20°C
- the night-day difference in °C is very slight
- the amounts of precipitation are spread over several hours
- in the short term the sunshine intensity can rise to 700 watt-hours per square metre (Wh/m^2) (exceptions); however the total during the day is below 3000 Wh/m^2
- high number of hours with air movement (0.1 – 1.5 m/sec); the wind rarely reaches peaks of 2 m/sec
- the relative humidity in the night is between 80 – 99 %, during the day likewise more than 80 % with few hours below 70 %

The slight fluctuations in temperature between day and night contradict the opinion so far on the time when infection is most likely to occur; so far high night-day fluctuations with the formation of dew were thought to cause infection.
The sunshine intensity is mentioned in literature (diffuse light), but not absolutely required. Besides the temperature presumably there is an important key with this parameter to assess the likelihood of infection.

Monitoring for the mildew infestation 2003

During a monitoring in connection with 36 hop growers, spread out all over the Hallertau, hops were planted on untreated plots up until mid-June. As no mildew infection occurred during the whole vegetation period, no pustules were found even during inspections of the untreated plots.

6.2.7 Botrytis (*Botrytis cinerea* PERS.)

Due to the weather conditions in 2003 there were no attacks of botrytis.
Special botryticides as permitted in viniculture, have not been tested as

- the necessary preventive treatment is only very difficult to lay down as far as timing is concerned and
- the expense for a preventive treatment would be far too high.

Registered fungicides with side effects on botrytis are Euparen M WG; Folpan 80 WDG, Ortiva and Flint.

6.3 Virusfree plant stock

5040 plants were tested for virus in 2003.

- **Field of work: Breeding**
  1986 mother plants tested for ApMV and HMV

- **Propagation nursery: Eickelmann**
  382 mother plants tested for ApMV und HMV
  of these: 4 Hersbrucker
  50 Hallertauer Magnum
  114 Hallertauer Mittelfrüher
  50 Hallertauer Merkur
  48 Perle
  30 Hallertauer Tradition
  36 Hallertauer Taurus
  50 Saphir

- **Ring Hallertau**
  81 ApMV for B-certificates and verifications

- **Ring Jura**
  26 ApMV for B-certificates and verifications

- **Own tests**
  101 ApmV
  96 HmV

7 Hop Quality and Analytics

Dr. Klaus Kammhuber, Dipl. Chemiker

7.1 Introduction

The alpha acids are by far the most important hop components for brewing beer. They are a criterion for the bitter potential of hops and also play an ever increasing role for payment. There are brewers who see hops as providers of pure alpha-acid and bestow no attention on all the other hop components. Others choose hops specifically according to variety and production region. In many brewing trials it has been proved that the bitterness and the aroma of a beer can be influenced by different hop varieties. Though the results cannot be allocated in every case to a spectrum of hop components.
Recent research by Prof. Schieberle (TU München, Garching) shows that the iso-alpha-acids are only responsible for 60 % of the hop bitterness. Presumably the bitter quality is determined by a complex combination of many different components acting together. For this reason other hop-components will attract increasing interest in the future. The polyphenols possess a high positive potential for health. Especially xanthohumol could be used as an additive for "functional drinks“ or for pharmaceutical preparations.
In the Work Group IPZ 5d all the analytical investigations are carried out which are needed to support questions on experiments by the Hops Section IPZ 5.

7.2 Breeding programmes

The aims for hop breeding Hüll were laid down on 17.01.1997 at a discussion on "Strategies in the variety policy for hops and hop-breeding objectives“. In 2003 two sessions of the Work Group "Quality criteria for hop-breeding in Hüll from the aspect of the hop-refining and brewing industry“ were held, when additional criteria and wishes were discussed. Besides the resistance to disease, the resistance to drought is becoming more and more important. The alpha-acid content as far as aroma varieties are concerned should only be subject to as few fluctuations as possible. The increase in the xanthohumol content was also defined as a breeding aim.

7.2.1 Breeding programme: aroma varieties

Table 7.1 shows analysis results for the 2002 crop with criteria of the Saaz group compared with the varieties Saazer, Spalter, Spalter Select and Tettnanger. Some breeding lines have a cohumulone proportion below 20% with an alpha-acid content of almost 10%.

7.2.2 Breeding programme: bitter varieties

As far as the bitter varieties are concerned, on the one hand bitter hops without qualitative requirements with the highest possible alpha-acid contents are desired, on the other hand bitter hops with qualitative requirements such as Hallertauer Magnum and Hallertauer Taurus should also be bred. According to recent investigations a low cohumulone content should no longer be pursued intensively as a main breeding aim. The Table 7.2 shows a selection of a few breeding lines with high alpha-acid contents compared with Hallertauer Magnum, Hallertauer Merkur and Hallertauer Taurus of the 2002 crop. Patenting will be applied for at the Federal Registration Office for the breeding lines 93/010/034, 93/010/036, 93/010/063 and 95/094/816 These breeding lines bring considerable breeding progress in ripening time, resistance, yield and alpha-acid yield.

Table 7.1 Breeding lines with criteria of the Saaz range, alpha-acid contents over 4 % and low cohumulone contents, 2002 crop

Breeding-line	Mycene	2-M.-iso-butyrate	Sub. 14b	Sub. 15b	Lina-lool	Aroma-dendrene	Unde-canon	Humu-lene	Farne-sene	γ-Muu-rolene	ß-Se-linene	α-Se-linene	Cadi-nene	Seli-nadiene	Gera-niol	α-acids	ß-acids	ß:α	Cohu-muloe	Colu-pulone
Saazer	2325	8	2	5	22	0	9	228	33	6	3	2	13	0	0	4.00	5.62	1.41	22.6	39.6
Spalter	2274	9	2	5	21	0	8	237	33	6	3	2	14	0	0	3.73	6.59	1.77	22.6	39.6
Spalter Select	4528	90	18	7	68	10	13	170	49	7	27	29	14	33	0	4.19	4.66	1.11	21.6	43.
Tettnanger	2236	11	4	4	23	0	12	222	27	6	2	2	13	0	0	5.06	5.96	1.18	22.2	40.2
82/036/028	1473	14	12	11	15	0	13	250	26	6	3	2	15	0	2	3.49	4.14	1.19	22.0	42.1
89/002/025	1308	35	8	2	23	0	13	220	21	5	2	2	13	1	0	9.16	6.98	0.76	19.0	51.3
91/013/025	3124	41	5	14	20	11	5	146	31	7	19	21	12	30	0	9.45	7.90	0.84	15.0	35.9
91/033/015	1508	12	17	7	14	0	10	242	50	7	3	2	14	0	0	8.26	3.93	0.48	14.4	35.2
93/053/033	1145	31	4	2	11	0	12	262	27	8	3	2	15	0	1	8.61	7.77	0.90	20.4	40.2
93/081/013	2497	46	8	9	33	0	23	244	39	6	2	2	13	0	0	6.25	6.92	1.11	20.7	42.7
96/031/027	2502	25	20	11	33	0	8	224	24	6	2	2	14	25	0	4.94	6.60	1.34	15.6	34.7
96/054/009	2778	45	15	5	35	0	13	302	36	9	4	3	16	0	0	3.82	5.01	1.31	20.8	41.5
97/010/023	3329	10	6	10	27	0	13	223	36	7	3	3	15	0	0	8.14	5.94	0.73	24.7	44.0
99/038/704	2580	21	63	10	15	0	9	215	27	7	4	3	14	0	0	6.76	6.95	1.03	23.9	43.5
2000/018/016	6987	197	5	18	36	18	15	147	52	7	18	20	14	28	0	7.88	8.55	1.09	19.0	40.5
2000/019/008	3971	12	4	4	53	1	8	201	31	5	5	4	13	1	0	2.80	7.64	2.73	20.6	42.4
2001/016/713	2042	126	6	52	7	0	21	233	23	7	4	3	14	1	0	8.61	4.05	0.47	20.4	42.6
2001/017/721	758	40	4	11	8	0	23	229	21	10	3	2	16	0	0	7.20	3.72	0.52	19.1	40.4
2001/018/707	1353	152	0	30	6	0	8	183	46	6	10	9	14	17	0	6.75	2.48	0.37	23.5	47.1
2001/019/737	725	32	6	4	3	0	6	189	23	7	3	3	13	0	0	7.40	3.23	0.44	21.1	44.8
2001/033/728	821	18	14	5	13	0	15	153	20	7	13	12	15	11	0	6.23	4.37	0.70	12.5	30.7

Essential oils = relative values. ß-Caryophyllene = 100; α- und ß-acids in % as is.; analoga in % of the alpha and beta acids

Table 7.2: Breeding programme, bitter varieties, 2002 crop

Variety/Breeding-line	α-Acids	ß-Acids	ß:α	Cohumulone	Colupulone
Hallertauer Magnum	15.29	6.51	0.43	22.2	43.1
Hallertauer Magnum	16.22	6.21	0.38	24.3	46.1
Hallertauer Magnum	16.25	5.98	0.37	23.8	46.9
Hallertauer Merkur	15.09	6.95	0.46	17.5	42.5
Hallertauer Taurus	17.21	5.87	0.34	20.7	45.3
Hallertauer Taurus	16.74	5.38	0.32	23.2	47.3
Hallertauer Taurus	15.26	4.71	0.31	23.2	47.7
91/045/021	16.07	5.26	0.33	21.3	43.3
92/085/766	15.04	9.79	0.65	19.8	42.3
93/010/034	15.60	5.57	0.36	24.5	46.5
93/010/034	13.42	4.49	0.33	21.6	43.0
93/010/036	15.82	5.79	0.37	26.3	48.9
93/010/036	17.98	6.79	0.38	27.5	50.7
93/010/063	14.32	6.65	0.46	31.2	54.9
93/010/063	15.32	6.03	0.39	28.4	51.7
94/075/064	15.50	8.54	0.55	23.8	46.4
94/075/240	15.19	7.44	0.49	19.6	37.7
94/075/733	15.26	7.05	0.46	23.9	45.2
94/075/758	16.89	8.05	0.48	20.6	40.6
94/075/761	15.53	6.69	0.43	14.5	30.9
95/093/702	16.00	4.59	0.29	24.0	46.3
95/094/816	17.26	6.00	0.35	36.6	56.9
95/094/816	18.47	5.84	0.32	36.3	56.8
95/103/735	15.09	5.96	0.39	22.5	45.8
95/103/743	15.66	4.65	0.30	24.7	44.5
96/069/037	16.08	6.30	0.39	20.1	40.1
99/061/009	17.77	5.05	0.28	19.6	36.7
99/061/744	16.98	5.65	0.33	17.7	38.4
99/062/735	18.31	5.61	0.31	23.0	45.0
99/065/004	16.10	4.73	0.29	20.1	39.1
99/065/710	15.66	5.48	0.35	20.8	37.7
99/066/025	15.74	5.53	0.35	19.8	38.3
99/093/003	18.47	7.23	0.39	22.0	45.2
2000/078/019	16.43	4.67	0.28	23.3	40.6
2000/102/008	15.83	6.03	0.38	21.9	47.4
2000/109/727	15.17	7.54	0.50	21.1	51.5
2001/056/018	15.79	4.71	0.30	21.9	45.7
2001/056/038	15.36	4.17	0.27	23.9	43.7
2001/093/013	16.13	6.40	0.40	23.4	45.4
2001/093/024	15.88	6.70	0.42	24.3	48.4
2001/095/024	15.26	5.95	0.39	19.1	43.0
2001/101/704	15.71	3.83	0.24	24.4	46.3
2001/108/014	17.51	4.15	0.24	23.0	47.1

α- and ß-acids in % as is.; analoga in % of the alpha- or beta-acids

7.3 World hop range

This research programme is carried out every year. The aim is to determine the quality and variety-specific components of the available domestic and foreign hop varieties regarding production under the conditions present at the location in Hüll. Table 7.3 shows the results of the crop year 2002. It can serve as an aid to allocate unknown hop varieties to a specific variety type.

Table 7.3: Word range of hop varieties, 2002 crop

Variety/ Name	Mycene	2-M-iso-butyrate	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendren	Unde-canon	Humu-lene	Farne-sene	γ-Muu-rolene	ß-Seli-nene	α-Seli-nene	Cadi-nene	Seli-nadien	Gera-niol	α-acids	ß-acids	ß:α	Cohu-mulone	Colu-pulone
Admiral	1795	731	9	9	34	0	6	172	6	6	3	2	13	0	0	16.21	6.04	0.37	43.5	65.3
Ahil	2846	274	15	1	10	0	5	133	50	5	7	6	10	0	0	9.27	4.32	0.47	38.4	60.7
Alliance	1430	79	1	3	14	0	4	240	9	6	4	3	14	0	0	5.69	3.25	0.57	33.3	55.2
Apolon	3353	50	29	4	17	0	3	148	52	5	4	3	11	0	0	8.74	3.84	0.44	28.4	51.9
Aquila	1477	72	5	21	23	24	14	17	0	9	53	50	8	57	0	6.61	5.01	0.76	50.2	72.6
Aromat	749	12	2	7	25	0	12	212	13	5	3	2	12	0	4	3.19	5.35	1.68	25.1	40.9
Atlas	836	383	13	1	11	0	3	100	19	4	6	4	7	0	0	6.02	3.86	0.64	40.7	62.0
Aurora	4197	90	4	24	27	0	19	217	26	5	3	3	12	0	0	10.40	4.38	0.42	20.4	46.8
Backa	192	193	7	1	11	0	6	210	6	9	3	2	17	0	0	8.89	7.50	0.84	38.5	62.6
Belgischer Spalter	826	40	1	3	11	7	8	136	6	7	24	26	12	44	0	6.38	4.26	0.67	23.9	49.2
Blisk	1132	264	22	1	21	0	3	146	28	8	8	6	14	0	0	7.89	3.60	0.46	33.8	56.2
Bobek	7118	119	11	72	41	0	12	193	31	5	2	2	12	0	0	7.71	6.54	0.85	25.2	48.3
Bor	2792	77	2	28	8	0	4	248	0	6	3	2	13	0	0	10.76	5.14	0.48	23.6	48.6
Braustern	2853	81	1	44	7	0	4	205	0	5	2	2	13	0	0	10.18	6.19	0.61	29.0	49.5
Brewers Gold	1504	224	5	8	11	0	2	134	0	6	7	5	11	0	2	6.34	4.00	0.63	42.6	68.8
Brewers Stand	2451	679	30	26	44	23	15	23	0	52	62	49	77	44	0	8.38	5.23	0.62	31.3	51.6
Buket	3332	131	3	59	19	0	9	199	24	7	3	2	15	0	0	10.37	5.52	0.53	22.7	53.3
Bullion	756	235	13	4	15	0	2	122	0	6	9	7	12	0	0	6.68	5.17	0.77	42.3	66.3
Cascade	1060	197	26	2	16	0	4	119	9	6	11	8	11	0	0	6.25	5.14	0.82	34.9	52.8
Chang bei no 1	1294	4	4	3	20	0	7	191	20	7	12	11	12	11	0	4.99	5.27	1.06	22.7	43.7
Chang bei no 2	1187	7	4	1	24	0	8	179	17	6	13	12	12	13	0	4.29	5.24	1.22	23.2	44.4
Columbia	212	36	15	0	16	0	5	220	0	8	19	15	17	0	0	4.31	6.43	1.49	20.3	33.6

Table 7.3 continued

Variety/ Name	Mycene	2-M-iso-butyrate	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendren	Unde-canon	Humu-lene	Farne-sene	γ-Muu-rolene	ß-Seli-nene	α-Seli-nene	Cadi-nene	Seli-nadien	Gera-niol	α-acids	ß-acids	ß:α	Cohu-mulone	Colu-pulone
Columbus	3870	99	9	12	7	0	4	127	0	15	10	9	30	10	0	13.95	5.50	0.39	36.5	59.3
Comet	276	135	13	3	15	0	4	10	0	3	52	50	6	10	0	8.92	4.30	0.48	42.6	63.3
Crystal	2516	375	9	61	6	0	5	113	0	4	6	5	9	0	0	8.33	6.55	0.79	42.4	65.9
Dunav	1901	43	2	57	5	0	3	169	17	5	2	1	12	0	0	8.86	8.84	1.00	25.9	58.1
Early Choice	1878	87	2	25	6	0	3	195	0	5	41	47	14	0	0	3.09	2.14	0.69	38.3	54.8
Eastern Gold	697	5	2	1	10	0	4	147	8	20	8	7	36	7	0	14.00	5.81	0.42	29.6	47.1
Eastwell Golding	1148	65	2	5	11	0	4	242	0	6	3	2	13	0	0	7.84	5.00	0.64	26.5	48.6
Emerald	561	35	5	5	5	0	6	257	0	6	4	3	14	0	0	7.07	5.68	0.80	24.8	45.4
Estera	2209	122	1	4	17	0	4	221	23	6	3	2	14	0	0	4.22	2.80	0.66	30.8	49.7
First Gold	2873	289	3	8	19	0	8	202	13	7	82	92	16	0	0	9.82	4.68	0.48	28.9	55.4
Fuggle	2127	146	2	5	20	0	6	219	14	6	2	2	13	0	0	4.92	3.41	0.69	28.8	47.7
Glacier	1094	18	5	1	16	0	6	170	0	5	3	2	12	0	0	5.77	8.15	1.41	13.0	39.8
Granit	2131	75	4	11	5	0	10	150	0	4	5	5	9	0	0	9.17	6.33	0.69	23.1	45.6
Hallertauer Gold	2103	54	15	5	19	0	5	229	0	5	3	2	13	0	0	7.40	6.91	0.93	20.1	41.9
Hallertauer Magnum	5984	112	21	21	8	0	4	248	0	5	3	3	12	0	0	14.76	7.09	0.48	26.2	46.0
Hallertauer Merkur	3264	142	13	6	17	0	6	249	0	6	5	5	13	0	0	13.49	6.07	0.45	17.2	42.3
Hallertauer Mfr.	676	48	2	1	18	0	6	267	0	8	3	3	16	0	0	3.90	4.84	1.24	19.1	38.2
Hallertauer Taurus	5524	74	12	11	29	0	7	212	0	6	52	56	15	0	0	16.48	5.72	0.35	20.4	44.1
Hallertauer Tradition	1558	78	8	2	22	0	6	245	0	7	3	2	13	0	0	6.83	5.70	0.84	22.9	45.5
Herald	4602	323	3	72	11	1	22	185	0	6	28	31	14	0	1	11.85	4.82	0.41	36.6	60.0
Hersbrucker Pure	2433	98	3	8	24	9	9	156	0	8	23	26	13	39	0	6.56	3.63	0.55	23.3	45.7
Hersbrucker Spät	1231	50	6	3	35	34	8	133	0	12	42	45	15	51	0	2.60	7.02	2.70	19.4	35.4

Table 7.3 continued

Variety/ Name	Mycene	2-M-iso-butyrate	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendren	Unde-canon	Humu-lene	Farne-sene	γ-Muu-rolene	ß-Seli-nene	α-Seli-nene	Cadi-nene	Seli-nadien	Gera-niol	α-acids	ß-acids	ß:α	Cohu-mulone	Colu-pulone
Horizon	3846	166	7	25	25	0	6	98	11	2	6	5	8	0	0	10.79	5.90	0.55	23.6	46.4
Hüller Anfang	326	46	4	2	13	0	5	267	0	8	3	2	15	0	0	2.74	4.84	1.77	23.6	38.4
Hüller Aroma	492	30	1	0	15	0	4	252	0	7	3	3	16	0	0	4.15	4.83	1.16	25.7	46.0
Hüller	429	290	34	7	38	13	10	106	0	51	57	42	67	39	0	5.23	6.03	1.15	32.7	49.3
Hüller Fortschritt	537	23	5	3	18	0	6	264	0	7	3	3	15	0	0	3.33	5.36	1.61	24.9	40.5
Hüller Start	338	25	1	1	7	0	7	259	0	9	3	2	15	0	0	2.82	4.44	1.58	22.2	39.9
Japan C-845	1569	29	6	15	5	0	3	239	26	7	3	3	13	0	0	12.01	5.35	0.45	24.5	42.8
Kitamidori	592	5	4	5	3	0	1	241	16	7	3	2	14	0	0	11.77	4.64	0.39	22.1	40.0
Kumir	2176	67	2	12	14	0	5	239	10	7	3	2	14	0	0	10.97	5.48	0.50	20.0	41.6
Late Cluster	14443	632	25	56	45	14	12	34	8	43	49	49	82	47	0	8.61	5.77	0.67	30.8	51.0
Liberty	699	40	2	2	15	0	6	249	0	8	3	3	17	0	0	4.86	4.20	0.87	22.6	40.6
Lubelski	1405	9	2	2	21	0	9	211	22	6	3	2	13	0	0	4.54	5.81	1.28	22.7	40.0
Malling	2054	102	2	4	20	0	5	214	20	6	3	3	13	0	0	3.79	2.61	0.69	31.8	51.7
Marynka	2545	137	2	19	7	0	7	127	75	5	5	5	10	0	0	10.81	5.16	0.48	19.4	46.7
Mount Hood	183	16	8	1	7	0	2	233	0	8	3	2	16	0	0	4.93	7.42	1.51	21.7	44.2
Northern Brewer	3847	110	2	53	8	0	4	211	0	5	2	2	12	0	0	9.99	4.99	0.50	28.8	50.7
Nugget	1933	99	3	10	13	0	3	147	0	3	5	5	9	0	0	10.76	4.54	0.42	29.5	55.5
Olympic	1453	65	3	11	12	0	4	150	0	4	7	6	9	0	0	12.95	4.99	0.39	27.1	54.0
Omega	2108	269	19	11	17	0	6	225	0	5	44	55	14	0	0	8.23	4.50	0.55	30.0	49.8
Orion	828	56	5	3	9	0	4	188	0	6	3	2	14	0	0	10.58	7.13	0.67	26.4	49.6
OT 48	330	56	7	4	22	0	9	185	0	5	4	3	11	0	0	4.85	4.04	0.83	36.2	62.7
PCU 280	2265	55	1	13	5	0	3	222	0	5	2	2	11	0	0	10.42	4.30	0.41	27.4	49.9

Table 7.3 continued

Variety/ Name	Mycene	2-M-iso-butyrat	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendren	Unde-canone	Humu-lene	Farne-sene	γ-Muu-rolene	ß-Seli-nene	α-Seli-nene	Cadi-nene	Seli-nadien	Gera-niol	α-acids	ß-acids	ß:α	Cohu-mulone	Colu-pulone
Perle	1373	51	1	22	4	0	3	243	0	6	3	3	13	0	0	8.23	4.84	0.59	30.1	55.2
Phoenix	3315	231	2	11	7	0	4	230	21	6	45	52	14	0	0	13.15	5.70	0.43	25.9	49.5
Pilgrim	4527	280	10	65	9	0	18	214	0	6	46	50	16	0	0	12.69	4.84	0.38	31.9	57.2
Pride of Kent	2578	49	2	3	23	0	5	211	0	5	3	2	11	0	0	5.60	2.73	0.49	31.3	52.3
Progress	1114	765	38	5	42	28	17	20	0	53	67	47	74	44	0	8.46	5.27	0.62	29.9	50.2
Saazer	2325	8	2	5	22	0	9	228	33	6	3	2	13	0	0	4.00	5.62	1.41	22.6	39.6
Saphir	5810	43	4	31	29	6	17	148	0	6	13	15	10	19	0	4.13	7.51	1.82	11.5	42.1
Serebrianca	889	73	1	4	26	0	4	126	50	9	35	34	18	0	0	1.37	4.41	3.22	20.1	36.2
Sirem	945	7	3	3	20	0	11	223	16	7	3	2	15	0	0	3.88	5.37	1.39	22.8	39.4
Sladek	2682	62	2	14	16	0	5	241	11	7	3	2	14	0	0	10.74	5.42	0.50	20.9	43.6
Spalter	618	10	3	0	31	0	11	218	13	8	3	2	12	0	3	2.48	4.71	1.90	26.1	43.0
Spalter Select	4130	32	18	4	53	9	12	136	52	6	17	18	11	31	0	5.48	5.21	0.95	21.2	43.3
Sterling	1453	117	3	15	13	0	3	144	0	4	6	5	9	0	0	10.92	4.55	0.42	29.9	55.8
Strisselspalter	814	30	1	3	24	20	5	131	0	8	28	31	12	35	0	2.51	7.07	2.82	19.0	35.7
Talisman	1360	56	2	17	7	0	3	173	0	4	5	5	10	0	0	10.78	5.63	0.52	27.8	51.4
Tettnanger	2236	11	4	4	23	0	12	222	27	6	2	2	13	0	0	5.06	5.96	1.18	22.2	40.2
Ultra	136	9	1	0	8	0	3	273	0	8	4	3	16	0	0	2.77	4.67	1.69	25.9	41.7
Urozani	2291	6	2	1	44	0	7	172	41	7	19	19	13	23	1	2.89	6.10	2.11	21.5	38.2
USDA 21055	4451	407	3	175	8	0	1	88	46	4	11	10	11	0	0	10.92	4.55	0.42	47.2	70.1
Vojvodina	1406	66	2	15	7	0	7	215	6	6	3	2	12	0	0	6.90	3.96	0.57	29.4	58.7
WFG	2760	13	3	6	24	0	8	200	30	6	2	2	11	0	0	4.57	5.16	1.13	24.5	41.6
Willamette	2285	136	2	6	15	0	3	208	19	7	3	3	13	0	0	5.66	4.61	0.82	32.8	54.6

Table 7.3 continued

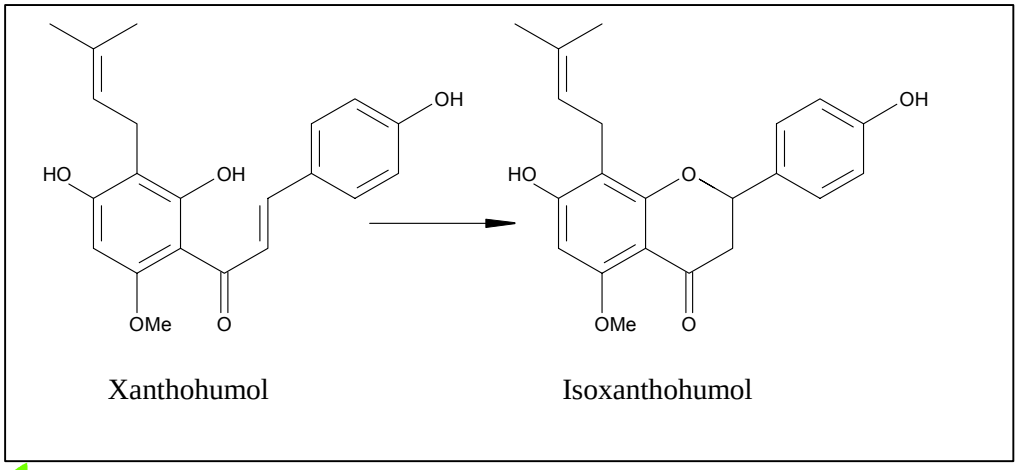
Variety/ Name	Mycene	2-M-iso-butyrat	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendren	Unde-canone	Humu-lene	Farne-sene	γ-Muu-rolene	ß-Seli-nene	α-Seli-nene	Cadi-nene	Seli-nadien	Gera-niol	α-acids	ß-acids	ß:α	Cohu-mulone	Colu-pulone
Wye Challenger	4662	421	6	32	30	0	8	205	0	6	48	53	14	0	0	6.87	5.79	0.84	23.5	45.2
Wye Northdown	2940	66	2	7	14	0	3	193	0	5	2	2	12	0	0	8.27	6.99	0.84	24.4	48.6
Wye Saxon	2370	70	3	95	7	0	5	144	28	5	35	42	13	0	0	6.59	5.18	0.79	20.5	39.8
Wye Target	172	569	5	23	41	0	24	84	0	22	13	8	31	6	0	9.88	4.87	0.49	34.9	57.6
Wye Viking	3925	122	5	49	12	0	9	173	65	6	34	40	13	0	0	7.59	6.16	0.81	23.2	39.8
Yeoman	2401	169	10	10	7	0	4	196	0	5	38	42	13	0	0	12.73	5.86	0.46	25.9	49.8
Zatecki	923	62	1	8	12	0	5	230	13	6	3	2	12	0	0	4.98	3.60	0.72	28.6	49.2
Zenith	3482	128	2	22	22	0	6	219	0	6	68	86	15	0	0	9.79	3.92	0.40	26.6	51.3
Zitic	3077	13	1	11	9	0	10	232	0	6	3	2	13	0	0	6.75	5.26	0.78	19.6	41.6
Zlatan	2927	17	3	5	21	0	9	195	32	5	3	2	11	0	0	4.90	5.06	1.03	24.7	42.5

Essential oils = relative values, ß-caryophyllene = 100; α- und ß-acids in % as is; analoga in % of the α- or ß-acids

7.4 Xanthohumol in hops

D. Buhler and C. Miranda at the Oregon State University in Corvallis found out that xanthohumol can stop the growth of cancer cells. Other researchers are working on the effects of xanthohumol on osteoporosis (Tobe 1997, Yamamoto 2000). Meanwhile research on xanthohumol is also being carried out at the Cancer Research Centre in Heidelberg. At the same time xanthohumol was able to pass first screening tests with flying colours. If you compare xanthohumol with resveratrol known in red wine then xanthohumol could attain an effect two-hundred times better. Now they are going over to testing xanthohumol not only on cell cultures (in vitro), but also on living organisms (in vivo). When brewing beer xanthohumol isomerises to iso-xanthohumol. The isomerised form likewise shows positive effects, even if it is to a lesser extent than xanthohumol. Traditional beers contain maximum 0.2 mg/l xanthohumol and up to 2.7 mg/l iso-xanthohumol. At the chair for Brewing Technology I at the TU Munich-Weihenstephan a "XAN-beer" was developed with up to 1 mg/l xanthohumol and 8 mg/l iso-xanthohumol. The Hallertauer Hopfenveredelungsgesellschaft (HHV) in Mainburg has worked out a process to isolate pure xanthohumol from hops. Xanthohumol could be used as an additive for "functional drinks" or for pharmaceutical preparations, therefore increasing the xanthohumol content in hops was also defined as a breeding aim in Hüll. Diagram 7.1 shows xanthohumol and the isomerising to iso-xanthohumol.

Diagram 7.1: Isomerising xanthohumol to iso-xanthohumol



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Of all the commercially grown varieties the Hüll-bred variety Hallertauer Taurus has the highest content of xanthohumol with about 1 %. However there are also some breeding varieties available with xanthohumol contents up to 2 %. So far the xanthohumol was not primarily researched in hop-breeding, a specific breeding will certainly lead to an even greater increase. The Table 7.4 shows some Hüll-bred lines with xanthohumol contents of more than 0.80 % compared with the varieties Hallertauer Taurus, Wye Target and Northern Brewer. The breeding-line 2001/101/704 holds the record so far with a xanthohumol content of 2.09 %. The relative ratio of the xanthohumol content to the alpha-acid content is also very favourable with 13 % which allows a good enrichment of xanthohumol in the beer.

Table 7.4: Breeding lines with xanthohumol contents of more than 0,80 % compared with three commercially grown varieties, 2002 crop

Variety/ Breeding-line	Xantho-humol	α-acids	ß-acids	ß/α	Cohu-mulone	Colu-pulone	Xanthohumol/ α-acids in %
Hallertauer Taurus	0.92	17.04	5.33	0.31	22.3	47.1	5.40
Wye Target	0.81	11.46	5.31	0.46	34.8	58.4	7.07
Northern Brewer	0.72	10.63	5.45	0.51	26.6	47.9	6.77
2001/101/704	2.09	15.71	3.83	0.24	24.4	46.3	13.30
99/047/001	1.28	9.95	12.25	1.23	29.6	49.7	12.86
2001/093/024	1.26	15.88	6.70	0.42	24.3	48.4	7.93
2001/093/013	1.23	16.13	6.40	0.40	23.4	45.4	7.63
93/010/036	1.14	15.82	5.79	0.37	26.3	48.9	7.21
95/099/748	1.14	13.36	5.34	0.40	23.7	44.7	8.53
93/010/036	1.10	17.98	6.79	0.38	27.5	50.7	6.12
2000/078/019	1.06	16.43	4.67	0.28	23.3	40.6	6.45
95/099/790	1.03	14.37	5.01	0.35	26.7	48.8	7.17
94/075/766	1.01	15.81	6.59	0.42	25.3	51.7	6.39
97/040/003	0.97	14.23	5.21	0.37	38.6	58.6	6.82
97/060/724	0.94	13.00	4.43	0.34	37.5	60.5	7.23
2000/109/703	0.94	13.98	5.07	0.36	28.8	53.9	6.72
99/062/727	0.92	14.77	5.38	0.36	25.4	45.3	6.23
2000/124/740	0.92	16.24	5.96	0.37	32.9	56.3	5.67
2001/077/702	0.92	14.83	8.03	0.54	31.5	54.1	6.20
95/093/702	0.91	16.71	5.08	0.30	26.2	48.6	5.45
2001/018/020	0.91	13.53	6.43	0.48	19.4	40.2	6.73
99/075/013	0.88	12.06	6.42	0.53	25.1	48.6	7.30
2001/092/005	0.88	16.01	6.48	0.40	31.8	52.2	5.50
97/060/754	0.87	11.28	4.65	0.41	39.1	57.9	7.71
99/093/003	0.87	18.47	7.23	0.39	22.0	45.2	4.71
2001/097/004	0.85	14.83	5.81	0.39	26.9	48.4	5.73
89/089/002	0.82	10.18	5.49	0.54	29.2	54.0	8.06
99/060/011	0.81	17.78	5.70	0.32	26.1	47.3	4.56
99/065/722	0.80	17.18	5.38	0.31	26.7	48.3	4.66

Xanthohumol. α- and ß-acids in % as is. Analoga in % of the α- or ß-acids

7.5 Ring analyses for the 2003 crop

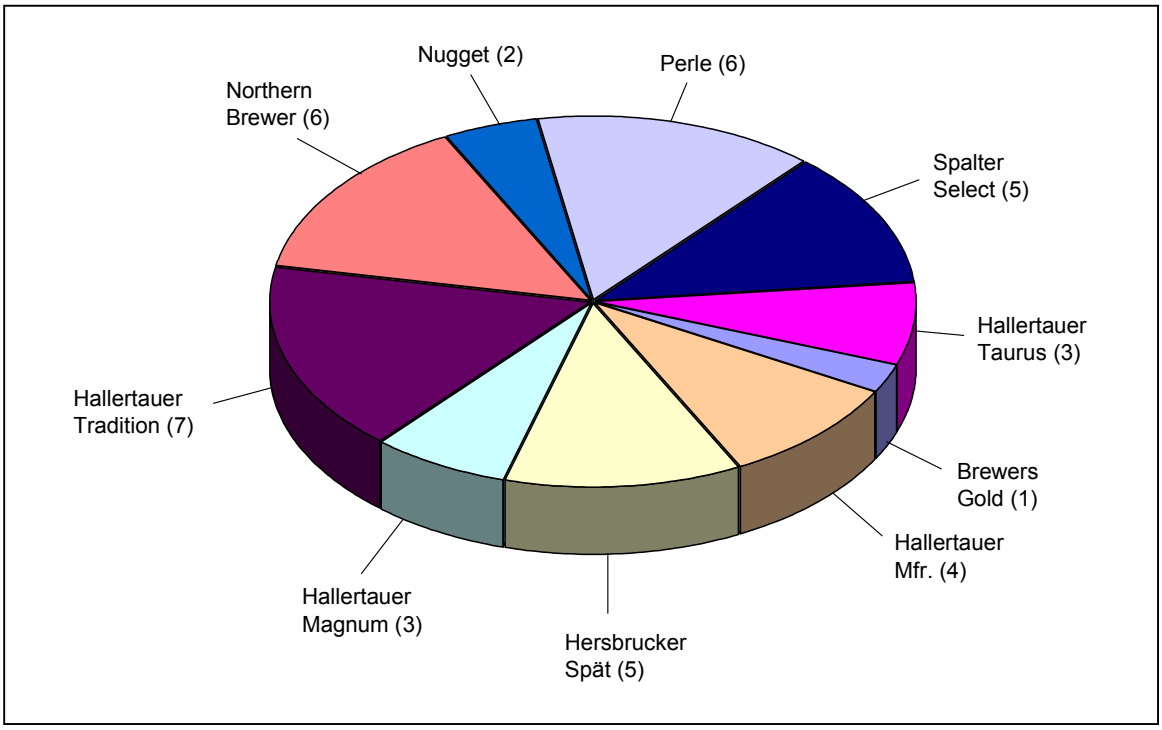
Since the year 2000 there has been a supplementary agreement to the hop supply contracts, in which the alpha-acid contents are taken into consideration. The price agreed in the contract applies if the alpha-acid content is within a neutral range. If this neutral range is exceeded or fallen short of there is a surcharge or a price reduction. This is precisely laid down in the duties record book of the Work Group for Hop Analytica how the samples are to be treated (division of samples, storage), which laboratories carry out further analyses and which tolerance ranges are permitted for the results of the analyses. Also in 2003 it was the task of the Work Sector IPZ 5d, as in the years 2000, 2001 and 2002, to organise and evaluate the ring analyses in order to guarantee the accuracy of the alpha-acid analyses.

The following laboratories participated in the ring test in 2003:

- Hallertauer Hopfenveredelungsgesellschaft (HHV), Werk Mainburg
- Hallertauer Hopfenveredelungsgesellschaft (HHV), Werk Au/Hallertau
- NATECO$_2$, Wolnzach
- Hopfenveredelung HVG Barth, Raiser GmbH & Co KG, St. Johann
- Hallertauer Hopfenverwertungsgenossenschaft (HVG), Mainburg
- Bayerische Landesanstalt für Landwirtschaft, Arbeitsbereich Hopfen, Hüll
- Agrolab GmbH, Oberhummel
- Agrar- und Umweltanalytik GmbH (AUA), Jena

The ring test was started on 02.09.2003 and ended on 14.11.2003 as the majority of hop lots had been analysed during this time in the laboratories. The sample material was kindly made available by Mr. Hörmannsperger (Hopfenring Hallertau). Each sample was only ever taken from one bale in order to ensure maximum homogenity. Each time on a Monday the samples were ground at the HHV Mainburg with a hammer mill, divided in Hüll with a sample divider, vacuum-packed and brought to every single laboratory. On the following weekdays one sample was analysed each day. The results of the analyses were sent back to Hüll a week later and evaluated there. Altogether 42 samples were analysed in 2003. The Diagram 7.2 shows the configuration of the varieties.

Diagram 7.2: Configuration of varieties in the ring analysis 2003



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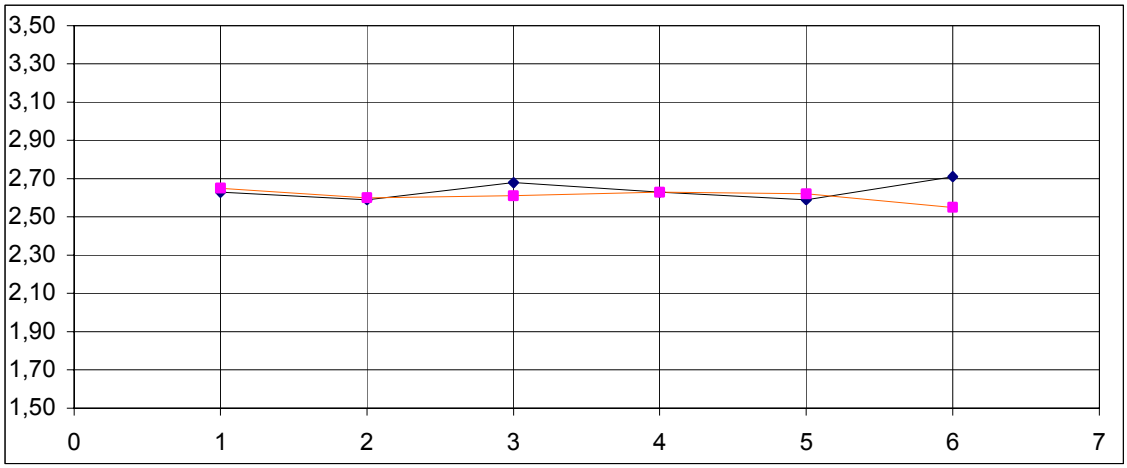
The evaluations were passed on as quickly as possible to the individual laboratories. The diagrams 7.3 and 7.4 show as examples the ring tests with the lowest and the highest standard deviation.

Diagram 7.3: Configuration of varieties with the lowest standard deviation

Nr. 31: HSE (28.10.2003)

Lab	KW		mean	s	cvr
1	2.63	2.65	2.64	0.014	0.5
2	2.59	2.60	2.60	0.007	0.3
3	2.68	2.61	2.65	0.049	1.9
4	2.63	2.63	2.63	0.000	0.0
5	2.59	2.62	2.61	0.021	0.8
6	2.71	2.55	2.63	0.113	4.3

mean	2,62
sr	0.052
vkr	2.0
sR	0.043
vkR	1.6
r	0.14
R	0.12
Min	2.60
Max	2.65



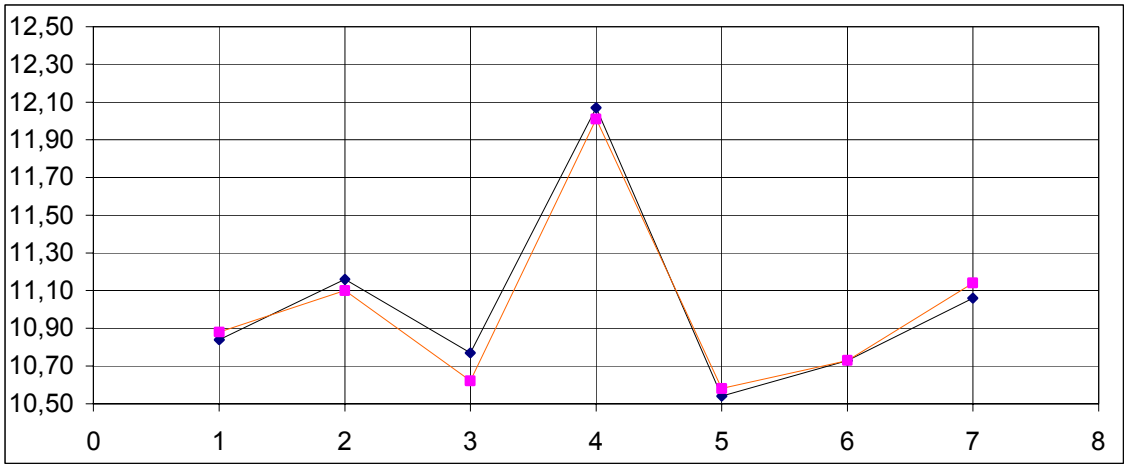
♦ = determination; 1; ■ = determination 2

Diagram 7.4: Ring analysis with the highest standard deviation

Nr. 9: HHM (17.09.2003)

Lab	KW		mean	s	cvr
1	10.84	10.88	10.86	0.028	0.3
2	11.16	11.10	11.13	0.042	0.4
3	10.77	10.62	10.70	0.106	1.0
4	12.07	12.01	12.04	0.042	0.4
5	10.54	10.58	10.56	0.028	0.3
6	10.73	10.73	10.73	0.000	0.0
7	11.06	11.14	11.10	0.057	0.5

mean	11.02
sr	0.053
vkr	0.5
sR	0.480
vkR	4.4
r	0.15
R	1.34
Min	10.56
Max	12.04



♦ = determination 1; ■ = determination 2

As a outlier test between the laboratories the Grubbs Test was calculated according to DIN ISO 5725. In 2003 a outlier was only recorded twice. Table 7.5 shows the tolerance limits (d critical. Schmidt. R.. NATECO$_2$. Wolnzach) from the methods collected by the European Brewery Convention (EBC 7.4. conductometric titration) and their exceedings in the years 2000. 2001. 2002 und 2003.

Table 7.5: Tolerance limits of the EBC method 7.4 and their exceedings in the years 2000. 2001. 2002 and 2003

	up to 6.2 % α-acids	6.3 % - 9.4 % α-acids	9.5 % - 11.3 % α-acids	ab 11.4 % α-acids
d critical	+/-0.3	+/-0.4	+/-0.5	+/-0.6
range	0.6	0.8	1.0	1.2
exceedings in 2000	0	3	0	3
exceedings in 2001	2	1	0	2
exceedings in 2002	4	4	2	4
exceedings in 2003	1	1	1	0

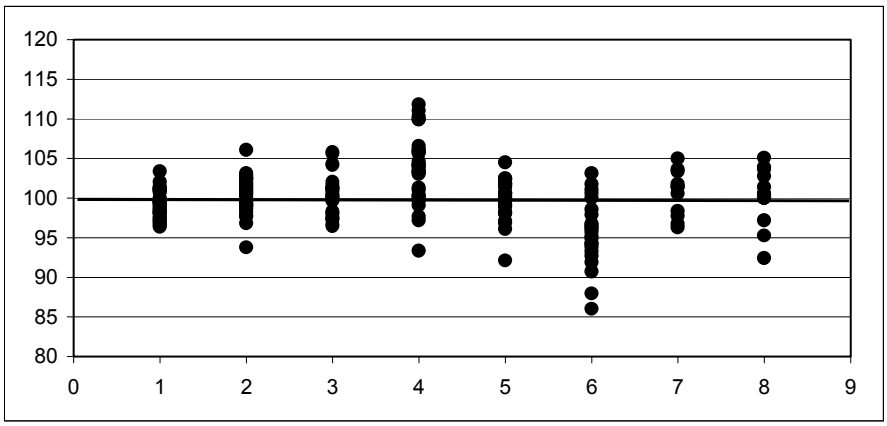
In altogether 42 samples there were only three exceedings of the permitted tolerance limits in 2003.

Resumé

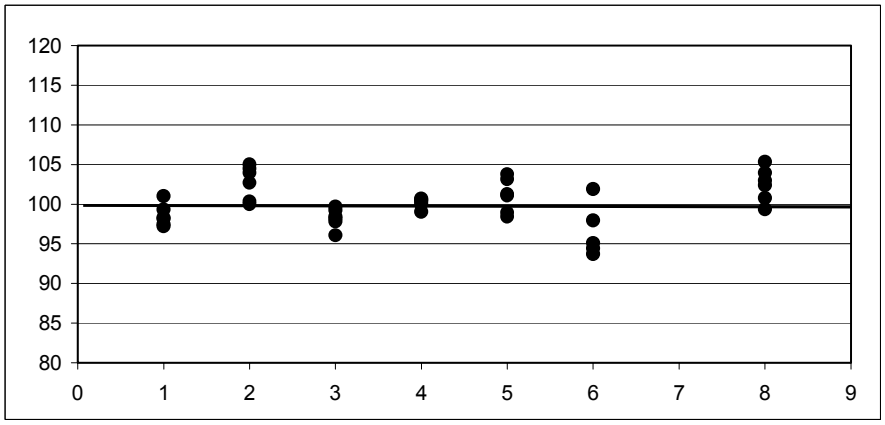
Since the year 2000 (beginning of ring tests) 2003 was the year with the least outliers and exceedings of the tolerance limits. Also the laboratory which caused very many outliers in the previous year turned out very good this year.
All the analysis results for each laboratory are listed in Diagram 7.5 as relative deviations from the mean average (= 100 %) differentiated according to alpha-acid content < 5 %. > = 5 % and < 10 %. > = 10 %.

Diagram 7.5: Analysis results of the laboratories relative to the mean average

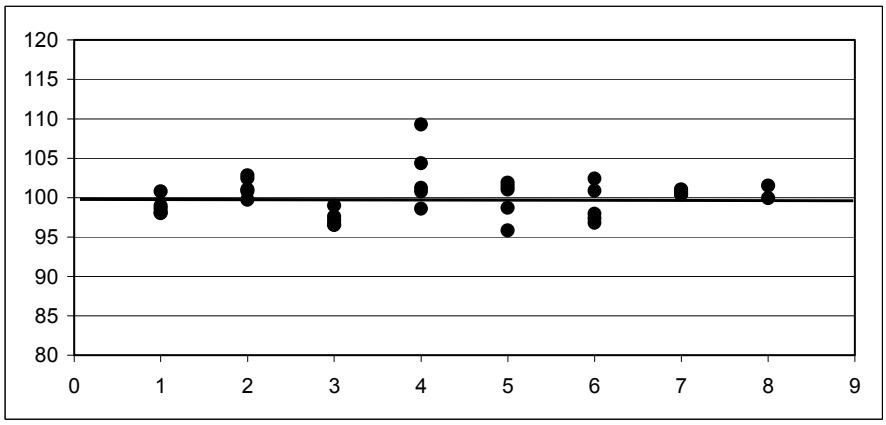
Proben < 5 %



Proben >= 5 % und < 10 %



Proben >= 10 %



8 Proben = samples

7.6 NIR-calibration

As a result of drought and heat in 2003 the alpha-acid contents were altogether about a third less than in the previous years. This also had an effect on the existing NIR-calibration. The HPLC-calibration sometimes even produced negative values as regards the variety Hersbrucker Spät. In the first half of the year 2004 all data of the 2003 crop will be added to the existing calibrations and afterwards validated. This work has not yet been completed.

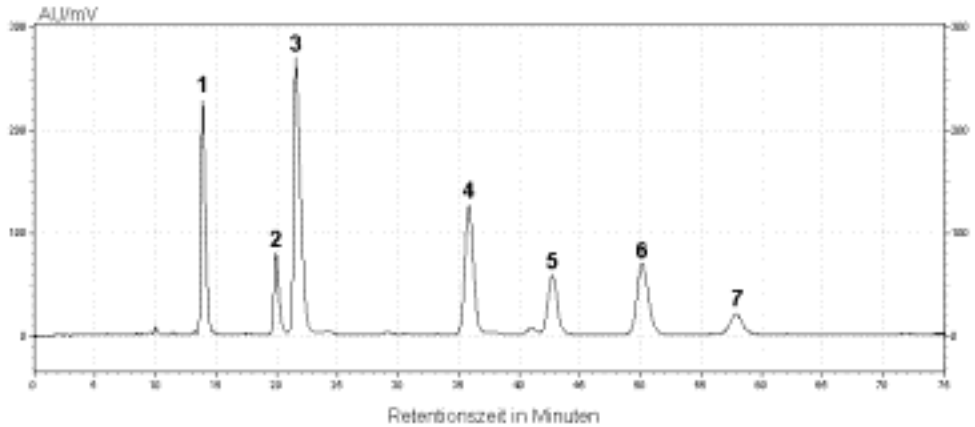
7.7 Diploma work "Quantitative definition of the ageing components in the essential oil of hops by means of SPME"

A ring test was carried out, in which each laboratory ot the AHA analysed 2-pentadecanone as pure substance and a hop oil according to their own gas-chromatographic method. The result was that in Hüll 2-pentadecanone and humulene-oxide I coincide and coeluate as one peak. As far as the other laboratories are concerned, the 2-Pentadecanon and the humulene-oxide I were separated. The statement that 2-pentadecanone increases with ageing is therefore wrong or can at least not be proven. Therefore no quantitative statements were possible in the diploma word by Mr. Plass.

7.8 Differentiating a selection of the world hop range and the Hüll-bred varieties according to alpha-acids and polyphenols and the influence these components have on the quality of the beer

The aim of this project is to find out whether varieties with extremely varied components have a noticeable effect on the quality of the beer. The Scientific Station for Brewing in Munich has financed this project with € 50,000.-
A HPLC-separation was worked out which enabled all six main bitter compounds such as xanthohumol to be analysed in one run.(Diag. 7)

Diagram 7.7: HPLC-separation of all six main bitter compounds as well as xanthohumol



1 = Cohumulone
2 = Adhumulone
3 = n-Humulone
4 = Colupulone
5 = Xanthohumol
6 = n-Lupulone
7 = Adlupulone

Using this method a start was made to analyse the world hop range of varieties available in Hüll as well as the Hüll-bred varieties. As far as the polyphenols are concerned, it is planned to analyse the total polyphenol content, the total flavonoid content, the bundled and free quercetins and the kampferol The analytical part of the work will be finished by July 2004. Next year brewing trials are to be carried out with hop varieties with extremely different components. (Versuchsbrauerei Hopfenveredelung St. Johann GmbH & Co. KG).

7.9 Research on plant protective residues in hops of the 2003 crop

The annual inspections for residues of plant protectives in hops give a very good survey over the actual situation. Contrary to many assumptions hops are free of harmful residues of plant protectives.
The unusually long extreme drought and the above-average high temperatures have also put high demands on the use of plant protectives. During various periods the sprayings had to be stopped as due to the strong protective film on the leaves the active ingredients could no longer penetrate the leaves or were no longer distributed in the plants. Pests were active very little so that in many cases the contact with the active ingredients was no longer sufficient. Despite all these special factors, with a few exceptions the hop-growers were capable enough to produce hops without much damage from pests and diseases.
High temperatures, little water on and in the plants and the conversion in the plant which is linked with it, also had effects on breaking down the plant protectives. Generally under theses conditions higher residues would have to be expected (especially with so-called contact agents). Therefore the results are particularly interesting this year. Due to the high costs for the whole analyses (approx. € 1,500,- per sample) the extent of the analyses also had to be limited this year to six samples. However a great many analyses will additionally be carried out in the residue laboratories of the Hopfenveredelungswerke.

7.9.1 Selecting the samples

Spread over the weighing-in and certifying season 2003 altogether 110 hop samples from all the important varieties of the Hallertau production region were delivered to the Hops Dept. of the Bavarian State Research Centre for Agronomy (LfL) by the Hopfenring Hallertau e.V. The samples were only marked with the name of the variety and the bale number. Consequently the LfL does not know the names of the hop farms concerned.
At the LfL two hop samples were selected from these samples for each of the six hop varieties listed in Table 7.6. and a mixed sample was made for each variety. The extensive residue analyses of a mix sample from two single samples are justified as the lots delivered to the buyers (breweries) are generally put together from several individual lots. The analyses were carried out at the Principal Agricultural Research Institute (HVA) of the Technical University of Munich (TUM) in Freising-Weihenstephan.

Table 7.6: Analyses for residues of plant protectives – 2003 crop

Active ingredients listed according to pest/disease	Max. amount permitted ppm	Milligram per kilogram = ppm					
		R 1/03 HE	R 2/03 SE	R 3/03 HT	R 4/03 NB	R 5/03 TU	R 6/03 HM
Peronospora							
Azoxystrobin	20	1.5	0.32	nn	nn	nn	nn
Captan. Folpet	120	2.2	0.85	25.5	nn	nn	nn
Captafol	0.1	nn	nn	nn	nn	nn	nn
Cymoxanil	2.0	nn	nn	nn	nn	nn	nn
Dimetomorph	50	nn	nn	nn	nn	nn	nn
Dithiocarbamate	25	nn	nn	nn	nn	nn	nn
Fentin-acetat	0.5	nn	nn	nn	nn	nn	nn
Fosethyl	100	nn	nn	nn	nn	nn	nn
Kupferverbindungen	1000	179	246	469	296	309	130
Metalaxyl	10	nn	nn	nn	nn	nn	nn
Phosphorige Säure	*)	nn	nn	nn	nn	nn	nn
Tolyfluanid	30	nn	nn	nn	nn	nn	nn
Mildew							
Fenarimol	5.0	nn	nn	nn	nn	nn	nn
Fenpropymorph	0.1	nn	nn	nn	nn	nn	nn
Myclobutanil	2.0	nn	1.8	nn	nn	nn	nn
Quinoxyfen	1	nn	nn	nn	nn	nn	nn
Triadimefon	10	nn	nn	nn	nn	nn	nn
Triadimenol	10	nn	1.3	3.9	nn	nn	nn
Trifloxystrobin	30	nn	nn	nn	nn	2.7	1.3
Triforin	30	nn	nn	nn	nn	nn	nn
Botrytis							
Dichlofluanid	150	nn	nn	nn	nn	nn	nn
Procymidon	0.1	nn	nn	nn	nn	nn	nn
Vinclozolin	40	nn	nn	nn	nn	nn	nn
Hop aphid							
Bifenthrin	10	nn	nn	nn	nn	nn	nn
3-Hydroxy-Carbofuran	10	nn	nn	nn	nn	nn	nn
Cyfluthrin	20	nn	nn	1.4	0.27	nn	nn
Lambda-Cyhalothrin	10	nn	nn	nn	nn	nn	nn
Cypermethrin	30	nn	nn	nn	nn	nn	nn
Deltamethrin	5	nn	nn	nn	nn	nn	nn
Diazinon	0.05	nn	nn	nn	nn	nn	nn
Endosulfan	0.1	nn	nn	nn	nn	nn	nn
Imidacloprid	2.0	0.15	<0.1	<0.1	0.15	nn	nn
Mevinphos	0.5	nn	nn	nn	nn	nn	nn
Omethoat	0.05	nn	nn	nn	nn	nn	nn
Parathion-methyl	0.1	nn	nn	nn	nn	nn	nn
Permethrin	0.1	nn	nn	nn	nn	nn	nn
Pirimicarb	0.05	nn	nn	nn	nn	nn	nn
Propoxur	0.1	nn	nn	nn	nn	nn	nn
Pymetrozin	5	nn	nn	nn	nn	nn	nn

Table 7.6 continued

Active ingredients listed acc. to pest/disease	Max. amount permitted ppm	Milligram per kilogram = ppm					
		R 1/03 HE	R 2/03 SE	R 3/03 HT	R 4/03 NB	R 5/03 TU	R 6/03 HM
Common spider-mite							
Abamectin	0.05	nn	nn	nn	nn	nn	nn
Amitraz	20	nn	nn	nn	nn	nn	nn
Azocyclotin/Cyhexatin	0.1	nn	nn	nn	nn	nn	nn
Brompropylat	5	nn	nn	nn	nn	nn	nn
Dicofol	50	nn	nn	nn	nn	nn	nn
Fenbutatinoxid	0.1	nn	nn	nn	nn	nn	nn
Fenpyroximate	10	nn	nn	nn	nn	nn	nn
Hexythiazox	3	nn	nn	nn	nn	nn	nn
Propargit	30	nn	nn	nn	nn	nn	nn
Alfaalfa weevil							
Acephat	0.1	nn	nn	nn	nn	nn	nn
Carbofuran	10	nn	nn	nn	nn	nn	nn
Methamidophos	2	nn	nn	nn	nn	nn	nn
Methidathion	3	nn	nn	nn	nn	nn	nn
Herbicides							
Cinidon-ethyl	0.1	nn	nn	nn	nn	nn	nn
Fluazifop-butyl	0.1	nn	nn	nn	nn	nn	nn
Monolinuron	0.05	nn	nn	nn	nn	nn	nn

*) No maximum amounts of residue laid down

HE = Hersbrucker Spät
SE = Spalter Select
HT = Hallertauer Tradition
NB = Northern Brewer
TU = Hallertauer Taurus
HM = Hallertauer Magnum

7.9.2 Assessing the results

As in previous years despite the extraordinary environmental conditions only few active ingredients were detected in hops through the residue analyses of the 2003 crop. In all cases the values were considerably below the legally permitted maximum amounts in accordance with the current regulation on maximum amounts in the valid version (Table 7.7).

7.9.3 Resumé

The long-term programme for determining residues of plant protectives in hops this year again confirmed that hops are free of harmful residues. There is not the least suspicion that the legally set maximum amounts have been exceeded. Consequently it can be ruled out that plant protectives have a negative effect on the beer.

Table 7.7: Residue situation in hops of the 2003 crop

Active ingredient (brand name)	Fre-quency	ppm min.- max.			ppm max. amount	ppm US toler-ance
Azoxystrobin (Ortiva)	2	0.32	-	1.5	20	20
Captan (Folpet)	3	0.85	-	25.5	120	120
Copper compounds (e.g. Funguran)	6	130	-	469	1000	ex.
Myclobutanil (Systhane 6W)	1		1.8		2.0	5
Triadimenol (Bayfidan)	2	1.3	-	3.9	10	-
Trifloxystrobin (Flint)	2	1.3	-	2.7	30	11
Cyfluthrin (Baythroid 50)	2	0.27	-	1.4	20	20
Imidacloprid (Confidor WG 70)	4	0.10	-	0.15	2.0	6

ex. = exempt

7.10 Checking that the variety is authentic

It is the duty of the work sector to prove to the food control authorities that the variety is authentic.

Checking varieties for the food control authorities (district administration offices)	23
Complaints thereof	0

8 Publications

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Portner, J. (2003): Sowing in the green fertilization. – Hopfen-Rundschau **54**(7): 170

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Portner, J. (2003): Use the vine chopper as early as possible. – Hopfen-Rundschau **54**(8): 208

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