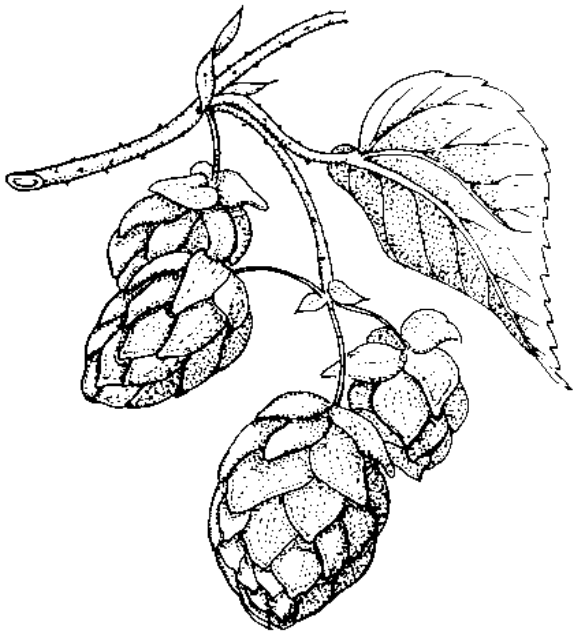
Bayerische Landesanstalt für Landwirtschaft

Gesellschaft für Hopfenforschung

Annual Report 2004
Hops



Bavarian State Research Center for Agriculture
- Institute for Crop Science and Plant Breeding -
and
Society of Hop Research

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Preface

Today hop varieties from the Hop Research Center in Hüll are grown on more than 70 percent of the German hop acreage. Hüll aroma varieties such as Perle or Hallertauer Tradition and Hüll bitter varieties such as Hallertauer Magnum or Hallertauer Taurus – to name just a few – are held in high esteem by brewers in more than 100 countries all over the world due to their aroma quality and/or high alpha-acid content. In addition to this the Hüll varieties are valued for their broad resistance to the most important hop diseases. Therefore high-quality hops in Germany today are produced not only efficiently but are also compatible with the environment.

The variety Hallertauer Magnum is by far the most popular Hüll variety grown worldwide with more than 5,200 hectares in 2004.

Also the varieties Smaragd, Opal and Herkules newly introduced by the Gesellschaft für Hopfenforschung (Society for Hop Research) show the typical characteristics of the Hallertau varieties: high yield, broad resistance to diseases and excellent brewing quality. Both the new aroma varieties have an outstanding aroma quality, which differs considerably from the varieties available at present and offer the brewers the opportunity to give their beers a special character. The high-alpha variety Herkules is above all marked by a very high yield with good brewing quality. A seven-fold increase in productivity in the case of Herkules compared with the traditional varieties Hallertauer Mittelfrüher and Hersbrucker is evidence for the enormous breeding progress at the Hop Research Center in Hüll (ref. 4.1.6 of the Annual Report).

The plant protection measures have also continually been improved due to the Hüll research work. Disease-tolerant or resistant hop varieties, which even resist the most important diseases – *Verticillium* wilt, powdery mildew mildew and downy mildew -, have been available since the mid-1970s.

Less plant protectives, higher productivity, best brewing quality and the resulting competitiveness of the new Hüll varieties on the world market are the results of continual, successful research. Both the breweries and the hop-growers profit from this to the same extent.

The vast majority of the altogether just under 250 members of the Society for Hop Research are breweries and brewery associations. The ongoing concentration in the trade as well as the unexpected increase in the beer tax for small and medium-sized breweries make it increasingly more difficult to maintain this position. On the other hand the hop-growers account for less than 10 percent of the members. It is necessary to close this gap.

"Our competitiveness on the global hop market is based on the hop research in Hüll". With this statement the President of the German Hop Growers' Association Dr. Johann Pichlmaier encouraged his hop growing colleagues to pay for membership in the Society for Hop Research. In this way they provide financial support for the cooperation with the Research Center for Agronomy, which functions optimally. In addition, with their member fee they signalise to the cooperation partner, the Free State of Bavaria, how important it is for them that hop research be continued at the present level.

Georg Balk
Chairman of the Management Board
of the Society for Hop Research

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

Preface

Contents

1 Research projects and main areas of research of the Hop Sector

1.1 Current research projects

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

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, *(Bavarian State Research Center for Agriculture)* Institut für Pflanzenbau und Pflanzenzüchtung *(Institute for Crop Science and Plant Breeding)*
Financed by:	Wissenschaftliche Station für Brauerei in München e.V. *(Scientific Funds of the Munich Breweries)*
Project Manager:	ORRin Dr. E. Seigner, OA 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

This project is aimed at identifying new kinds of resistances in the gene pool of wild hops which up to now are unknown. These new, still fully effective powdery mildew resistance genes are to be used for crossing in and widening the genetic basis in the Hüll breeding material.

Results

- Since 2001 over 10,000 wild hops have been tested in the greenhouse and in the laboratory for their powdery mildew resistance. For the test in the greenhouse powdery mildew (PM) races were used which represent the virulence spectrum of the PM populations dominant in the Hallertau (with the virulence genes *v3, v4, v6, vB*). The reaction of the wild hops compared with an English powdery mildew isolate of the *v1, v2* virulence type was examined in the laboratory.
- By 2003 it was possible to select 96 wild hops which had proved to be resistant to all the PM races (*v1, v2, v3, v4, v6, vB*) used so far in tests in the greenhouse and in the laboratory. Also in 2004 it was possible to confirm their PM resistance for these hops in the greenhouse and out in the open.
- In the 2004 resistance test many wild hops with American provenance were tested. Most of the plants from the USA in fact showed no attacks in the laboratory but in the greenhouse PM pustules developed on almost all the plants.
- 20 wild hops which originated from Germany were tested for the first time in 2004 and did in fact show resistance in the greenhouse but showed high susceptibility in the

laboratory test to PM strains of the *v1*- and *v2* types which are much wider spread in England and the USA.

- The decisive evidence whether new resistance can be found in the wild hop germplasm can only be produced in summer 2005 when the screening in the laboratory with the PM isolate of the *v5* virulence type has been finished.

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

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, *(Bavarian State Research Center for Agriculture)* Institut für Pflanzenbau und Pflanzenzüchtung *(Institute for Crop Science and Plant Breeding)*
Financed by:	Bayerisches Staatsministerium für Landwirtschaft und Forsten *(Bavarian State Ministry for Agriculture & Forestry)*
Project Manager:	ORRin Dr. E. Seigner
Working on project:	Dr. H. Radic-Miehle, P. Hartberger
Duration:	01.11.2001- 31.12.2004

Target

The aim of this research project which started on 01.11.2001 is to establish an efficient transformation method for gene transfer in hops. After establishing the transformation technique for important Hüll hop varieties ultimately the resistance genes particularly against fungal pathogens are to be transferred into the hops.

Results

- Internodia of the Hüll hop varieties ’Hallertauer Mittelfrüh’ and ’Saazer’ were successfully transformed several times with four binary constructs containing a hop chitinase gene (= *HCH1*, according to Henning and Moore, 1999).
- Plants could be regenerated and selected in the case of both varieties. With the ’Saazer’ hop variety several of the plants selected for kanamycin were already tested positive on the DNA level using PCR and transferred to the S1-greenhouse. Comparable tests are to follow shortly for the variety ’Hallertauer Mittelfrüh’.
- In further tests the activity of the transferred resistance gene is to be proved on the protein (expression) level: In addition methods for checking the chitinase activity must be established under laboratory conditions (SDS-PAGE, chitinase isolation and immuno-assay):

- in ’chitin binding assay’ with following SDS-PAGE it was not possible to differentiate definitely between the transgenic plants by the positive and negative inspections.

- In the first infection tests with PM on *in vitro* plants the first resistant and partly resistant genotypes of the 'Saazer' variety were found in the laboratory using the detached leaf assay.

Development of molecular selection markers for powdery mildew resistance for the effective support for breeding quality hops *(Humulus lupulus)* (Wifö-No. B 80)

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, *(Bavarian State Research Center for Agriculture)* Institut für Pflanzenbau und Pflanzenzüchtung *(Institute for Crop Science and Plant Breeding)*
Financed by:	Hopfenverwertungsgesellschaft e.G. Wissenschaftsförderung der Deutschen Brauwirtschaft e. V.
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 (bis 30.06.03), LTA L. Logothetis, CL V. Mayer, LA A. Lutz, ORRin Dr. E. Seigner
Duration:	01.05.2002- 31.06.2005

Target

To work out molecular selection markers for speeding up breeding for PM resistance.

Results

- In the course of the project, for the first time it was possible to map a resistance gene on a genetic map in hops. The PM resistance gene *R2* deriving from the variety `Wye Target` could be located on a specific linkage group. The basis for this mapping was a segregating population from crossing the breeding lines 84/8/24(*R2*) x 98/44/49.
- First of all the phenotypic resistance data of the *R2* mapping population was gained after artificial infection with a characterized PM isolate.
- Afterwards in the molecular screening of the resistant and susceptible plants it was possible to identify several resistance markers so far. Above all 6 markers very closely linked with the resistance gene were successfully identified. Two flanking markers were identified with a distance of 1.7 and 1.6 cM from the *R*-gene.
- All PM resistance markers identified so far could be verified on four mapping populations with 120 plants each.

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

Sponsored by: Bayerische Landesanstalt für Landwirtschaft,
(Bavarian State Research Center for Agriculture)
Institut für Pflanzenbau und Pflanzenzüchtung
(Institute for Crop Science 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 (bis 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 components relevant for the brewing process. In addition, agronomic characteristics should be described in a molecular way which are valuable for breeding such as yield, internodia intervals and cone form.

Results

- This project is based on a mapping population from crossing 'Spalter Select' x the male Hüll breeding line 93/9/47. This mapping population consists of 139 female plants. Using fingerprint analyses it was checked and ensured that all plants of the mapping population (150 plants) and the 3 repetitions had been implanted from each genotype at the correct locations.
- For the first time a start was made to record various phenotypical characteristics from these genotypes planted out in several replications.
- 556 hop samples were harvested in the year 2004 in each of the standardized experimental yards in Hüll und Rohrbach. The meanwhile standardized hop-picking by machine again proved its worth for this project in 2004.
- Important phenotypical data was gained from altogether 1112 hop samples.
- In the mapping population approx. 600 segregating molecular markers have been identified so far for the planned QTL calculation. These markers form the basis for a genetic map.
- The chemical data required for this calculation is at present being gained by analyzing all hop samples.

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

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, *(Bavarian State Research Center for Agriculture)* Institut für Pflanzenbau und Pflanzenzüchtung (*Institute for Crop Science and Plant Breeding)*
Financed by:	Busch Agricultural Resources International, Inc. (BARI); DOW Agro Sciences
Project Manager:	Ltd. LD B. Engelhard
Working on project:	Bernhard Engelhard, Dr. Klaus Kammhuber, Renate Huber, Herfried Hesse, Stefan Fuß
Duration:	2003 – 2006
Targets:	1. Determining the main infection periods (primary and second dary infection) 2. Developing a prognosis model for specifically combating pow dery mildew

Results:

1. Comparison of weather parameters with the amount of mildew attacks in plot trials, 1997 – 2004

Compared with the parameters from the 2003 vegetation period there were slightly changed values after evaluating the data from1997 – 2004:

Temperature	
5.01 – 20.00 Uhr	∅ > 10 °C
20.01 - 5.00 Uhr	∅ > 10 °C
Sunshine intensity	
5.01 – 20.00 Uhr	∑ < 4.000 Wh/m^2
Rainfall	
5.01 – 20.00 Uhr	∑ > 1 mm or > 5 mm the night before
20.01 - 5.00 Uhr	∑ > 0,1 mm oder > 1 mm the day before

The days are divided into two sections. A spray warning is set off when five adjoining sections of the day coincide in which the conditions are fulfilled. It must be pointed out that these are only provisional results which still have to be checked in the practice.

2. Spraying date

The dates for the spray warnings show a logical correlation with the attacks in the various years. According to the present state of evaluation, following the spray warning there are still two to five days left before spraying has to be carried out. As tractors cannot be driven through the hop yards immediately after a spray warning, this head start would be a great advantage.

Literature:

Fuß, S. (2004): Checking the prognosis model backed up by weather conditions for the appearance of powdery mildew in hops – Thesis, 100 pages.

Evaluation of production measures in organic hop growing

Sponsored by: Bayerische Landesanstalt für Landwirtschaft,
(Bavarian State Research Center for Agriculture)
Institut für Pflanzenbau und Pflanzenzüchtung)
(*Institute for Crop Science and Plant Breeding)*

Financed by: 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 for supporting beneficial insects in organic hop production, particularly by creating hibernating shelters; evaluation of plant protectives that comply with the production regulations in organic hop growing

Results:

In 2004, the third and final year of the project, the following sub-sections have been worked on, with a brief description of the achieved results:

For **use and establishment of predatory mites in hop yards** as in the previous year a large-scale trial was started at the Buch location on about 1 ha with four parts to the experiment, each of which was replicated four times. On altogether eight plots predatory mites (*Typhlodromus pyri* and *Phytoseiulus persimilis* in four plots each) from a commercial breeder were released in bags, each bag containing about 100 mites (altogether approx. 16,000 mites), punctually on every seventh plant on 17.06. The further development of spider mites (*Tetranychus urticae*) and predatory mites in the stand was monitored weekly. On 01.07. predatory mites were released for the second time in the middle of the plots (approx. 16,000 mites); thereby altogether on an average 40 predators were released per plant. Contrary to the two previous years, the desired effect for controlling spider mites was

in 2004 achieved for the first time, as it was possible to differentiate between infestation of common spider mites in the predatory mite plots and the untreated plots until harvest. Besides, with 1,632 predatory mites more than twelve times as many were found again during field monitoring than in 2003. An experimental harvest carried out on 28.08. showed no significant difference in yield in the predatory mite plots even compared with the "practice" plot normally treated with acaricide. With regard to alpha-acid contents, the values in the experimental plots were even significantly above the practice, which can be further evidence for the fact that moderate infestation by two-spotted spider mites up to the economic threshold stimulate the hop plants to a higher production of alpha-acids.

Prior to harvesting, felt bands were again put at the hop poles as hibernating shelters for predatory mites, and one hop bine was left hanging at each pole until winter. When evaluating the felt bands, as in previous years no hibernating predatory mites could be found. Nevertheless, in spring 2004 during monitorings the predators could be proved to a low level in the predatory mite plots that were identical with those of the previous year even before the dates when they were released – so far this is the first proof that predatory mites overwintered in high-trellis hop yards of the Hallertau.

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 the fourth part of the experiment. Regarding spider mite infestation, this glue variant was again considerably below the untreated variant, differed not significantly from the practice yield and likewise had significantly higher alpha-acid values. The use of a tractor-drawn heated applicator for glue application again caused no technical problems even over wide areas.

Due to the bad results of the two preceding years, the application of artificial "honeydew" for **attracting lacewings to combat aphids** was omitted in 2004. Instead of this, insect traps were established in the spring at five locations and baited with various scents (kairomones). The traps were left hanging for 16 weeks until the harvest was over, emptied each week and the catches of lacewings and hoverflies was evaluated. A highly significant attracting effect for the lacewing species *Peyerimhoffina gracilis* was found by the substances (1*R*,4*S*,4a*R*,7*S*,7a*R*) dihydronepetalactol and nepetalactone. However, so far no kairomone could be found as an attractant for the actual target of these tests, the common and widely distributed predator *Chrysoperla carnea.*

As in previous years the **creation of hibernating quarters for lacewings in hops** can be regarded as successful. At the end of August 32 specially designed "lacewing hotels" were exposed on hop poles in the experimental hop-yards at the locations Ursbach und Buch before the hops were harvested or they were set up near the hop-yard (on climbers, in little glades) on wooden poles 150 cm high. The hotels were dismantled on 14.12. and stored temporarily in a cool, dark barn. Determining and counting the arthropods hibernating in them had not been completed when this report was written but showed comparable results as in 2003/2004: The by far greatest number of hibernating lacewings up to nowwas found on the hop poles with a maximum 396 insects per hotel. The hibernating rates at the other exposition sites were again significantly lower.

The specific use of this potential when the hotels in the experimental yard were opened in May 2004 nevertheless showed no increased rate of eggs laid by lacewing females on hops. Although this year there were still a lot of insects in the hotels during the very cool, dark storage, when they are set free they seem to disperse in the surrounding areas and obviously do not remain in the stand despite the already given presence of hop aphids.

For the **evaluation of plant protectives that comply with the production regulations in organic hop growing**, two large-scale trials were run at the Ursbach location with three replicates, respectively, per test unit to control the hop aphid (*Phorodon humuli*). The products "Spruzit Neu“, "NeemAzal T/S“ were tested as spraying and paint variants as well as "TRF-002“, a quassia product which is applied by painting it to the bines. With the extremely severe hop aphid infestations in the test year 2004 the effects of all insecticides tested were most unsatisfactory, so that the test plants were sprayed at the end of June with the usual mixture of self-boiled quassia extract and coconut soaps which made it possible to reduce the numbers of hop aphids to a very low level.

Development of plant protection strategies in the organic production of hops, as alternatives to the use of insecticides containing copper and sulphur

Sponsored by:	Bayerische Landesanstalt für Landwirtschaft, *(Bavarian State Research Center for Agriculture)* Institut für Pflanzenbau und Pflanzenzüchtung *(Institute for Crop Science and Plant Breeding)*
Financed by:	Federal program for Ecological Agriculture at the Federal Institute for Food & Agriculture (BLE)
Project Manager:	Ltd. LD Bernhard Engelhard
Cooperation:	Bioland e.V.
Working on project:	M. Eckert, A. Bogenrieder, Dr. F. Weihrauch
Duration:	01.04.2004 – 30.11.2006
Target:	Control of pests and diseases in the organic production of hops without synthetic plant protectives and with regard to substitute or reduce products containing copper and sulphur. Effective products should obtain licensing or authorization according to the plant protection laws.

Results:

The tests were carried out in the hop yards at the farms of G. Prantl, Ursbach and N. Eckert, Herpersdorf, both recognized organic farms.

1. Control of powdery mildew

Test variants: whey, calium-bicarbonate + Micula (bonding agent), reacre (injected), compared with sulphur preparation.

As no powdery mildew occurred in the untreated plots, the trial could not be evaluated.

2. Control of downy mildew

Test variants Frutogard, whey, Kanne Brottrunk, Cuprozin, farmer's own mixture. Compared with Funguran (copper).

Whey and Kanne-Brottrunk showed no effect during a very severe primary infection. Cuprozin was unsatisfactory. The test had to be broken off on 21.06. in order to save the hops which were then treated uniformly in rotation with the farmer's own mixture and copper.

The variant "Molke“ produced the lowest yield with 4.8 dt/ha, the highest yield was produced with the farmer's own mixture with 13.9 dt/ha.

3. Control of hop aphid

Test variants: Spruzit Neu, NeemAzal T/S sprayed and painted, quassia extract, TRF-002 painted.

Despite a severe aphid infestation situation, it was possible to obtain good results with the exception of Spruzit Neu. Backed up by statistics only Spruzit Neu was lower in yield .

The good effect in the painted variants was surprising.

Differentiation of a selection from the world range of hops and the Hüll varieties according to alpha-acids and polyphenols and the influence of these components on the beer quality

Sponsored by: Bayerische Landesanstalt für Landiwrtschaft,
(Bavarian State Research Center for Agriculture)
Institut für Pflanzenbau und Pflanzenzüchtung
(Institute for Plant Breeding &Cultivation)

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

Results:

A HPLC separation was worked out which makes it possible to analyse all six hop bitter compounds such as xanthohumol in one go. With this method the entire world hop range (altogether 118 samples) available in Hüll was analyzed. In addition to this the total content of polyphenols and flavanoids was determined from these samples.

13 varieties were selected which differ very considerably in their cohumulone, adhumulone and phenol content. Brewing trials took place at the experimental brewery in St. Johann. A first tasting showed obvious differences in the beers. Further tastings are to follow. Finally it is to be worked out which components have a noticeable influence on the quality of the beer. A closing report and a publication in a brewing trade magazine are planned.

1.2 Main areas of research

1.2.1 Main areas of research in breeding

Breeding powdery mildew-resistant high-quality varieties in the aroma and bitter sectors

Project manager: Dr. E. Seigner

Processing: A. Lutz, J. Kneidl

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

Target

The main focus of the Hüll breeding work is in developing high-quality varieties adapted to the market and the environment. As a good to very good resistance and/or tolerance towards the hop downy mildew and the V*erticillium* wilt has already been anchored in the Hüll-bred varieties, for some years now work has been carried out on improving resistance to powdery mildew (PM).

Techniques

- 108 specific crossings with PM resistant crossing partners were carried out in 2004 in the aroma and/or bitter sector .
- Tests for PM resistance in the greenhouse and in the field
  - Seedlings from the various breeding programs were screened after being artificially inoculated with four different PM isolates to test their resistance. Hüll varieties and 10 other varieties as well as 41 breeding lines were likewise included in this greenhouse screening.
  - Only individuals classed as resistant in the greenhouse tests, were examined in the field under natural infection conditions and without the use of fungicides (approx. 4000 seedlings per year) for their PM resistance properties.
- Testing for PM resistance in the laboratory (detached leaf assay)

- At the moment 13 different PM isolates with characterized virulence genes are available for testing in the Petri dish. Therefore almost all the resistances used worldwide in breeding have been tested.
- In order to test for resistance towards PM races which have not yet occurred in Germany, 5 varieties, 30 breeding lines and 355 wild hops were tested in the Petri dish after being artificially inoculated with an English PM isolate.

- Breeding work will only be continued with hops which show resistance towards powdery mildew in all the tests.

1.2.2 Main focus of research in hop production, production techniques

Developing an EDP water balance model for controlling irrigation in growing hops

Project Manager: LOR J. Portner

Working on project: LA J. Münsterer

Cooperation: Dr. P. Capriel, Institut für Agrarökologie, Ökol. Landbau und Bodenschutz, Freising

Dr. T. Rötzer, Regenstauf

The target of the project is to develop an EDP water balance model which calculates the water balance of the hops (potential and actual evaporation, interception, soil water content, drainage and irrigation doses) in daily steps from meteorological data. This will take the type of soil, the phenology of the hops and the optional irrigation into account.

The recording of the key soil values and the weekly readings of the soil water contents at the locations Berg, Brunn and Eichelberg were used to calibrate and validate the model.

As a result a simple DOS program was developed which can simulate the water content of the hop-yards at the 3 locations with an error rate between 3 and 6 %. Before being introduced into the practice a further calibration and validation of the model is to be made with new series of tests and it will be examined in an irrigation test at 2 locations when the optimum time is for irrigation.

Optimizing the application techniques in spraying equipment

Project Manager: LOR J. Portner

Working on project: LA J. Münsterer

Plant protection problems with combating pests before the hops reach the top of the trellis and later in the top region of the hop plants have stimulated general discussion with regard to optimizing the wetting. In order to locate deficits in the distribution of the deposit, the deposits were measured on hop leaves at various heights with water-sensitive paper. The quantifying of the wetting was made with the aid of a scanalyzer.

The first results confirm the suspicion that with the present recommended sizes for jets and settings the sprayed liquid is not sufficiently evenly distributed on all parts of the plant. Above all the top region and the topsides of the leaves are not adequately wetted. Differences were also ascertained between various brands of spraying apparatus with the same amount of water and the same traveling speed. By changing the pressure and the positioning of the jets the first findings were collected towards optimizing the application technique.

Research on the accumulation, volume weight and nutrient content of chopped bines at the time when they are distributed

Project Manager: LOR J. Portner

Working on project: LOR J. Portner, LA J. Münsterer

Cooperation: F. Peretzki, Institut für Agrarökologie, Ökol. Landbau und Bodenschutz, Freising

To ascertain fertilizer requirements the recycling of nutrients from organic materials at the time when they are distributed must be added. The examinations at the time when they are distributed should take into account any change in the amount of the chopped bines and the nutrient contents due to the hot rotting phase. By ascertaining the volume weight it makes it easy for the farmer to assess the amount distributed and therefore the amount of nutrients to be added to the fertilizer.

Recording the optimal harvest time for the following varieties: Hallertauer Mfr. and Saphir

Working on project: LOR J. Portner, LA A. Lutz

Once again the variety Hallertauer Mfr. has gained in importance over the past few years and is already the fourth largest variety in the Hallertau. Saphir, as a new variety, will be grown on 183 hectares in the practice.

In order to find the optimum harvest time in the Hallertau, 20 training wires were harvested from a practice stand of hops each at intervals of 3-4 days and this was repeated four times. In the case of Hallertauer Mfr. the harvesting was carried out on 7 harvest dates and in the case of the variety Saphir on 5 harvest dates. Evaluations were made regarding yield, alpha-acid content, aroma and exterior quality (picking, colour and lustre, cone growth and defects).

Research on the corn borer occurring in hops

Working on project: LA E. Niedermeier

Cooperation: Dipl. Ing. agr. (FH) S. Schinagl,

Prof. Dr. Schuphan. Rheinisch Westfälische Technische Hochschule Aachen

The corn borer (*Ostinia nubilalis*) mainly damages maize plants, but under favourable conditions can cause economic losses (2002 in the Jura region) locally in the hop yards. In order to learn more about the occurrence, development and detrimental effects of the corn borer in hops, extensive investigations and monitorings were carried out within the scope of a thesis and in cooperation with the Technical University of Aachen.

Trials in training hops with the varieties Hallertauer Taurus and Saphir

Working on project: LA E. Niedermeier

With a rising number of bines per training wire the labour time needed for training the hops on and up the wires increases as well as the spread of disease due to the thick foliage. As always the optimum yield is still of decisive importance for economic success. The trials for training the hops are to find out the optimum number of bines per wire as far as the more recent varieties are concerned.

1.2.3 Main research areas in hop quality and analytics

Project Manager: RR Dr. K. Kammhuber

Developing 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

Working on project: 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 a start was made by the laboratories of the above-mentioned firms and the Bavarian State Research Center for Agriculture (LfL) in Hüll to construct a NIR calibration based on HPLC data. This calibration is expanded and checked every year.

The calibration proved to be poor in 2003 as the hops this year contained very little alpha-acid. The calibration could be considerably improved by adding the data rates of the year 2003. In the Work Group for Hop Analytics (AHA) it was decided that this method would then be suitable for the practice and can be used as an analytical method for the hop supply contracts if it is at least as accurate as the conductometric titeration in accordance with EBC 7.4.

2 Weather conditions 2004

Bernhard Engelhard, Dipl. Ing. agr.

Following the very dry year in 2003 the water reserves in the soil were filled up again during the winter months. It was possible to carry out the necessary winter work (trellis repairs and hanging up the training wires) and spring work (pruning, training bines) under altogether good conditions, without an adverse effect on the structure of the soil. Bad attacks by soil insects such as the alfalfa weevil and the wire worm were above average. In this respect there is basically a lack of authorized effective insecticides available.

Except for two weeks in July the whole vegetation period was marked by below average temperatures and a deficit in rainfall. The impression was generally that it was a wet summer; but actually there were only a few millimetres of rain at a time which quickly evaporated.

The hops developed slowly so there were short internodes (spaces between the levels of leaf nodes) and a lot of flower buds were formed particularly on the laterals and additionally at the leaf joints. Then the essential sunshine came and adequate rainfall fell in each case at the last minute when the hops came into burr (the last ten days in July and at the beginning of August).

The start of flowering was delayed by 8-10 days compared with the mean average over many years. The first half of August brought settled, warm, midsummer-like weather but still little rainfall.

Heavy thunderstorms and lightning from 12th – 14th August brought approx. 120 ha of trellises down and in many hop-yards caused wind damage, i.e. the cones are adversely affected in their appearance by a brown discolouring. All hop varieties were ready for harvesting about a week later than in the previous year. For the harvest itself the weather turned warm and dry with temperatures over 20°C.

As was the case in 2002 the southern part of the Hallertau had considerably better weather than the northern part. Here they had up to 90 mm more rainfall in the months April - September. Besides good crops better alpha-acid values were mostly obtained here.
The constant, even if not very abundant rainfall, together with considerable wind, made the plant protective measures extremely difficult. While the common red spider only sporadically occurred (but to a bad extent in these hop yards), the flight of the hop aphid was unusually early and strong; up to 200 winged aphids were counted on the small top leaves. It was the worst attack since 1993. Due to well-timed control measures and the combination of plant protectives these attacks could be checked from spreading.

As far as the peronospora or downy mildew is concerned, the occurrence of primary infections, the so-called "spikes", constantly resulted in new infections until mid-July. In combination with the weather conditions, this year seven sprayings were necessary for susceptible varieties and six spray warnings in the case of tolerant Hüll varieties. These figures are above the mean average taken over many years. Powdery mildew was found only very occasionally. The 50-year mean average applies to the years 1927 up to and including 1976, the 10-year mean average applies to the years 1994 up to and including 2003.

Table 2.2: Weather data (monthly mean averages or monthly totals) from 2004 compared with the 10- and 50-year mean averages

Month		Temperature at height of 2 m			Rel. air moisture	Rainfall	Days w. rainfall	Sun-shine
		Average (°C)	Min.∅ (°C)	Max.∅ (°C)	(%)	(mm)	>0.2 mm	(Std.)
January	2004	-1.3	-5.1	2.0	89.0	109.5	14.0	43.9
∅	10-j.	-1.0	-4.0	2.4	87.6	35.6	11.0	62.5
	50-j.	-2.4	-5.1	1.0	85.7	51.7	13.7	44.5
February	2004	1.7	-2.7	5.6	81.1	13.6	8.0	93.2
∅	10-j.	1.1	-3.2	6.0	82.8	36.5	11.4	99.8
	50-j.	-1.2	-5.1	2.9	82.8	48.4	12.8	68.7
March	2004	2.7	-2.4	8.4	80.7	47.1	6.0	162.2
∅	10-j.	4.7	0.3	9.8	78.8	65.9	15.1	135.2
	50-j.	2.7	-2.3	8.2	78.8	43.5	11.3	134.4
April	2004	9.3	2.9	15.9	74.2	49.7	11.0	218.5
∅	10-j.	7.8	2.4	13.5	74.1	61.4	11.0	162.0
	50-j.	7.4	1.8	13.3	75.9	55.9	12.4	165.0
May	2004	11.3	4.7	17.3	72.3	63.2	10.0	192.4
∅	10-j.	13.8	7.7	20.0	72.0	78.9	12.1	214.5
	50-j.	11.9	5.7	17.8	75.1	86.1	14.0	207.4
June	2004	15.7	9.0	22.1	72.6	74.0	17.0	210.3
∅	10-j.	16.6	10.3	22.8	72.3	92.1	14.1	231.2
	50-j.	15.3	8.9	21.2	75.6	106.1	14.2	220.0
July	2004	17.4	11.4	24.4	74.9	108.3	22.0	210.9
∅	10-j.	17.8	11.9	24.1	74.6	100.1	14.9	226.0
	50-j.	16.9	10.6	23.1	76.3	108.4	13.9	240.3
August	2004	18.1	11.7	25.8	74.0	61.8	13.0	232.9
∅	10-j.	17.9	11.7	24.8	75.5	71.8	11.3	225.4
	50-j.	16.0	10.2	22.5	79.4	94.9	13.3	218.4
September	2004	13.9	8.1	20.9	76.7	46.4	12.0	190.6
∅	10-j.	12.8	7.7	18.8	81.3	72.4	12.7	158.6
	50-j.	12.8	7.4	19.4	81.5	65.9	11.4	174.5
October	2004	9.9	5.4	15.9	84.9	69.2	14.0	101.6
∅	10-j.	8.9	4.8	13.7	85.3	64.8	13.4	110.0
	50-j.	7.5	2.8	13.0	84.8	60.0	10.4	112.9
November	2004	3.3	0.5	6.5	86.6	48.7	14.0	53.9
∅	10-j.	3.6	0.6	6.8	89.6	57.3	11.3	64.0
	50-j.	3.2	-0.2	6.4	87.5	58.8	12.6	42.8
December	2004	-0.7	-3.3	1.9	88.7	13.3	3.5	44.3
∅	10-j.	0.1	-2.8	3.0	88.6	43.7	13.5	55.8
	50-j.	-0.9	-4.4	1.6	88.1	49.1	13.3	34.3
Year 2004		8.4	3.4	13.9	79.6	704.8	144.5	1754.7
10-yr. average	Mean	8.7	3.9	13.8	80.2	780.5	151.8	1744.9
50-yr. average	Mean	7.4	2.5	12.5	81.0	828.8	153.0	1663.0

3 Statistical data on hop production

Bernhard Engelhard

3.1 Production data

3.1.1 Structure of hop production

In the year 2004 the hop acreage in the Federal Republic of Germany decreased by 87 ha to 17,476 ha compared with 17,563 ha in the previous year (- 0.50%).

The number of hop farms also decreased in 2004, i.e. by 90 (=5.03 %) from, 1,788 to 1,698 farms. The average hop acreage per farm for the whole Federal Republic of Germany is now 10.29 ha compared with 9.82 ha in 2003.

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

Year	No. of hop farms	Average hop acreage per farm in ha
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
2004	1.698	10.29

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

Production region	Hop acreage				Hop farms				Hop acreage per farm in ha	
	in ha		Increase + / Decrease - 2003 to 2004		2003	2004	Increase + / Decrease - 2003 to 2004		2003	2004
	2003	2004	ha	%			Farms	%		
Hallertau	14 391	14 411	+ 20	+ 0.14	1 416	1 355	- 61	- 4.31	10.16	10,64
Spalt	395	388	- 7	- 1.77	107	98	- 9	- 8.41	3.69	3,96
Hersbruck	98	104	+ 6	+ 6.12	16	15	- 1	- 6.25	6.13	6,93
Tettnang	1 257	1 220	- 37	- 2.94	210	196	- 14	- 6.67	5.99	6.22
Bitburg u. Rheinpfalz	20	20	± 0	± 0	2	2	± 0	± 0	10.00	10,00
Elbe-Saale	1 402	1 333	- 69	- 4.92	37	32	- 5	- 13.51	37.89	41,66
Fed. Republic of Germany	17 563	17 476	- 87	- 0,50	1 788	1 698	- 90	- 5,03	9,82	10,29

Figure 3.1: Hop acreage in Germany and in the Hallertau production region

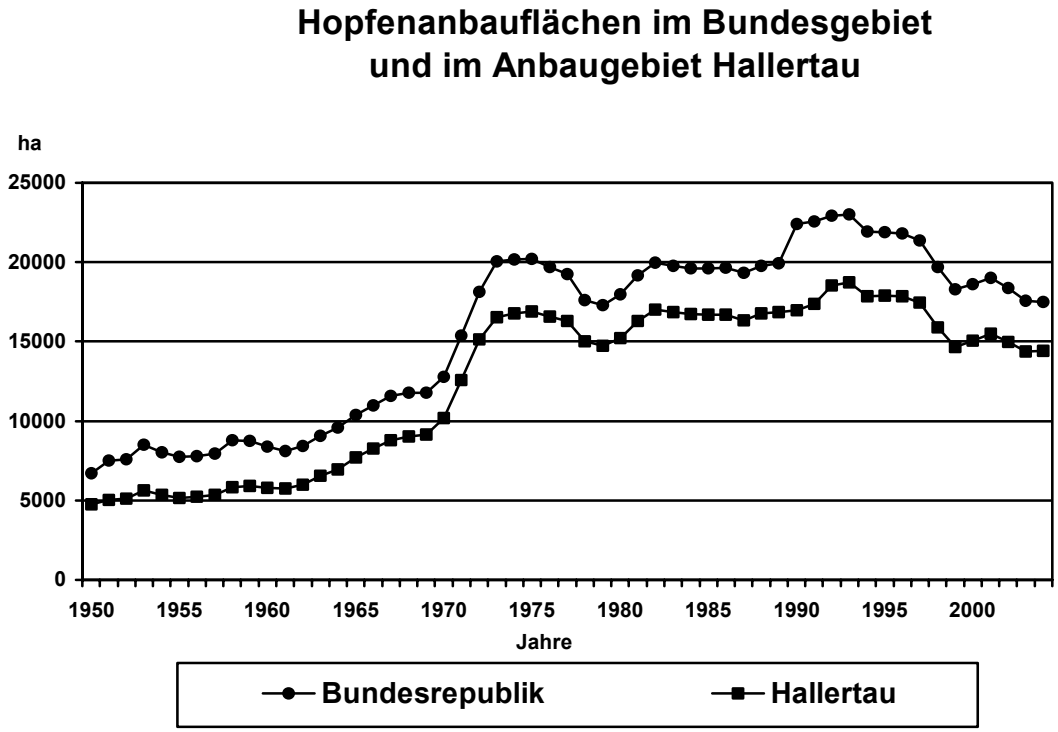


Figure 3.2: Hop acreage in the regions Spalt, Hersbruck, Tettnang and Elbe-Saale

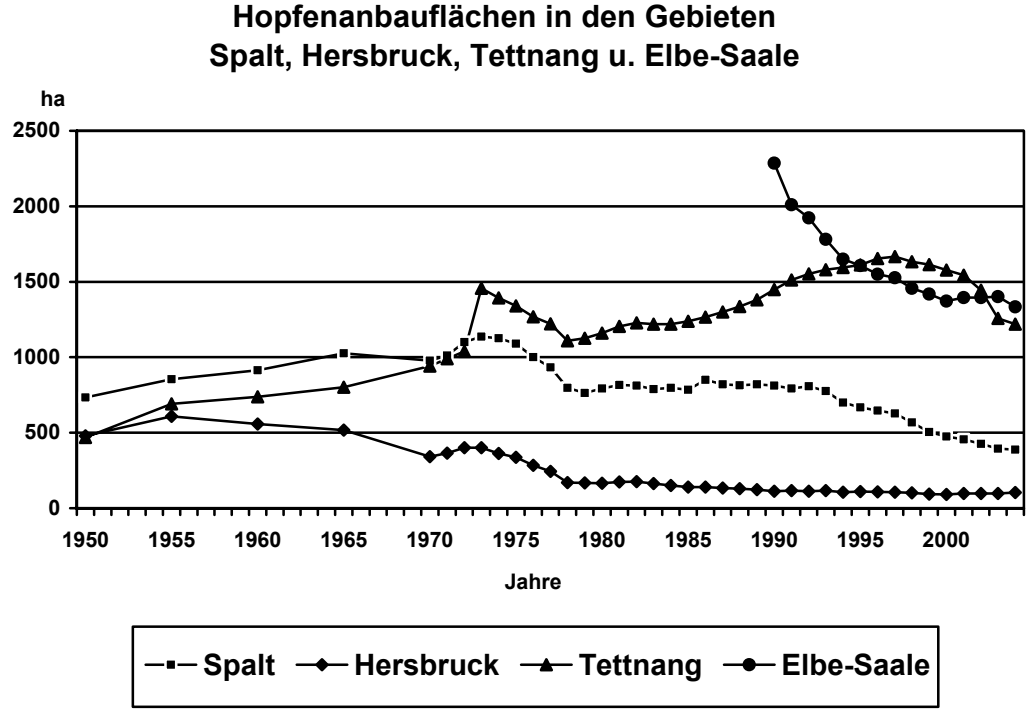


Table 3.3: Hop varieties in the German production regions in ha in 2004

Part 1 – Aroma varieties

Production region	Total acreage	Haller-tauer Mfr.	Spalter	Tett-nanger	Hers-brucker Spät	Hüller Bitterer	Perle	Spalter Select	Hall. Tradition	Saphir	Aroma varieties	
Hallertau	14.411	1.416			1.179	1	2.672	712	1.905	180	8.065	55,96 %
Spalt	388	114	102		9		17	115	18		375	96,65 %
Hersbruck	104	24			7		19	22	14	3	89	85,58 %
Tettnang	1.220	414		790			10		3		1.217	99,75 %
Rheinpfalz } Bitburg	20	1				2	7	2	3		15	75,00 %
Elbe-Saale	1.333						115		14		129	9,68 %
Germany	17.476	1.969	102	790	1.195	3	2.840	851	1.957	183	9.890	56,59 %
Proportion per variety **in %**		11,27	0,58	4,52	6,84	0,02	16,25	4,87	11,20	1,05		

Changed varieties in the Federal Republic of Germany

2003 ha	17.563	1.903	116	822	1.271	2	2.829	867	1.727	131	9.668	55,05 %
2004 ha	17.476	1.969	102	790	1.195	3	2.840	851	1.957	183	9.890	56,59 %
Changes **in ha**	- 87	+ 66	- 14	- 32	- 76	+ 1	+ 11	- 16	+ 230	+ 52	+ 222	+ 2,30 %

Table 3.3: Hop varieties in the German production regions in ha in 2004 Part 2 – Bitter varieties

Production region	Northern Brewer	Brewers Gold	Nugget	Target	Hall. Magnum	Hall. Taurus	Hall. Merkur	Colum-bus	Others	Bitter varieties	
Hallertau	474	37	381	29	3.984	1.238	149	9	45	6.346	44.04 %
Spalt					3		10			13	3.35 %
Hersbruck		2			11		1		1	15	14.42 %
Tettnang					1	2				3	0.25 %
Rheinpfalz Bitburg					2	3				5	25.00 %
Elbe-Saale	191		69	4	868	30	40	2		1204	90.32 %
Germany	665	39	450	33	4.869	1.273	200	11	46	7.586	43.41 %
Proportion per variety **in %**	3.81	0.22	2.58	0.19	27.86	7.28	1.15	0.06	0.26		

Changed varieties in the Federal Republic of Germany

2003 ha	870	43	501	40	4.924	1.285	179	13	40	7.895	44.95 %
2004 ha	665	39	450	33	4.869	1.273	200	11	46	7.586	43.41 %
Changes **in ha**	- 205	- 4	- 51	- 7	- 55	- 12	+ 21	- 2	+ 6	- 309	- 3.91 %

3.1.2 Hop varieties

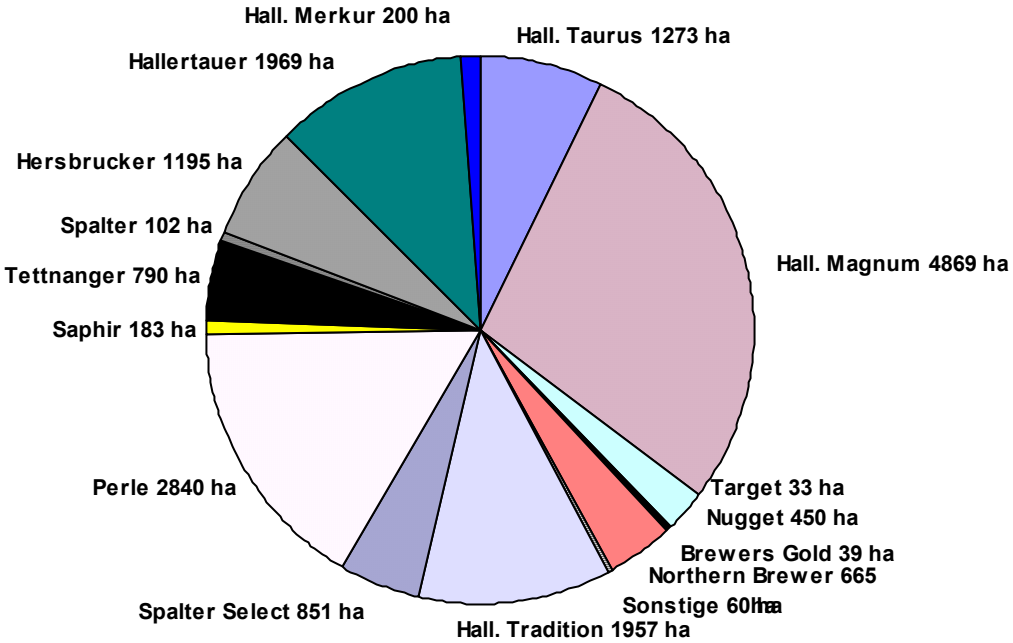
As far as the hop varieties are concerned, in 2004 there was a slight shift in favour of the aroma varieties. In 2004 the proportion of aroma varieties was 56.59 % compared with 55,05 % in 2003. The bitter varieties hold a proportion of 43.41 % of the production area compared with 44.95 % in 2003.

With the aroma varieties the acreage for Hallertauer Mfr. (+ 66 ha), Perle (+ 11 ha), Hall. Tradition (+ 230 ha) and Saphir (+ 52 ha) was increased. All the other aroma varieties show a slight reduction in the acreage.

With the bitter varieties the acreage of all varieties (except for Hall. Merkur + 21 ha) was reduced.

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

Figure 3.3: Distribution of varieties in hectares in 2004 in Germany



3.2 Crop situation in 2004

The total crop in the Federal Republic of Germany amounted to 33,207,364 kg (= 664,147 ztr.) compared with 25,325,768 kg (= 506,515 zentners) in 2003. The size of the crop is about 7,881,596 kg (= 157,632 zentners) above the result of the previous year; this means an increase of about 31.13 %.

The yields per hectare and relative figures in the Federal Republic of Germany are shown in Table 3.4. The yields per hectare for the various varieties and production regions are listed in Table 3.5 as well as the yields for the entire Federal Republic of Germany compared with the figures for 2003.

Table 3.4: Yields per hectare and relative figures in the Fed. Republic of Germany

	1997	1998	1999	2000	2001	2002	2003	2004
Yield ztr./ha or kg/ha	31.9	31.4	30.5	31.5	1660 kg (33.2 ztr.)	1758 kg (35.2 ztr.)	1442 kg (28.8 ztr.)	1900 kg (38.0 ztr.)
Relative to 100% (long-term ∅ = 35 ztr.)	91.1	89.7	87.1	90.0	94.9	100.6	82.40	108.6
Acreage in ha	21.381	19.683	18.299	18.598	19.020	18.352	17.563	17.476
Total crop In ztr. or kg	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.	33.207.364 kg = 664.147 ztr.

Figure 3.4: Average yields in the various production regions in kg/ha

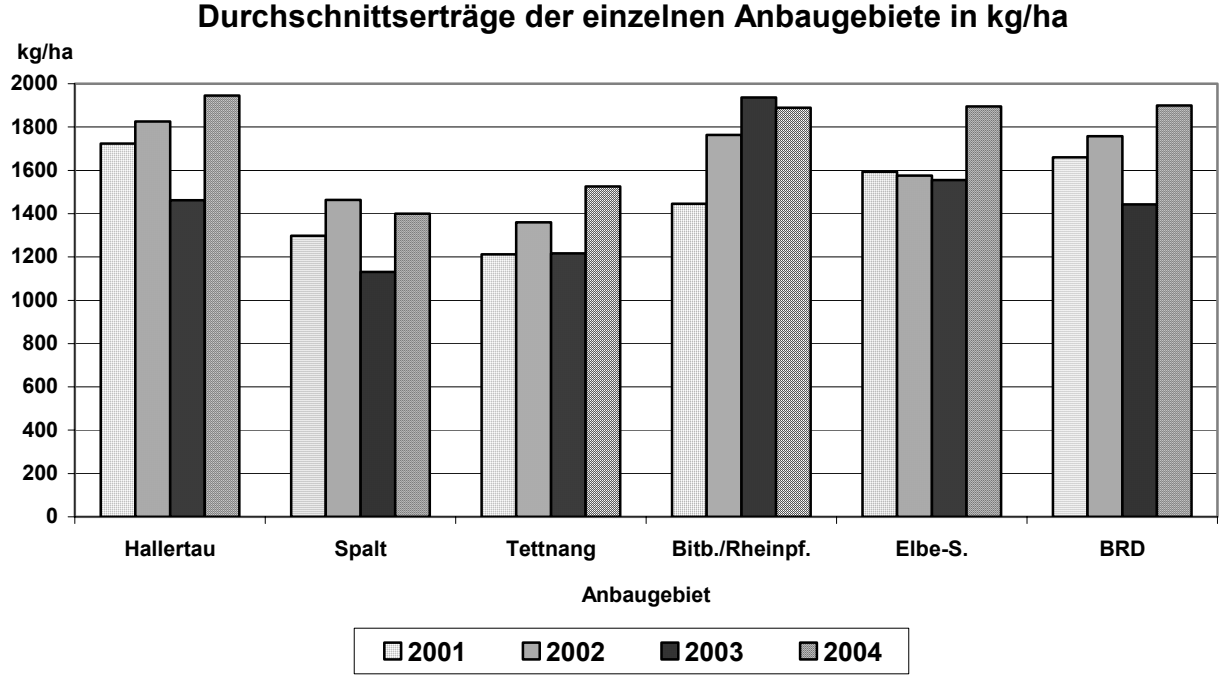


Table 3.5: Average yields for the various hop varieties in the German production regions in 2004 in kg per ha

Aroma varieties

Production region	Haller-tauer	Spal-ter	Hers-brucker	Hüller Bitterer	Tett-nanger	Perle	Spalter Select	Hall. Trad.	Saphir
Hallertau	1322		1701	2071		1871	1943	1782	1331
Spalt	1302	1149	1471			1702	1689	1353	
Tettnang	1731				1413	1696		1185	
Bitburg }	1327			1581		1946	1936	1787	
Rheinpfalz }									
Elbe-Saale						1950		1170	
Fed. Republic									
2004	1407	1149	1699	1710	1413	1872	1909	1773	1331
2003	697	925	1682	1405	1212	1388	1636	1563	639
± to 2003 kg/ha	+ 710	+ 224	+ 17	+ 305	+ 210	+ 484	+ 273	+ 210	+ 692
Crop in tons Germany	2771.4	116.7	2031.9	3.6	1116.4	5315.1	1622.5	3471.0	243.5

Bitter varieties

Production region	North. Brewer	Brewers Gold	Nugget	Target	Hall. Magnum	Hall. Taurus	Hall. Merkur	Columbus	Others	Total
Hallertau	1968	2290	2378	2440	2306	2129	1793	2668	1184	1946
Spalt					1998		1060		853	1400
Tettnang									2223	1525
Bitburg }					2552	1696				1889
Rheinpfalz }										
Elbe-Saale	1733		1756	1893	1936	2248	1849	2018		1895
Fed. Rep.										
2004	1900	2290	2282	2378	2240	2131	1767	2564	1255	1900
2003	1010	2158	1759	1831	1714	1534	1198	1985	1244	1442
± to 2003 kg/ha	+ 890	+ 132	+ 523	+ 547	+ 526	+ 597	+ 569	+ 579	+ 11	+ 458
Crop in tons Germany	1263.8	89.5	1027.8	79.0	10904.2	2707.8	354.3	27.2	61.6	33207.4

Source: EU report

Figure 3.5: Crop volume in the Federal Republic of Germany

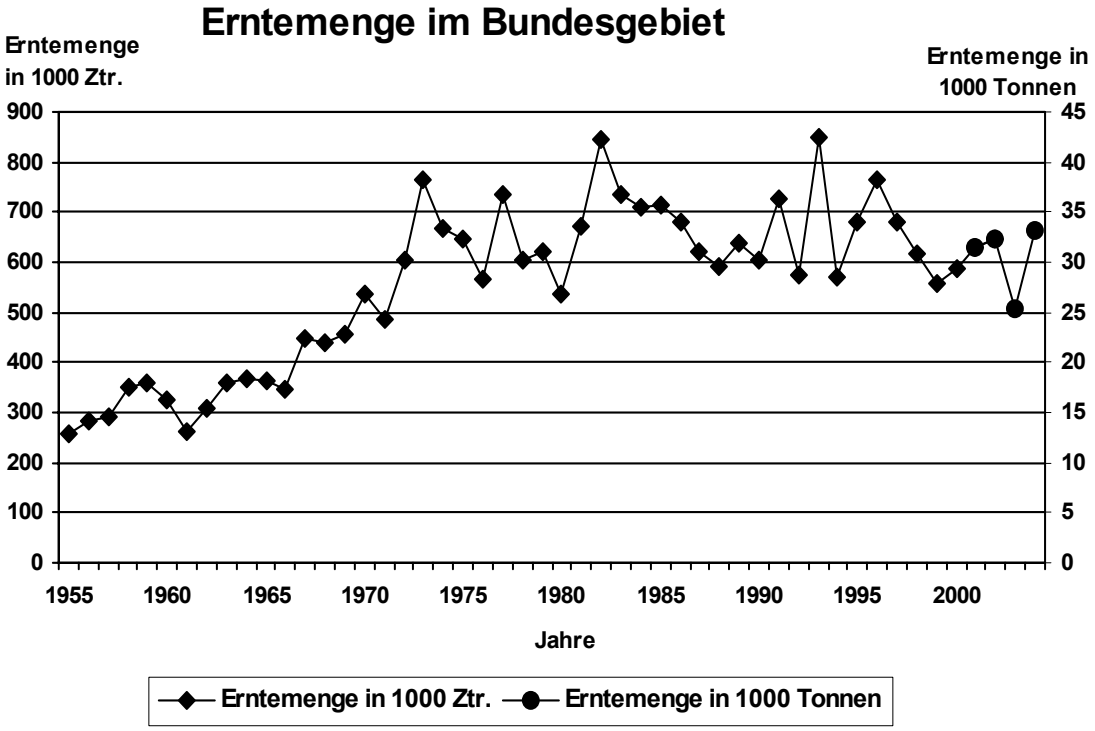


Diagram 3.6: Average yield per hectare hop acreage in the Fed. Republic of Germany

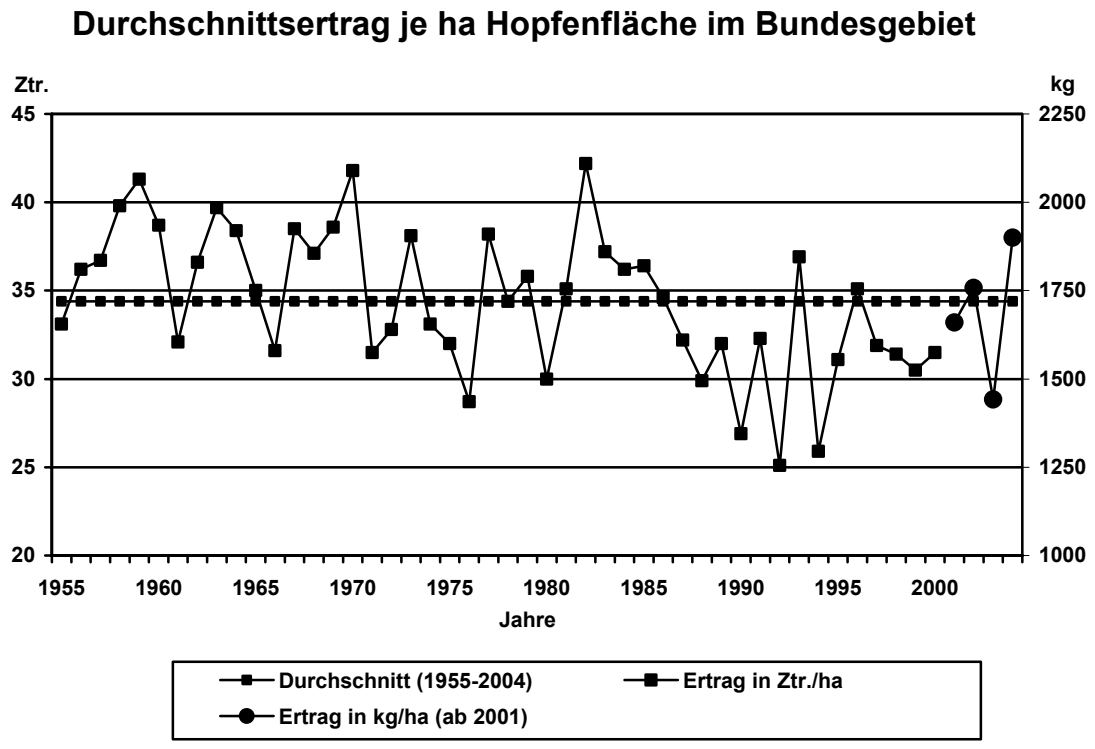


Table 3.6: Yields per hectare in the German production regions

Production region	Yields in ztr./ha total acreage (as from 2001 in kg/ha)								
	1996	1997	1998	1999	2000	2001	2002	2003	2004
Hallertau	35.1	32.8	32.5	31.2	33.6	1724	1825	1462	1946
Spalt	32.3	26.5	22.1	28.2	20.9	1298	1464	1131	1400
Hersbruck	27.9	28.3	28.8	23.5	26.8	1233	1306	983	- *
Tettnang	28.9	31.2	26.8	28.3	16.4	1212	1360	1216	1525
Bitburg } Rheinpfalz }	39.0	34.9	30.1	31.4	31.6	1445	1763	1936	1889
Elbe-Saale	30.6	23.6	27.5	27.3	30.0	1594	1576	1555	1895
∅ yield per ha Germany	35.1	31.9	31.4	30.5	31.5	1660 kg	1758 kg	1442 kg	1900 kg
Total crop Germany	766 070	681 035	617 181	558 247	585 841	31576 to 631 529	32271 to 645 413	25326 to 506 515	33207 to 664 147
Acreage Germany	21 813	21 381	19 683	18 299	18 598	19 020	18 352	17 563	17 476

* from 2004 onwards the production region Hersbruck belongs to the Hallertau production region

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

Production region/variety	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	10-year ∅
Hallertau Hallertauer	3.6	5.4	5.4	4.7	4.1	4.9	4.6	4.6	3.1	4.3	4.5
Hallertau Hersbrucker	2.2	4.3	4.7	3.7	2.1	4.9	3.0	3.2	2.1	3.0	3.3
Hallertau Hall. Saphir										3.4	
Hallertau Perle	5.5	8.5	9.3	6.7	7.0	8.1	7.0	8.6	3.9	6.4	7.1
Hallertau Spalter Select	3.9	5.7	6.8	5.5	4.5	6.4	4.8	6.0	3.2	4.9	5.2
Hallertau Hall. Tradition	4.9	6.8	7.0	5.6	6.0	7.1	6.3	7.2	4.1	6.3	6.1
Hallertau Northern Brewer	7.7	10.5	10.8	9.1	9.0	10.1	9.6	10.1	6.0	9.8	9.3
Hallertau Hall. Magnum	11.8	14.2	16.9	14.0	13.4	14.4	13.9	14.6	11.7	14.8	14.0
Hallertau Nugget	9.7	10.7	13.6	11.2	10.0	12.9	11.9	12.4	8.5	10.6	11.2
Hallertau Hall. Taurus			16.6	13.7	15.9	15.6	15.7	16.5	12.3	16.5	
Hallertau Hall. Merkur										13.5	
Tettnang Tettnanger	3.0	4.8	5.4	4.0	3.8	4.9	4.4	4.6	2.6	4.7	4.2
Tettnang Hallertauer	3.5	5.0	5.5	4.3	4.2	4.8	4.5	4.8	3.1	5.0	4.5
Spalt Spalter	3.2	5.6	5.6	4.4	3.8	4.0	4.4	4.6	3.1	4.4	4.3
Elbe-Saale North. Brewer	-		9.3	8.1	8.0	9.8	7.6	8.8	6.0	8.5	
Elbe-Saale Hall. Magnum	-		15.4	12.4	12.2	14.0	13.9	13.9	10.2	14.1	

Source: Work Group Hop Analysis (AHA)

3.2.1 Hop marketing 2004

In the case of all varieties the yield was considerably above the long-term mean average. The alpha-acid figures were satisfactory; but rather disappointing in the case of Perle and Hersbrucker Spät, Magnum and Taurus were particularly good. Based on the total alpha volume produced, the yield was almost twice as much as in 2003.

The course of the market showed completely varied tendencies: There was a high demand for aroma hops; the fixed prices hovered between € 3.2 – 3.8 per kg. Considering how quickly the aroma market was cleared the hop-growers could have expected higher prices. The price level for high-alpha varieties was a catastrophe. In the aggressive struggle for market shares between US and German high-alpha hops the dollar/euro exchange rate created considerable advantages for the US hops.

3.2.2. Global hop market

Table 3.8: Global hop market

	1995	1996	1997	1998	1999	2000	2001	2002	2003
World hop acreage in ha	81 466	76 967	70 290	60 111	57 427	58 991	58 903	56 237	53 570
Change in ha	-5 320	- 4 499	- 6 677	-10 179	- 2 684	+ 1 564	- 88	- 2 666	-2 667
World hop crop in million zentners	2.53	2.49	2.24	1.89	1.91	1.93	1.98	2.01	1.75
Change in million zentners	+ 0.10	- 0.04	- 0.25	- 0.35	+ 0.02	+ 0.02	+ 0.05	+ 0.03	- 0.26
World average yield in ztr./ha	31.06	32.35	31.92	31.48	33.24	32.79	33.68	35.74	32.60
World α production in 1000 kg	7 831	9 300	8 782	7 248	7 393	8 294	8 646	8 749	6 727
World beer product. In million hl	1 248	1 269	1 300	1 301	1 365	1 392	1 424	1 443	1 478
Increase/decrease (%)	+ 2.80	+ 1.68	+ 2.44	+ 0.8	+ 3.46	+ 1.98	+ 2.30	+ 1.33	+ 2.42
Volume of hops harvested per hl beer produced in grams	101	98	86	72	70	69	70	70	59
α production per hl beer produced in grams	6.27	7.33	6.76	5.57	5.42	5.96	6.08	6.06	4.55

Source: Barth report

Figure 3.7: World hop acreage

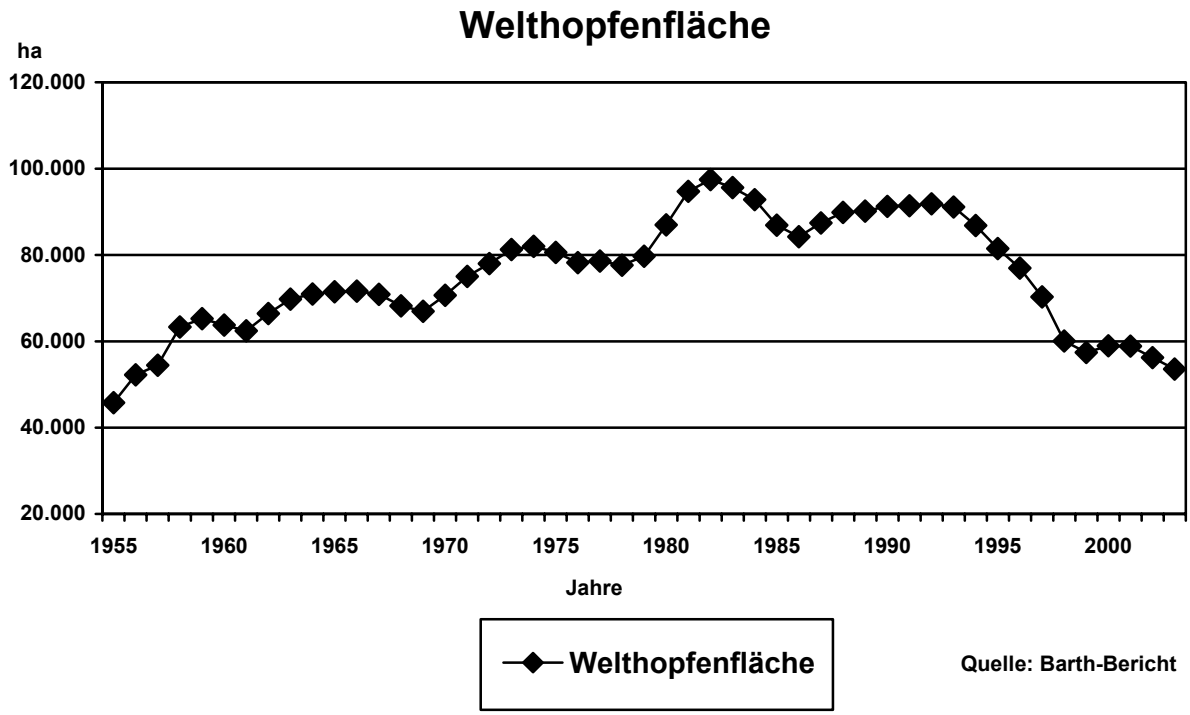


Figure 3.8: Hop acreage of the various countries

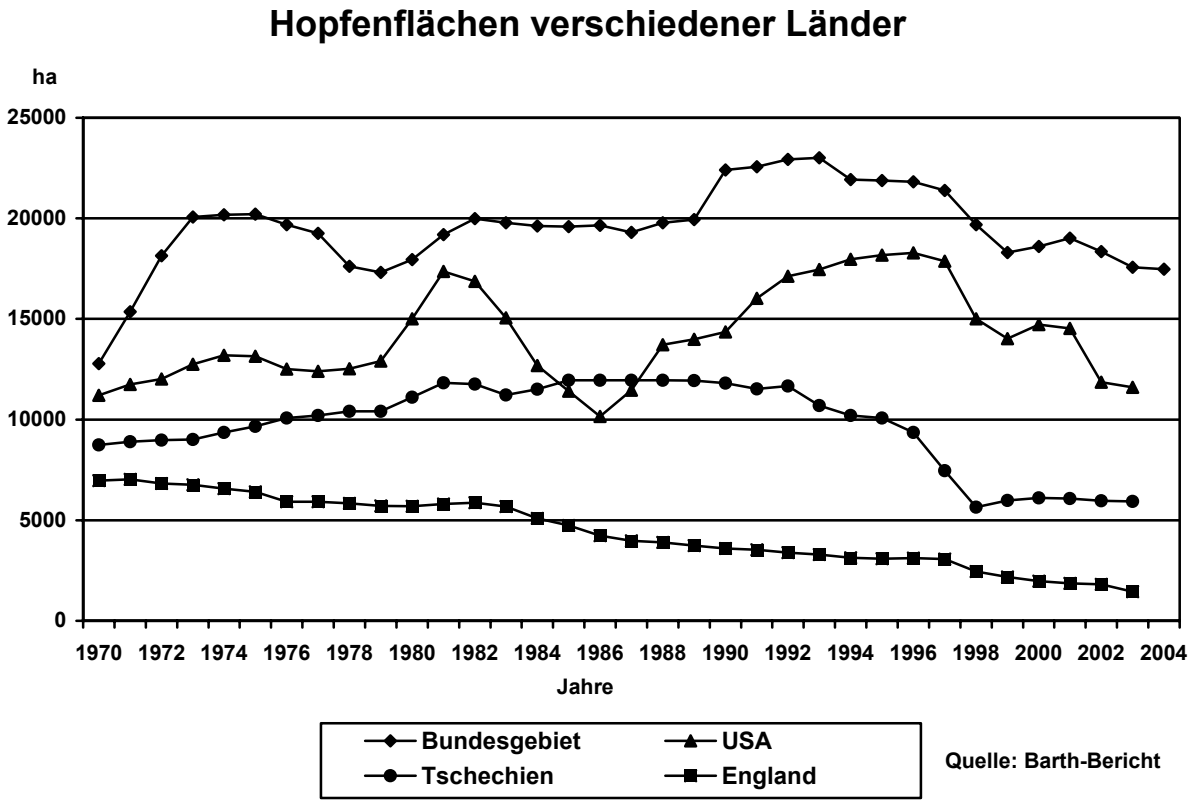


Figure 3.9: World hop crop

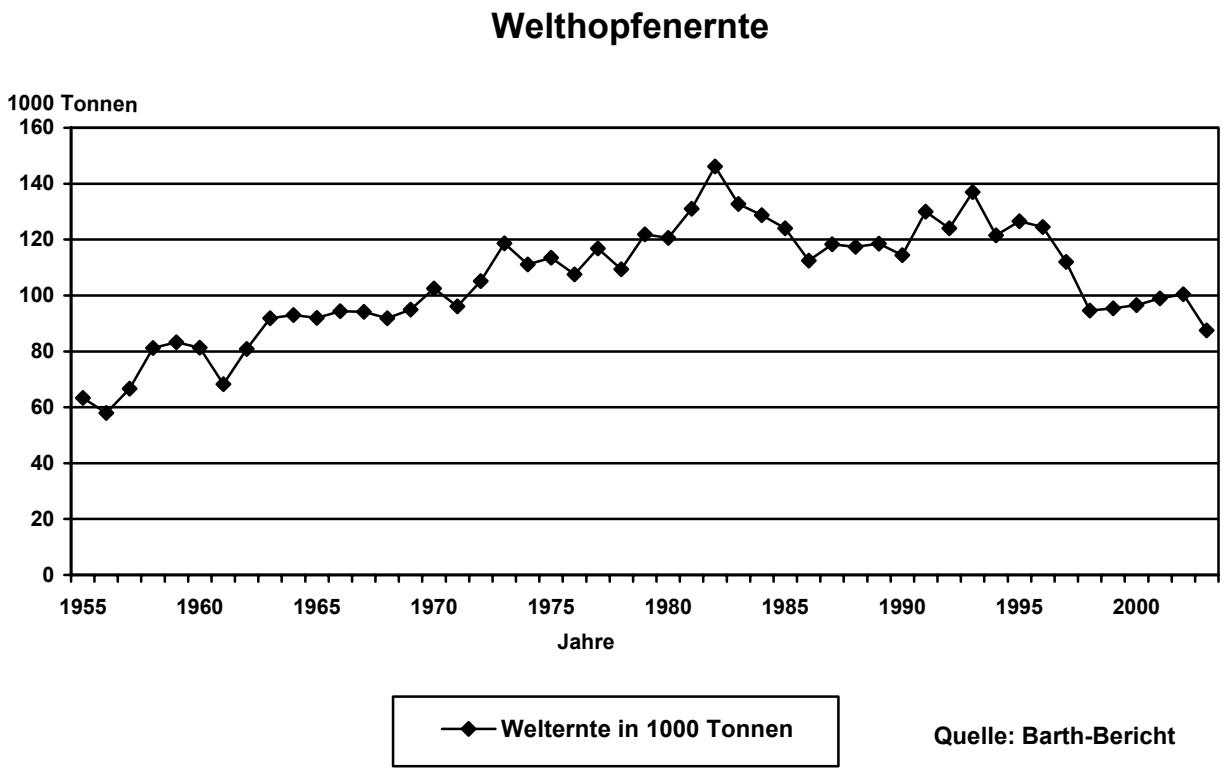
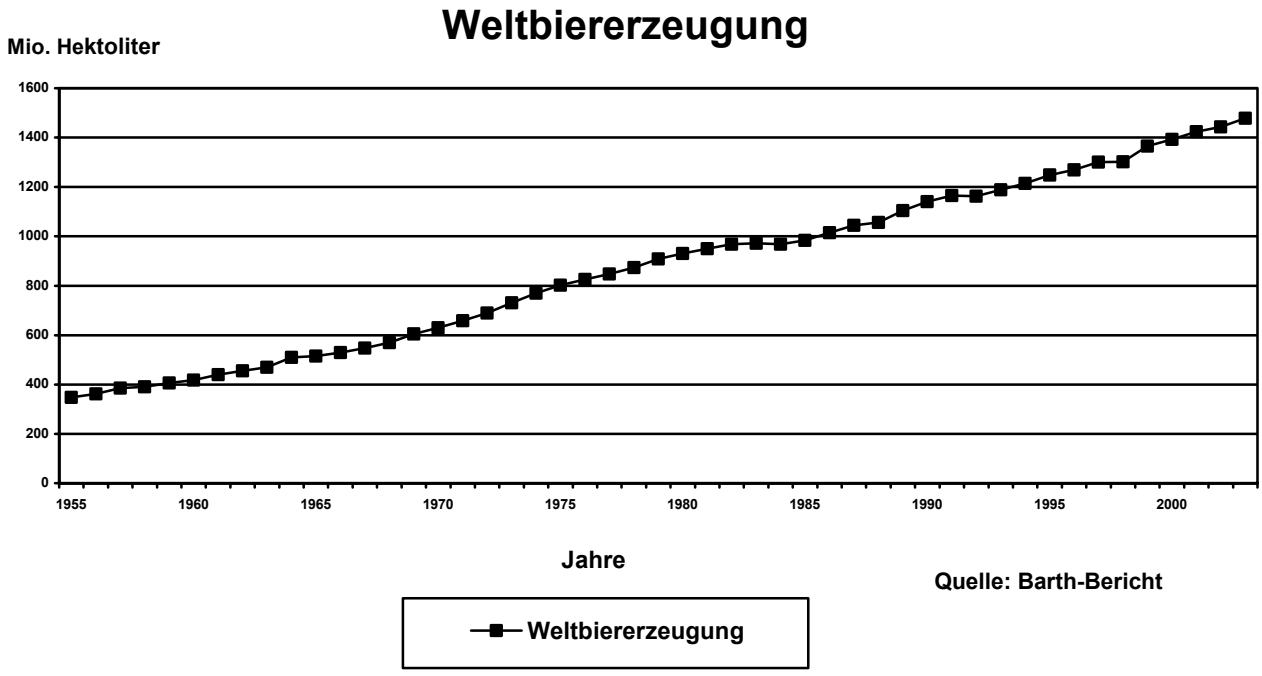


Figure 3.10: World beer production



4 Research in hop breeding

ORRin Dr. Elisabeth Seigner, Dipl. Biol.

4.1 Practical hop breeding

4.1.1 Crosses 2004

128 crossings were carried out in 2004. Based on the results of the powdery mildew resistance tests the number of crossings could be reduced to 102 when being sowed.

In 38 aroma hop crosses the breeding aim was good tolerance or resistance to downy mildew (Peronospora) and powdery mildew respectively in which the wilt tolerance in five crossings and the aphid tolerance in two crossings were additionally taken into account.

57 crossings were carried out with the aim to breed for bitter hops with good downy mildew tolerance and powdery mildew resistance, in six crossings from this breeding programme a high xanthohumol content is also the major breeding aim.

Seven crossings were carried out with low growing varieties and breeding lines. The aim is to select suitable breeding lines with good Peronospora (downy mildew) tolerance and powdery mildew resistance for production in low-trellis yards.

4.1.2 Result of the seedling tests

Following the extremely dry year in 2003, in 2004 the seedlings could reveal their full potential.

The spread of disease with powdery mildew and botrytis was very slight. In comparison there were bad attacks of downy mildew throughout the whole vegetation period. The primary spread of infection - so-called spikes – occurred early in the spring. As no sprayings were carried out in the breeding yards, the primary attacks could be monitored very well.

As a result the cool, damp weather conditions promoted the spread of the secondary infection of downy mildew. When selecting the seedlings for harvesting, the susceptibility for downy mildew could be monitored very well directly before the harvest and when the cones were assessed in the autumn.

4.1.2.1 Seedlings 2001

Of the seedlings in 2001 approx. 3800 descendants from 55 aroma and 57 bitter crossings were being grown in the breeding yards in Hüll. This seedling trial was grubbed in autumn 2004.

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

Altogether 285 seedlings were harvested during the three years. 24 of them attained alpha-acid contents above 15 %.

In the years 2003 and 2004 eight breeding lines respectively were already included in the „Stammesprüfung“ (trials with replications at two different locations). Another five breeding lines are envisaged for the „Stammesprüfung“ in 2005. This test will include eight aroma and 13 bitter lines.

4.1.2.2 Seedlings 2002

Of the seedlings 2002 approx. 4950 descendants from 38 aroma and 40 bitter crossings are being grown in the breeding yards in Hüll.

The varieties Hallertauer Mfr., Hallertauer Tradition, Spalter Select, Saphir and Perle were planted as reference varieties in the aroma sector as well as Hallertauer Magnum, Hallertauer Taurus, Hallertauer Merkur and Wye Target in the bitter sector.

As it had already been possible to harvest drought-tolerant breeding lines in 2003, all in all 73 seedlings were harvested in 2004. So far it has been possible to select 14 seedlings with alpha-acid values above 14 %.

Four particularly drought-tolerant bitter lines were already included in the „Stammesprüfung“ (trials with replications at two different locations) in 2004. Another ten breeding lines among them seven aroma lines are envisaged for the „Stammesprüfung“ in 2005.

4.1.2.3 Seedlings 2003

Of the seedlings 2003 approx. 4400 descendants from 26 aroma and 68 bitter crossings are being grown in the breeding yards in Hüll.

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

The seedlings 2003 were planted in the breeding yards in autumn 2003 and developed so well up to the harvest that 119 seedlings could already be harvested in the first year. 26 breeding lines attained alpha-acid values above 15 %.

12 breeding lines are envisaged for the „Stammesprüfung“ in 2005.

4.1.3 Results of the „Stammesprüfung“ (trials with replications at two different locations)

4.1.3.1 „Stammesprüfung“ 2000/2 in Hüll and Rohrbach

Table 4.1: Results of the 2004 harvest

Line/Variety	Yield kg/ha	α-acids	α - acids	Cohu-mu-lone	Aroma 1-30	Yield kg/ha	α - acids	α - acids	Cohu-mu-lone	Aroma 1-30
	Hüll (clay soil)					Rohrbach (sandy soil)				
Hall. Trad.	2103	7.4	4.4	27.8	26	2185	8.0	4.5	29.1	26
Hall. Merkur	2423	16.2	5.4	20.5	22	2071	16.4	6.1	20.1	22
96/069/037	2329	18.1	6.0	24.3	20	2184	17.9	5.8	24.1	20
96/001/001	1919	8.5	6.3	28.9	25	1801	8.0	6.1	29.5	26
96/001/017	1878	8.4	7.0	24.5	27	1403	7.5	6.9	25.5	27
96/001/018	1700	9.3	5.5	23.8	26	1721	6.9	4.2	25.5	26
96/001/021	3117	7.4	7.3	31.7	25	1495	4.7	6.6	24.1	25
96/001/024	2379	7.2	6.9	29.5	24	2413	6.2	6.9	27.9	25
96/008/014	2680	5.4	8.8	30.9	25	2264	4.4	8.4	34.7	26
96/010/024	1850	7.0	10.4	26.3	24	1997	6.4	9.5	25.0	23
96/012/011	1967	6.6	3.5	25.0	26	1695	5.4	2.8	24.1	26
96/015/030	2402	6.0	3.9	24.5	23	2360	7.2	4.7	25.8	25
96/016/034	2227	5.2	2.7	25.1	25	1920	4.9	2.7	25.9	26
96/026/017	1972	9.8	6.5	27.6	25	1477	8.6	6.1	27.4	26
96/030/011	3003	5.4	9.2	22.4	26	2596	4.9	9.0	22.1	26
96/030/016	950	4.9	6.3	26.4	27	534	4.5	7.0	30.0	27
96/030/041	2583	5.2	8.6	12.6	25	2143	4.7	8.1	13.4	26
96/031/009	1976	4.0	9.5	18.4	24	1690	4.4	11.8	33.7	25
96/031/027	2566	6.5	5.5	23.7	23	2439	5.5	4.8	22.4	23
96/035/026	2046	6.0	5.2	20.8	25	2340	4.9	5.9	20.2	26
96/037/025	1870	7.1	5.7	21.8	26	2199	5.9	5.7	23.6	26
96/001/008	1784	7.3	7.8	29.0	26	-	-	-	-	-
96/054/009	2283	4.0	3.9	23.8	24	-	-	-	-	-

Alpha- and beta-acids in % as is ; Cohumulone in % of the alpha-acids

The „Stammesprüfung“ SP 2000/2 set for the year 2000 was harvested for the fourth time.

As far as seedling year 96 is concerned, only the seedling 96/069/037 fulfilled the required combination of breeding aims in the bitter sector. It is true that this seedling reached the performance level of Hallertauer Taurus but showed high susceptibility for crown rot.

In comparison many interesting aroma breeding lines could be included in the test, from these 12 lines have been planted meanwhile in a “Hauptprüfung” (advanced trials on farms).

4.1.3.2 „Stammesprüfung“ 2001 in Hüll und Rohrbach

Table 4.2: Results of the 2004 harvest

Line/Variety	Yield kg/ha	α - acids	α - acids	Cohu-mu-lone	Aro-ma 1-30	Yield kg/ha	α - acids	α - acids	Cohu-mu-lone	Aroma 1-30
	Hüll (clay soil)					Rohrbach (sandy soil)				
Hall. Trad.	2156	7.4	3.8	26.0	25	2259	5.5	3.2	29.9	26
Hall. Merkur	2247	16.5	5.7	20.5	22	1570	15.9	5.0	20.2	23
97/007/011	2215	6.3	3.8	28.7	26	2399	5.7	3.8	29.4	25
97/007/040	1416	7.8	5.9	30.5	26	1859	6.7	6.0	31.2	26
97/010/023	2392	10.0	5.7	26.6	26	-	-	-	-	-
97/025/007	1920	0.2	8.4	34.5	25	1986	0.2	6.8	35.9	24
97/026/006	2050	5.3	8.5	20.4	24	-	-	-	-	-
97/033/014	2238	6.6	4.8	22.7	24	-	-	-	-	-
97/040/003	2552	15.6	5.9	34.0	22	3080	14.2	5.3	34.6	23
97/040/036	1403	12.1	6.4	25.7	20	1595	12.1	6.5	18.7	23
97/060/008	2783	14.3	5.9	31.5	20	2412	13.7	5.3	30.5	22
97/060/011	3162	16.4	6.6	36.4	21	2705	15.7	6.5	32.4	21
97/060/025	2425	14.6	5.6	36.2	22	1980	13.4	5.0	34.6	21
97/060/030	1631	9.8	5.5	20.4	18	2425	9.4	5.2	20.5	19
97/060/054	2692	12.4	4.8	30.5	22	2626	12.4	5.7	30.8	22
97/060/721	2454	15.8	6.4	40.3	21	-	-	-	-	-
97/060/724	3044	17.2	6.7	33.0	18	-	-	-	-	-
97/060/754	2151	14.6	5.4	38.0	19	-	-	-	-	-
97/065/753	2836	17.3	6.4	24.5	19	2945	16.5	6.2	24.2	19
97/071/737	2684	14.6	9.4	28.6	21	-	-	-	-	-
97/076/754	3042	14.0	8.6	32.7	19	3334	13.7	8.1	33.9	23
97/077/763	1984	9.5	3.4	24.6	19	-	-	-	-	-
97/079/005	2056	12.0	3.5	24.2	21	-	-	-	-	-
97/081/722	2036	16.8	5.8	26.5	22	-	-	-	-	-

Alpha- and beta-acids in % as is; Cohumulone in % of the alpha-acids

In the aroma sector three breeding lines showed good agronomic and analytic characteristics. They were put into a “Hauptprüfung”. A special feature of breeding line 97/025/007 is the almost total lack of alpha-acids. Compared with this the beta-acids are relatively high. Therefore a few crossings have already been carried out in order to produce breeding lines with very high beta-acids. In the bitter sector the breeding lines 97/060/011, 97/060/721 and 97/065/753 produced the best results in the three trial harvests so far. They have already been put into a “Hauptprüfung” (advances trials on farms).

4.1.3.3 „Stammesprüfung“ 2002 in Hüll und Rohrbach

Table 4.3: Results of the 2004 harvest

Line/Variety	Yield kg/ha	α - acids	α - acids	Cohu-mu-lone	Aro-ma 1-30	Yield kg/ha	α - acids	α - acids	Cohu-mu-lone	Aro-ma 1-30
	Hüll (clay soil)					Rohrbach (sandy soil)				
Perle	2008	6.6	3.3	32.4	25	1934	7.8	4.4	35.6	25
Hall. Merkur	2284	15.4	5.3	20.2	21	2128	15.2	5.2	18.6	22
Hall. Taurus	1898	19.0	5.3	23.8	20	2194	16.8	4.6	24.4	21
97/014/009	1991	5.9	6.0	23.7	26	1997	4.6	6.7	27.0	27
98/009/013	2042	6.5	6.8	22.4	27	1321	5.6	7.1	24.8	26
98/034/028	2203	5.1	4.8	26.7	27	2124	4.8	5.2	27.0	26
98/066/770	2365	14.2	6.5	30.7	22	3126	14.4	7.0	33.7	21
98/071/724	2728	16.9	4.1	30.6	21	2472	16.8	4.1	31.8	22
98/097/731	2810	15.6	5.2	23.3	20	2975	15.8	5.6	25.0	21
98/097/738	2356	15.0	5.2	27.0	18	2858	14.1	5.2	26.8	20
98/037/021	2523	10.1	5.8	19.6	25	2481	8.2	8.1	17.8	25
98/038/012	2455	12.4	5.4	22.5	23	2519	11.8	5.4	22.4	24
99/041/001	2307	10.8	2.5	23.0	24	2468	14.6	3.9	24.1	24
99/056/021	2979	16.0	4.4	25.9	19	3026	15.5	4.8	27.2	22
99/060/011	2745	18.3	4.9	25.3	20	2907	16.5	4.6	26.2	20
99/061/009	2380	19.1	5.6	22.7	19	3093	18.7	4.9	23.6	21
99/062/727	2326	17.5	5.9	26.2	20	1822	17.5	5.6	26.7	19
99/090/013	1895	13.7	4.7	24.1	21	1740	14.0	4.7	24.3	22
99/093/718	1779	18.1	6.4	23.2	19	2940	18.3	6.1	25.4	19
99/093/722	2396	15.1	5.6	25.6	20	2447	14.1	4.7	25.6	21

Alpha- and beta-acids in % as is; Cohumulone in % of the alpha-acids

The „Stammesprüfung“ 2002 was harvested for the second time. In the aroma sector the breeding line 97/014/009 stood out due to good agronomic characteristics and an outstanding aroma.

In the bitter sector almost all the breeding lines are higher in their yield than the reference varieties. Some parts of the trial additionally produce very high alpha-acid values. The most interesting of these have already been put into a “Hauptprüfung”.

In addition three aroma breeding lines are being tested with higher alpha-acid contents. At the same time a descendant of Hersbrucker Spät with the reference number 98/037/021 shows the most balanced performance potential. It produces high yields, alpha-acids up to 10 % and a good aroma.

4.1.3.4 „Stammesprüfung““ 2003 in Hüll und Rohrbach

Table 4.4: Results of the 2004 harvest

Line/Variety	Yield kg/ha	α acids	α - acids	Cohu-mu-lone	Aro-ma 1-30	Yield kg/ha	α - acids	α - acids	Cohu-mu-lone	Aroma 1-30
	Hüll (clay soil)					Rohrbach (sandy soil)				
Hall. Merkur	1619	13.0	4.6	18.8	22	1226	12.5	4.2	18.7	22
Hall. Taurus	1692	16.1	4.4	21.5	21	2017	14.8	4.4	24.1	21
99/036/019	1942	8.6	6.1	31.2	25	1933	7.0	5.2	31.2	25
99/061/006	1844	15.3	3.8	26.2	22	2209	13.2	3.3	28.0	21
99/065/710	1724	13.9	4.0	22.9	21	1730	13.2	3.9	23.5	22
99/066/025	1747	13.3	4.4	20.8	20	2105	12.9	3.9	20.9	21
99/067/007	2339	12.3	4.9	24.1	22	2277	13.3	4.7	24.9	22
99/093/003	1318	14.4	4.5	20.8	19	1560	14.6	5.4	22.0	19
2000/066/724	1937	13.6	4.7	23.8	22	2662	13.3	4.1	23.2	21
2000/078/750	2226	15.6	5.3	23.8	22	2199	15.2	4.8	25.3	21
2000/109/703	2560	15.6	5.1	25.1	20	2404	13.4	4.5	25.3	22
2000/109/727	2236	15.9	6.2	23.5	20	2316	17.6	6.4	23.3	21
2000/109/728	1970	20.9	5.7	24.2	21	2468	19.8	4.3	25.6	21
2000/118/716	1925	16.4	4.5	28.4	21	1969	18.8	4.8	28.9	21
2001/070/003	1020	8.3	4.0	17.9	23	1374	8.5	2.8	18.5	23
2001/077/702	2521	11.4	6.1	31.4	21	2902	13.0	6.1	32.2	22
2001/085/016	2207	14.3	4.8	26.5	23	2491	11.4	4.9	27.7	22
2001/093/013	2137	13.0	5.5	24.1	21	2393	13.8	5.4	24.8	21
2001/093/024	1809	11.8	8.5	27.0	21	1908	12.5	8.2	27.6	22
2001/095/024	2426	12.4	3.8	24.6	20	2399	11.9	3.5	22.3	20
2001/097/004	2540	9.5	5.2	27.5	21	2386	9.4	4.8	27.4	21
2001/101/704	2412	12.3	3.8	28.1	20	2390	12.4	3.7	28.7	19

Alpha- and beta-acids in % as is; Cohumulone in % of the alpha-acids

The „Stammesprüfung“ 2003 was planted out at the beginning of June 2003 and developed very well despite the extreme drought up until the autumn. Therefore it was possible to carry out double-hill training in 2004. However, the ongoing rainfall deficit resulted in considerable drought damage in August, as the root system was not yet completely developed. In spite of this, in 2004 all breeding lines produced yields on the level of Hallertauer Merkur and Hallertauer Taurus or to some extent even considerably higher.

As far as the alpha-acid contents are concerned, only a few breeding lines could attain the level of Hallertauer Taurus. The alpha-acid contents in breeding line 2000/109/728 were outstanding with values around 20 %.

4.1.4 Results of the "Hauptprüfung" (advanced trails on farms)

4.1.4.1 "Hauptprüfung" 2000 in Rohrbach

Table 4.5 : Results of the harvests 2002-2004

Line/Variety	Yield in kg/ha			α -acids in %			kg α̃ acids per ha			Aroma 1 -30		
	2002	2003	2004	2002	2003	2004	2002	2003	2004	2002	2003	2004
Hall. Trad.	2530	1855	2201	6.3	2.3	7.1	158	42	156	27	27	26
91/013/025	2515	1625	1920	7.5	2.4	6.9	188	40	132	27	27	26
91/024/015	1645	920	953	5.1	1.5	5.0	84	14	47	27	25	26
91/033/015	1785	1215	1398	5.9	2.4	5.0	106	29	70	27	26	27
Hall. Taurus	2780	1830	2618	17.0	11.0	18.4	474	201	481	22	23	21
Hall. Merkur	2105	1455	1422	13.6	7.4	14.4	286	108	205	23	23	23
93/010/034	2450	1640	2517	13.4	11.6	16.3	329	190	409	23	20	22
93/010/036	3480	1995	2802	15.8	12.0	16.5	551	240	465	23	21	22
93/010/063	3435	2540	3234	14.2	12.5	14.0	486	319	468	22	22	22
93/024/733	2120	1045	2160	12.7	7.3	13.4	269	77	288	23	24	24
94/075/758	2545	2010	1937	15.8	12.2	19.4	402	244	375	21	21	21
94/075/761	2535	2030	2336	15.5	13.6	18.2	393	276	424	22	22	21
94/075/766	2870	2380	2265	15.8	11.6	18.2	454	277	412	22	21	22
95/094/721	3185	2520	2640	12.3	11.1	15.0	390	279	397	21	21	21
95/094/730	3040	2275	1983	14.9	8.5	14.5	453	193	287	22	23	23
95/094/850	2705	1820	1614	13.8	11.3	15.9	373	206	256	22	22	22

Alpha- and beta-acids in % as is; Cohumulone in % of the alpha-acids

Following the very good results in 2002 the extreme drought in 2003 resulted in considerably lower yields and alpha-acid values. In 2004 a storm shortly before harvesting caused considerable crop losses.

Of the three aroma breeding lines tested, the line 91/013/025 produced results comparable to Hallertauer Tradition. In addition it possesses very good agronomic properties and a low susceptibility to disease.

In the bitter sector so far only the two breeding lines 93/010/036 und 93/010/063 for which registration has been applied brought results which are about 10 % higher than the reference variety Hallertauer Taurus. The "Hauptprüfung" 2000 will be completed with the harvest in 2005.

4.1.4.2 “Hauptprüfung” 2001 in Rohrbach

Table 4.6 : Results of the harvests 2002-2004

Line/Variety	Yield in kg/ha			α -acids in %			kg α acids per ha			Aroma 1 -30		
	2002	2003	2004	2002	2003	2004	2002	2003	2004	2002	2003	2004
Hall. Merkur	2260	1630	2055	12.7	9.2	15.3	286	150	315	23	23	22
94/075/248	2750	1820	2145	12.3	8.0	14.8	338	145	318	21	22	20
94/075/806	2590	1830	2110	12.9	11.3	14.8	334	207	313	20	22	20
95/094/741	3080	2155	2510	13.4	9.5	13.5	414	205	339	23	23	22
95/094/769	2380	1825	1845	14.7	9.6	15.0	351	176	277	22	22	22
95/094/816	3820	2985	4120	15.9	11.9	19.2	605	354	790	22	20	21
95/094/834	2705	1840	2045	14.9	13.0	17.6	402	240	360	22	22	21
95/099/790	3045	2490	2750	14.4	8.8	15.2	438	220	419	22	19	21

Alpha- and beta-acids in % as is

Cohumulone in % of the alpha-acids

Also in the “Hauptprüfung” 2001 there were considerably lower yields and alpha-acid values due to the drought in 2003. As this test was placed in the middle of the breeding yard the storm shortly before the harvest only had slight effects on the yields.

The result from 95/094/816 (Herkules) definitely stands out compared with Hallertauer Merkur and the other breeding lines tested. The yield in kg α per hectare is approx. 60 % higher than the result of the second best line 95/099/790 and more than 100 % above that of the reference variety.

The “Hauptprüfung” 2001 (advanced trials on farms) will likewise be completed with the harvest in 2005.

4.1.5 Results of the production trials in the practice

4.1.5.1 Aroma and bitter lines at the Schwarzmeier farm in Rohrbach

This production trial was repeated twice with 26 breeding lines and reference varieties. Since the year 2000 it has been almost completely relocated so that all the promising aroma and bitter lines can now be tested on one field.

The result of the line 95/094/816 (Herkules) is particularly remarkable as it produced the second highest yield and the highest alpha-acid content in the whole trial.

Table 4.7: Results of the 2004 harvest

Line/Variety	Year planted	Yield kg/ha	α - acids	α - acids	Cohumu-lone	Aroma 1-30
Aroma lines:						
Perle	2002	2330	6.6	3.7	32.6	25
Hall. Tradition	1989	1966	7.0	4.5	25.2	26
Saphir	2001	2238	3.8	6.3	13.7	27
Opal	2000	2521	9.4	5.3	18.7	25
Smaragd	1997	2505	5.1	4.9	16.3	25
83/069/008	2001	2476	5.8	5.1	23.0	27
87/024/003	2002	2050	7.5	4.8	19.1	26
89/002/025	2001	2585	7.8	6.1	31.5	27
91/013/025	2000	2483	6.4	5.2	28.1	25
Bitter lines:						
Hall. Magnum	1989	3784	15.7	6.0	26.4	23
Hall. Merkur	1995	2449	17.9	5.8	20.2	23
Hall. Taurus	1994	2956	16.8	4.5	24.6	22
93/010/036	2000	3584	17.3	5.3	28.9	22
93/010/063	1997	4173	13.8	5.1	34.2	22
95/094/721	2000	3229	15.4	5.9	30.3	22
95/094/816	2001	4122	18.0	5.9	32.0	22
97/060/011	2002	3342	16.7	6.4	32.9	21
97/060/721*	2004	-	12.7	5.5	37.1	22
97/065/753	2003	2387	14.0	5.0	24.3	20
98/097/738	2003	2227	14.0	4.6	28.3	20
99/056/021*	2004	-	14.7	5.4	27.8	22
99/061/006*	2004	-	15.1	4.3	29.2	22
99/062/727	2003	2154	16.1	5.3	26.5	22
99/093/718	2003	2753	17.2	5.9	26.2	21
2000/118/716*	2004	-	14.6	6.1	30.0	21
2001/085/016*	2004	-	15.3	5.5	27.2	23

Alpha- and beta-acids in % as is * young hops

Cohumulone in % of the alpha-acids

4.1.5.2 Testing Hüll breeding lines with low cohumulone values at the Busch Farm in Hüll

Table 4.8 : Results of the harvest in 2004

Line/Variety	Year planted	Yield kg/ha	α-acids	α - acids	Cohumu-lone	Aroma 1-30
Saphir	1994	2200	3.3	6.1	13.4	28
Opal	1994	2015	10.2	5.1	18.1	26
Smaragd	1994	1800	6.1	4.7	17.6	27
Glacier	2001	2160	6.3	9.1	18.4	24
87/024/003	1994	1780	8.4	5.1	18.0	26
91/013/025	2001	2275	8.2	6.1	26.3	27
91/033/015	2001	1430	7.3	3.9	19.1	26
93/053/033	1999	2125	7.0	7.3	27.4	27
93/059/005	1999	2315	7.2	7.6	27.0	27
93/081/013	1999	1805	4.8	5.6	32.1	26
93/088/003	1999	2200	4.3	6.6	26.2	27
94/015/041	2002	1930	7.2	3.6	25.1	26
94/029/015	2002	2260	4.3	6.4	16.4	25
94/045/015	2002	2675	7.6	4.9	24.8	27
96/001/017	2003	1495	7.1	5.4	24.9	26
96/001/024	2001	2170	6.6	5.6	26.8	27
96/008/014	2001	2555	5.1	8.1	25.9	27
96/016/034	2003	1800	5.0	2.5	25.4	27
96/030/011	2001	2000	5.5	7.1	24.6	27
96/035/026	2003	1805	5.5	4.3	20.1	26
96/037/025	2003	1845	7.0	6.5	22.2	26
97/007/011	2003	2065	10.1	4.8	26.2	27
97/026/006	2003	1420	4.9	6.7	21.9	25

Alpha- and beta-acids in % as is

Cohumulone in % of the alpha-acids

The testing of aroma breeding lines at the Busch Farm began as early as 1994. In the past three years many breeding lines which did not correspond to the brewing requirements were grubbed and replaced by new breeding lines.

Meanwhile the six most promising varieties and breeding lines are being tested on large plots approx. 1 hectare in size.

4.1.5.3 Testing Hüll breeding lines and varieties at the Thuringian State Institute for Agriculture

Table 4.9: Results of the harvests 2003-2004

Line/Variety	Year planted	Yield in kg/ha		α-acids in %	
		2003	2004	2003	2004
Aroma lines:					
Perle	1988	2035	1940	2.6	6.6
Hall. Tradition	1992	-	1930	-	6.5
Saphir	2001	-	2030	-	5.3
Opal	1996	1540	1550	2.4	6.5
Smaragd	1997	1450	2320	2.3	5.3
83/069/008	2002	1390	2400	3.2	5.5
89/002/025	2002	1040	2060	3.2	5.8
Bitter lines:					
North. Brewer	1988	980	1390	6.2	7.7
Hall. Magnum	1992	2210	2210	11.8	16.8
Hall. Merkur	1996	1970	2020	9.4	15.8
Hall. Taurus	1996	-	1670	10.6	17.4
Nugget	1988	2120	2240	6.9	9.1
93/010/034	2002	1500	1400	11.2	18.3
93/010/036	2002	1910	2450	10.2	16.8
93/010/063	2002	1410	1710	6.8	17.0
95/094/721	2002	2300	2190	9.9	15.0
95/094/730	2002	2120	1980	10.1	13.6
95/094/816	2002	1910	2915	10.4	16.0

The Thuringian State Institute for Agriculture has been testing the most interesting Hüll breeding lines and varieties since the end of the 1980s for their suitability for production in the Elbe-Saale region.

The breeding lines newly planted in 2002 suffered particularly badly by the extreme drought in 2003 as the root system was not fully developed. This is particularly shown by the very low alpha-acid contents compared with the values in 2004.

4.1.6 Newly bred varieties at the Hop Research Center in Hüll

After 18 years of intensive breeding work the new aroma varieties Smaragd and Opal were released for production. Hops especially aroma hops provide the breweries with an opportunity to make their beers differ from other brands. The two aroma varieties stand out by an outstanding and very individual aroma, which shows definite differences from the aromas of the existing varieties. In this way the breweries can create new specific beers.

Opal and Smaragd produced good results in the brewing trials to date in all the beer types tested starting with the typical pils via the Bavarian light beer and the lightly hopped American-type beers up to the white beers.

In the brewing trials the beers additionally stood out due to good foam and storage stability. The new varieties are not to replace the varieties bred so far by the Hop Research Center but only to supplement them.

Table 4.10: Results of the variety Smaragd

Mean average	Yield kg/ha	α-acids	α - acids	Cohumu-lone	Aroma 1-30
2004	2180	5.6	4.4	18.1*	26
2003	1780	3.2	2.7	15.2	25
2002	2135	6.3	5.4	13.8	25
1991-2004	1955	5.6	4.6	14.9	25

* Cohumulone content a little higher when measuring with NIR method

Table 4.11: Results of the variety Opal

Mean average	Yield kg/ha	α - acids	α - acids	Cohumu-lone	Aroma 1-30
2004	2100	9.1	5.0	18.1*	26
2003	1605	4.7	3.9	14.1	25
2002	2045	8.4	5.8	14.0	26
1995-2004	2050	7.6	5.0	15.2	25

* Cohumulone content a little higher when measuring with NIR method

In the bitter sector, in December 2003 registration was applied for four breeding lines in which the breeding line 95/094/816 particularly showed outstanding results. This can be seen in Table 4.12 but also in the results of the “Hauptprüfungen” (Tables 4.6, 4.7 and 4.9). The progress in the alpha-acid yield per hectare determined in the tests to date may help to increase the competitiveness of the German hop-growers on the global market also in the future.

Therefore the board of the Society for Hop Research decided on 6th December 2004 to release the breeding line 95/094/816 for sale under the name "Herkules" (HS).

Table 4.12 : Results of the variety Herkules (95/094/816)

Mean average	Yield kg/ha	α - acids	α - acids	Cohumu-lone	Aroma 1-30
2004	3409	17.2	5.5	30.7	22
2003	2477	11.4	3.6	29.6	20
2002	3113	15.6	5.2	36.0	22
1997-2004	3057	15.6	4.9	32.8	21

In spring 2004 the big hop-trading companies received up to 1000 root cuttings each of the aroma varieties Smaragd and Opal as well as the new high-alpha variety Herkules in order to be able to supply the interested breweries with sufficient hops for brewing trials. The smaller hop merchants received the required trial samples from the HVG.

All three varieties have already been described in detail in the new atlas of varieties which appeared in December 2004.

4.2 Biotechnology

4.2.1 Working out an effective method to produce fungus resistant hops via gene transfer

Target

The aim of the research project begun on 01.11.2001 is to establish an efficient transformation method for gene transfer in hops. After establishing the transformation technique for important Hüll hop varieties resistance genes against fungal pathogens will ultimately be transferred into the hops.

Results

Producing own constructs:

Parallel to optimizing the method in autumn 2003 our own first constructs were made with a resistance gene.

The work with the hop chitinase1 gene (= *HCH1*, acc. to Henning and Moore, 1999) proved to be more complicated than first expected. It was possible to obtain the gene from Dr. Henning, Oregon State University, USA, actually as a genomic clone, not as cDNA so that the isolating and amplifying had to be done in a complex way via an induction of the transcription (by infecting the variety 'Zenith' with a resistance-breaking mildew isolate), RNA-isolation, RT-PCR and PCR within the scope of the project on hand.

The further cloning of this cDNA also proved to be difficult – presumably due to pronounced secondary structures at the end of the gene. Finally it was possible to equip the gene successfully with restriction sites and put it in a promoter. In each case the control of the constructs was made via sequencing. Finally one of these constructs was transferred into a binary vector.

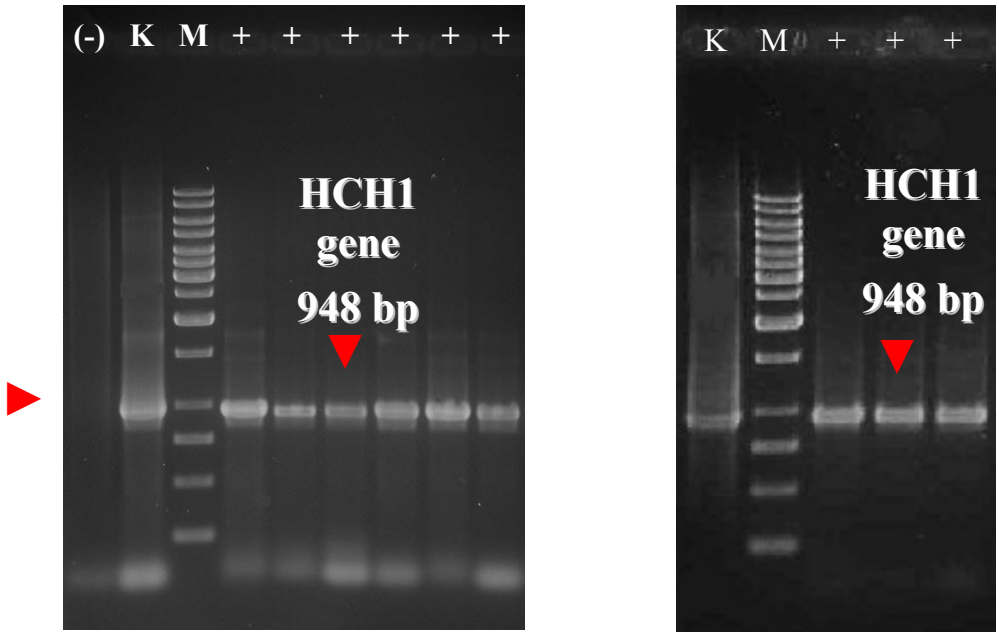
Transformation:

Internodia of the Hüll hop varieties 'Hallertauer Magnum', 'Hallertauer Mittelfrüh' and 'Saazer' were successfully transformed several times with four of the binary constructs (c1B up to c4B), which contained the resistance gene described above. Due to the gene sequence the above-mentioned authors assume that this chitinase plays a role in the resistance reaction against powdery mildew.

Regeneration and control of transgene plants:

a. GUS gene: nine transgenic 'Saazer' plants of the first test series have been successfully cultivated in the greenhouse since February 2003. Other *GUS* transgenic plants are kept in *in vitro* culture. All of them proved to be uniform, stable plants. Gene 'silencing' or the formation of chimaera has not been observed in any case so far.

b. HCH1gene: plants can be regenerated and selected from internodes. In the case of `Saazer' as well as ´Hallertauer Mfr.` several plants selected for kanamycin were tested positive by means of PCR (= DNA level) (Fig. 4.1). Consequently it was proved that these plants have integrated the chitinase gene *HCH1* in their genetic material. These transgenic plants have already been transferred to the S1 greenhouse.



(a) (b)

Fig. 4.1: Proof of the integrated chitinase gene *HCH1* in transgenic plants of the varieties `Saazer` (a) and ´Hallertauer Mittelfrüh` (b) via PCR. K = positive control with the construct of the chitinase gene; M = marker; (+) = transgenic plants; (-) = plant without inserted gene;

The activity of the transferred resistance gene is to be proved in further tests on protein (expression) level: to do this, methods to check the chitinase activity under laboratory conditions (SDS-PAGE, chitinase isolation and immuno-assay) have to be established:

- in a 'chitin binding assay' with following SDS-PAGE (Gijzen et al. 2001) it was not absolutely possible to differentiate the transgenic plants from the positive and negative controls.
- however in the first infection tests of transgenic *in vitro* plants with specific well characterized powdery mildew isolates (Seigner et al. 2002) resistant, partly resistant and susceptible genotypes were found in the Petri dish scale.

More resistance genes

More resistance genes were shortlisted parallel to the transformation tests running. Meanwhile PCR protocols were optimized for four more chitinases. Consequently these are available for future cloning and gene transfer work.

Optimizing the transformation-regeneration system:

Further phytohormone combinations (TDZ, IAA; 2-iP) and series of antibiotics (augmentin) were tested in regeneration trials. At present various modified MS media are being included in our test series.

Endogenous contamination with fungal and bacterial pathogens in the hop tissue culture continue to cause problems as well as exogenous pathogens and pests (spider mites) in the greenhouse.

Outlook

The optimizing of the regeneration and transformation protocols for Hüll varieties and particularly for the variety 'Hallertauer Mittelfrüh' are to be continued. The meristem culture is to be taken up again and extended to enable healthy plants to be made available for gene transfer tests.

Other possible tests for proof of the transferred resistance gene on protein (expression) level (e.g. Western Blot, infection tests) are being tested at present. In the case of further infection tests with defined powdery mildew races (acc. to Seigner et al. 2002) in the Petri dish scale transgenic plants with the chitinase gene from the greenhouse should be checked to find resistant, partly resistant and susceptible genotypes.

More constructs for transferring fungus-resistant genes into hops are to be made shortly. At the same time in particular the aim is to reach an increased resistance to powdery mildew by integrating this gene into the hop genome.

Literature

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Seigner, E., Seefelder, S. and Felsenstein, F. 2002. Untersuchungen zum Virulenzspektrum des Echten Mehltaus bei Hopfen (*Sphaerotheca humuli*) und zur Wirksamkeit rassenspezifischer Resistenzgene. Nachrichtenblatt des Deutschen Pflanzenschutzdienstes 54: 147-151.

4.3 Genome analysis

4.3.1 Identifying markers for powdery mildew resistance

The aim of the research project "Development of molecular markers for powdery mildew resistance to support effectively the breeding of high-quality hops" (Wifö-No. B80) is to increase the selection efficiency in breeding for varieties which are resistant to this disease. The combination (pyramidising) of several powdery mildew resistance genes in one hop individual is an important criterion in various breeding programs which can easily and rapidly be achieved using marker assisted selection.

This project focuses on working out and mapping molecular markers for the *R2* gene of the variety ´Wye Target`. In Huell, breeding for PM resistance has focused on use of the *R2* gene derived from the English cultivar ´Wye Target` and so far this gene still confers protection against powdery mildew infections. Virulent powdery mildew (PM) races, which could break the *R2* resistance, have not been detected in the Hallertau growing region so far.

Several mapping populations were created in the course of this project. First of all resistance markers were identified using segregating populations via the “bulk segregant method”. Afterwards these markers were verified with regard to their reliability in other crossings. The resistance data for the respective mapping populations were obtained in the laboratory by using the detached leaf assay. 120 plants of each mapping population were infected with characterized PM strains and monitored for infection. Segregation for resistance to PM (resistant : susceptible) was checked with a chi-square test and compared with the expected 1:1 segregation. The crossing 84/8/24 (R2) x 98/44/49 produced 53 resistant and 67 susceptible hop seedlings. With values of χ^2 =1.63; P> 0.05 and df =1 it can be assumed that a dominant major gene is involved in the resistance reaction.

During the course of this project the locus of a gene for disease resistance could be mapped for the first time in hops. Starting with a total of 620 AFLP and 17 microsatellite markers, it was possible to construct a male and a female genetic map using the JoinMap 3.0 software for the linkage analysis. From a total of 20 hop chromosomes, 17 coupling groups could found. Using a LOD of 6, 303 AFLP and 18 SSR (simple sequence repeat) markers could be assigned to 9 female linkage groups. All these markers describe 320.6 cM of the genome. The male map consists of 150 AFLPs and 15 SSRs and covers 237.4 cM of the male genome. The *R2* resistance gene and several powdery mildew resistance markers could be mapped on the largest female linkage group with altogether 101 cM (Fig. 4.2). The markers 172_N_180 and 67_N_212 flank the *R2* gene with 1.7 cM respectively. The resistance markers could be verified and confirmed in the crossings Target (*R2*) x 93/36/2; Target (*R2*) x 96/9/1 and Buket x 98/ 27/ 731 (*R2*).

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

The aim of this research project is to develop molecular markers for various important brewing components, which should increase the selection efficiency for excellent brewing quality in our hop germplasm. The focus is on the alpha- and beta acids, cohumulone and the xanthohumol, meanwhile this prenylflavonoide is also very important for breeding due to its anti-carcinogenic effect.

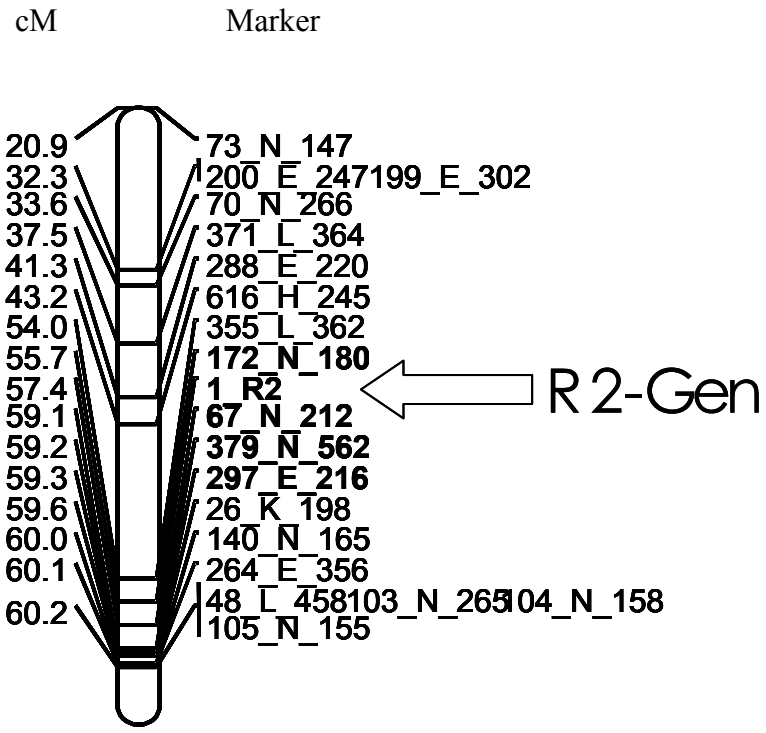


Figure 4.2: Mapping the *R2* powdery mildew resistance gene in the hop genome

From all phenotypical data gained so far in the field-monitoring, the colour of the bine proved to be a characteristic which is very easy to assess and above all which is easy to reproduce. Variations in the colour of the bines (0-4) in clones of the same plant were considerably less in comparison to their siblings. There seems to be less influence of the environment on this trait, and consequently this characteristic has good pre-requisites that a molecular marker can be identified for the colour of the bine. The planned investigations on the internode length and the length of the laterals proved to be very difficult and was therefore stopped after a short time. Strong fluctuations even occurred in genetically identical individuals. Additionally an extensive assessment of the cones was carried out for all 1120 hop samples from Hüll and Rohrbach. The individual parameters scored were: disintegration of the cones, size and form of cones, leafiness and diseases of the cones.

Now all hop samples from all the locations are analyzed using HPLC. 660 markers have so far been scored for the genetic map based on 100 AFLP primary combinations. 39 alleles could be detected with 15 micro-satellites.

4.3.3 Practical use of genome analysis in breeding, propagation and in the hop industry

Molecular markers could be applied successfully to test varieties for their genetic identity for the hop industry. Above all, this concerned problems relating to purity of variety which could be solved via AFLP and micro-satellite analyses.

In the breeding work at Hüll it was possible to select male hops via DNA markers from a group of disease-resistant seedlings which had not yet revealed their sex by late autumn.

Furthermore a start was made to update the existing hop phylogenetic tree. For this project, 265 AFLP markers were produced using 28 AFLP primary combinations. Currently these markers are used to determine the phylogenetic relationship of more than 120 hop varieties from the Hüll germplasm collection. Data from the phylogenetic tree of the Hüll hop germplasm was used so often to select specific hops for various research projects.

The most important example of applied breeding research last year proved to be fingerprint analyses for the new varieties ´Opal` and ´Smaragd` which were carried out during their successful launching on the market.

5 Hop Cultivation, Production Techniques

Johann Portner, Dipl. Ing. agr.

5.1 Nmin tests 2004

Nitrogen fertilization according to DSN (Nmin) was introduced into the practice and has become an integral part of the fertilizer planning. In Bavaria 4029 hop yards were tested in 2004 for their Nmin content and a fertilizer recommendation was compiled.
The development of a number of the samples for the Nmin test has been drawn up in Table 5.1. It is noticeable that after years with low Nmin values very high contents of nitrogen were found in the soil in spring 2004. The high Nmin values can be traced back to the dry year in 2003 when nitrogen was transported upwards in the capillary water, fertilizer was only partly dissolved in the soil and due to the low yields less N was absorbed.

There were no changes compared with the previous years with regard to calculating the requirements for N fertilizer and the fertilizer recommendations.

Table 5.1: Number of the Nmin tests and average Nmin contents as well as fertilzer recommendation in hop yards in the Bavarian production regions

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
1993	3149	124	146
1994	4532	88	171
1995	4403	148	127
1996	4682	139	123
1997	4624	104	147
1998	4728	148	119
1999	4056	62	167
2000	3954	73	158
2001	4082	59	163
2002	3993	70	169
2003	3809	52	171
2004	4029	127	122

In Table 5.2 the number of the hop-yards tested, the average Nmin value as well as the average nitrogen fertilizer recommendation calculated thereof is for the Bavarian production

regions based on the administrative districts. It can be noted that the admin. districts of Eichstätt and Roth show the highest Nmin values and the admin. district of Hersbruck the lowest Nmin value. Appropriately the recommendations for nitrogen fertilizer recommendations are the other way round.

Table 5.2: Number, average Nmin contents and fertilizer recommended in the hop yards in the admin. districts and production regions in Bavaria in 2004

Production area	Admin. district	Number of samples	Nmin kg N/ha	Fertilizer recommended kg N/ha
Hallertau	Kelheim	1571	123	128
	Pfaffenhofen	1291	124	122
	Freising	448	141	109
	Landshut	292	107	132
	Eichstätt	253	156	97
Average	**Hallertau**	**3855**	**127**	**122**
Spalt	Roth	143	156	101
	Weißenburg-Gunzenhausen	0		
Average	**Spalt**	**143**	**156**	**101**
Hersbruck	Hersbruck	31	71	141
Bavaria		**4029**	**127**	**122**

In Table 5.3 the values are listed according to varieties.

Table 5.3: Number, average Nmin contents and fertilizer recommended for various hop varieties in Bavaria in 2004

Variety	5.1 Number of samples	Nmin kg N/ha	Fertilizer recommended kg N/ha
Nugget	100	95	147
Hallertauer Merkur	43	99	141
Hallertauer Mfr.	506	107	126
Hallertauer Magnum	1016	109	135
Saphir	31	116	31
Brewers Gold	10	120	126
Hallertauer Taurus	382	122	128
Target	16	128	122
Hersbrucker Spät	269	129	121
Hallertauer Tradition	501	138	115
Spalter Select	236	144	113
Perle	725	151	103
Spalter	49	161	99
Northern Brewer	133	171	101
Others	12	94	146

5.2 Accumulation, volume weight and nutrient contents of bine choppings at the time when they are distributed

The recycling of nutrients from organic fertilizers or crop residues must be taken into account when ascertaining the fertilizer requirements. As bine choppings are not transported back into the hop-yards to the same amount in which they accumulate it is necessary to make a special calculation to determine the quantities and nutrient contents.
The aim of the tests was to find out the extent the bine choppings change in volume, weight and nutrient content through the hot rotting phase. As weighing organic fertilizers rarely takes place in agricultural facilities but the volume of the transporting vehicles is known, it was also interesting to find out the volume weight of the bine choppings at the time when they are distributed.

Method

The bine choppings of the varieties Perle, Hallertauer Magnum and Hallertauer Taurus from hop-yards of a defined size were stored on special heaps out in the open as is usual in the practice. When the harvesting work was finished the bine choppings were loaded with the front loader onto the fertilizer or compost distributor, weighed and driven to the hop-yards. The conversion to volume weight was made with defined loads (level loading) via the calculation of the total number of transports.

Samples to determine the nutrient content were drawn from various places in the heap and this was repeated six times. After pre-drying and separating the wire pins the nutrient contents were analyzed in the laboratory in Freising.

Results

The **accumulation** of bine choppings fluctuated considerably according to the respective farm and variety. Despite good yields Farm A suffered more from drought. In the size of the bines and/or habitus there were consequently considerable differences in the case of the variety Hallertauer Magnum, which were reflected in the accumulation of bine choppings. The average accumulation of 130 dt/ha bine choppings in the Green Pamphlet was confirmed taking the habitus into account, although corresponding deductions must be made for hop stands and varieties with weaker bine forms.

The **volume weight** of the bine choppings ascertained at the time when they were distributed fluctuated according to the respective farm and variety between 320 and 363 kg/m^3. If you take into account a certain amount of compacting or overloading compared with the size of the transporting vehicle then a volume weight of 350 kg/ m^3 can be assumed on an average.

The **nutrient contents** fluctuated particularly strongly particularly with regard to nitrogen between the repetitions but also between the varieties and farms.

Further analyses must be made in order to deduce universally applicable averages.

When comparing with the amounts in the "Green Pamphlet" it can be noticed that there are greater deviations in the K_2O and MgO content. Further analyses could contribute to clarifying the differences.

Table 5.4: Comparing the analyses of bine choppings with the values in the "Green Pamphlet"

	Farm A			Farm B	Average	
	PE	Taurus	HM	HT	Tests 2004	Green pamphlet
Harvest	28.08.-1.09.	8. – 11.09.	2. – 8.09.	7. – 9.09.		
Distributed	16.09.	16.09.	16.09.	21.09.		
Rotting (Ø days)	17	7	11	13	**12**	**-**
Cone yield (kg/ha)	1946	2667	2100	2797	**2377**	**2000**
Accumulation (dt/ha)	94	124	111	156	**121**	**130**
Bine size Habitus	Ø	Ø	Unter Ø	Über Ø		
Volume weight (kg/m^3)	363	347	320	324	**339**	**-**
Nutrient contents (kg/t) At 27 % TS (Ø 6WH) pH value	6.7	6.8	6.9	6.6	**6.8**	**-**
Total N	8.2	5.4	5.6	7.4	**6.6**	**5.5**
NH_4-N	0.4	0.3	0.3	0.4	**0.4**	**-**
P_2O_5	2.0	1.4	2.0	1.9	**1.8**	**2.0**
K_2O	5.1	4.2	4.1	6.4	**5.0**	**7.7**
MgO	3.1	2.7	2.8	2.3	**2.7**	**1.2**
S	0.8	0.6	0.7	0.6	**0.7**	**-**

5.3 Wetting tests to optimize the application technique regarding spraying equipment

Tests to optimize the spray deposit have already been carried out in the 1970s. At that time interest was focused upon influential factors such as amount of water, traveling speed, blowing capacity and working width. With the introduction of the TurboDrop jets in the 1990s and increasing problems with the control of pests especially in the top regions of susceptible varieties, the problem of improving the wetting was approached anew. With the present generation of jets there are other problems relating to the influential factors of the number and arrangement of the jets and the spraying pressure.

To locate the deficits in the spray deposit in 2004 the first deposit measurements were made when the spraying equipment was in use. At the same time strips of water-sensitive paper approx. 6 x 2 cm were fastened and repeated four times on hop leaves in the lower, middle and upper areas of the bines as well as on one shoot leaf on the under and upper sides of the

leaf, the colour of which change from yellow to blue when they come into contact with water. After the application with a working width of 6.40 m the dry paper strips were taken off, labeled and preserved in air-tight containers for later evaluation.

The spray deposit determined as a percentage was made by using a scanalyzer. At the same time the original picture taken by the camera is converted into a colour-graded picture (ref. Diag. 5.1) and the colour grades are quantified proportionally blue (=wetted), yellow (=not wetted) and white (= background).

Figure 5.1: Original and colour-graded scanalyer picture

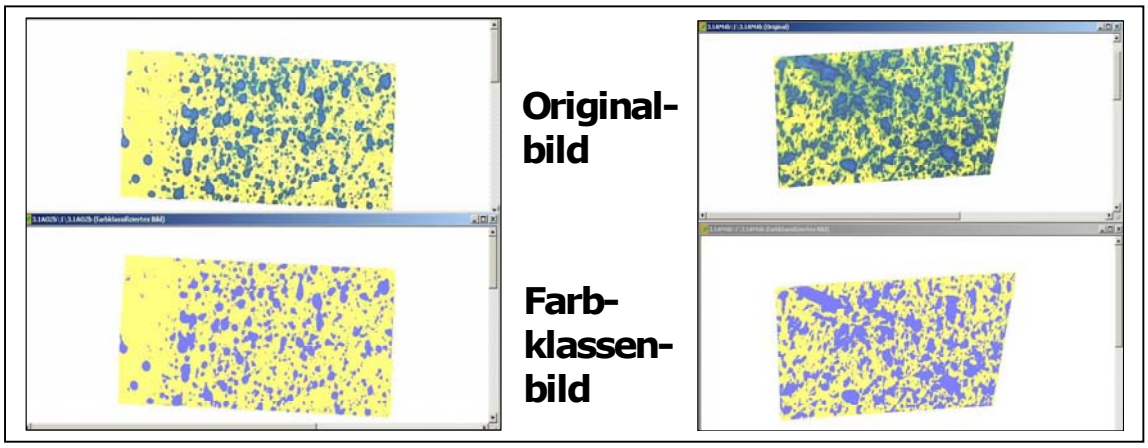
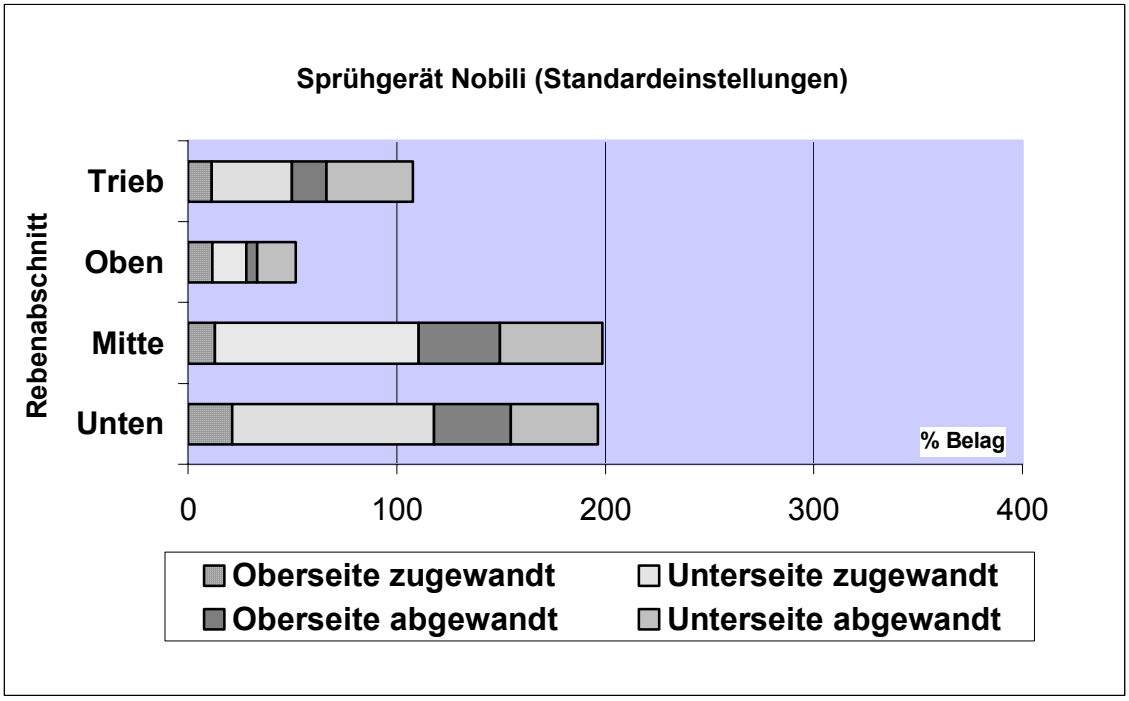


Figure 5.2: Wetting shown as a percentage of the test spraying in Hüll under standard conditions



The wetting with the test spraying in Hüll is shown as a percentage in Figure 5.2. The application was carried out on 30.07.04 for the variety Hallertauer Mfr. with 2400 l water, 2 km/h traveling speed, 24 bar pressure and with the standard jets 1 recommended in the "Green Pamphlet". Considerably poorer wetting in the top region (top, shoot) is noticeable; this corresponds with the test results in earlier years. It can also be seen that on the leaves of the "bines turning away" (between the aisles) less deposit was measured than on the "facing side" (in the aisles). Evaluations on all the test rows show a 45% wetting for the bines in the aisle while on an average the training wires between the aisles were only wetted to 33 %.
In a test variant the jets were each reduced by one size and the pressure respectively increased. As a result the average spray deposit increased by 11 %, in the top region (top + shoot) the deposit was even increased by 22 % to 38 % .

A comparison of the test spraying in Hüll (Nobili), equipped with standard 14 jets, with a sprayer which has an additional jet on right and left in the upper part, led to the following result. The total wetting was 44% using the sprayer with the 16 jets (Nobili: 37 %). The top region (top + shoot) was definitely wetted better at 36 % than 22% with the Hüll spray. The wetting of the ground including losses through drips was less.

The test results have shown that there is room for improvement in the application technique and jets recommended up to now. Prerequisite for an optimum wetting is that the apparatus functions perfectly (regular "sprayer MOT") and the amount of water, working breadth, traveling speed and air capacity are best suited to the conditions of use. In addition to this the spraying pressure plays a more important role for the generation of the injector jets which are now state-of-the-art in hop-growing. Furthermore, according to the respective conditions of use the number and arrangement of the jets must be varied better than has been the case in the past. Respective recommendations should be worked out in the continuation of the tests.

5.4 Hop stripping by singeing

Singeing was used to strip the hops in a practice test. The aim was to collect preliminary experience with the technique, to see the effects and ascertain the cost of this method.

4 single burners were attached to the front hydraulics of the tractor (ref. Diag. 5.3) for each side row. By hydraulically adjusting the height and sides of the burners it was possible to take into account the development stage of the hops and the optimum distance and height for treatment could be set. As a source of energy 9 propane gas canisters each with 33 kg gas were transported in the rear part. The application took place in front of the fields when the height of the hop growth was approx. 3 m. With a traveling speed of 3.2 km/h a the rate of area covered was 0.8 ha per working hour. The consumption of propane gas was 30 kg /ha, whereby energy costs of approx. € 30/ha were incurred for the singeing.

Figure 5.3: Burners for singeing mounted on the front of the tractor

At present the good rate of area covered is restricted due to the propane gas canisters icing when in use. Consequently the gas supply to the burners is inadequate and the singeing is forced to break off.

Figure 5.4: Effects of the singeing 1 hour after application

5.5 Stripping hops with Reglone and various spraying agents

The dosage of additives to herbicides to improve wetting, absorption and effectiveness is being discussed in the practice. By reducing the amount of spray due to part of the yard being stripping by singeing the result led to the idea to keep the concentration of active ingredients in the spray liquid by reducing the water required or to obtain improved effectiveness by using additives. These problems are to be clarified in a field trial.

The spraying down test was carried out with the variety Taurus in Osterwaal on Friday, 23.07.04 with a under-stem spraying attachment on the front of the tractor with 2 TD jets (04) per side. The conditions were optimum. Preceding rainfall had soaked the leaves. There was little weed spread; on the other hand lower shoots and low hanging laterals covered up to one-third of the row. The test procedure and monitoring can be seen in the following tables.

Table 5.5: Test plan

No.	Herbicide +Additive	Requirement/ha	Amt. of water/ha
1	Reglone +Adhäsit	1.8 l +0.1 %	500
2	Reglone +Adhäsit	1.5 l +0.1 %	500
3	Reglone +Adhäsit	1.2 l +0.1 %	500
4	Reglone +Oleo FC	1.5 l +0.1 %	500
5	Reglone +Arma	1.5 l +0.03 %	500
6	Reglone +Break Thru	1.5 l +0.03 %	500
7	Reglone +Arma	1.5 l +0.03 %	300
8	Reglone +Break Thru	1.5 l +0.05 %	300

Result:

Good effects were achieved in all variants due to the favourable test conditions. Only the 3rd plot with the reduced amount of Reglone visibly dropped in effectiveness. The wetting and penetration agent Arma and the Super-Spreiter Break Thru S 240 produced equally good results despite reducing the water requirement by 40 %.

Table 5.6: Monitoring leaf for the Reglone test with wetting agents in Osterwaal 2004

	1			2			3			4			5			6			7			8		
		DG	Monitored		DG	Monitored		DG	Monitored		DG	Monitored		DG	Monitored		DG	Monitored		DG	Monitored		DG	Monitored
		%	29.7./9.8.		%	29.7./9.08.		%	29.7./9.08.		%	29.7./9.08.		%	29.7./9.08.		%	29.7./9.08.		%	29.7./9.08.		%	29.7./9.08.
1. Repeat	S			S			S			S			S			S			S			S		
	V	**5**	10 / 10	V	**5**	9 / 10	V	**5**	7 / 10	V	**5**	10 / 10	V	**10**	10 / 10	V	**10**	10 / 10	V	**7**	10 / 10	V	**7**	10 / 10
	JR			JR			JR			JR			JR			JR			JR			JR		
	TN			TN			TN			TN			TN			TN			TN			TN		
	ST	**15**	7 / 9	ST	**15**	8 / 9	ST	**20**	5 / 8	ST	**20**	8 / 9	ST	**20**	7 / 9	ST	**20**	8 / 9	ST	**15**	7 / 8	ST	**17**	8 / 9
	BT	**7**	7 / 9	BT	**7**	6 / 8	BT	**7**	5 / 8	BT	**7**	8 / 8	BT	**7**	7 / 9	BT	**10**	7 / 9	BT	**5**	8 / 8	BT	**7**	8 / 9
2. Repeat	S			S			S			S			S			S			S			S		
	V	**5**	10 / 10	V	**5**	9 / 10	V	**5**	7 / 10	V	**5**	10 / 10	V	**10**	10 / 10	V	**10**	10 / 10	V	**10**	10 / 10	V	**7**	10 / 10
	JR			JR			JR			JR			JR			JR			JR			JR		
	TN			TN			TN			TN			TN			TN			TN			TN		
	ST	**15**	7 / 9	ST	**15**	8 / 10	ST	**20**	6 / 9	ST	**20**	8 / 9	ST	**20**	6 / 8	ST	**15**	8 / 9	ST	**15**	8 / 8	ST	**15**	8 / 10
	BT	**7**	7 / 9	BT	**7**	7 / 9	BT	**7**	5 / 8	BT	**7**	7 / 8	BT	**10**	6 / 7	BT	**7**	7 / 9	BT	**7**	7 / 8	BT	**7**	8 / 8
3.Repeat	S			S			S			S			S			S			S			S		
	V	**5**	10 / 10	V	**5**	9 / 10	V	**5**	7 / 10	V	**5**	10 / 10	V	**7**	10 / 10	V	**7**	10 / 10	V	**7**	10 / 10	V	**7**	10 / 10
	JR			JR			JR			JR			JR			JR			JR			JR		
	TN			TN			TN			TN			TN			TN			TN			TN		
	ST	**15**	7 / 9	ST	**15**	8 / 10	ST	**20**	6 / 9	ST	**20**	8 / 9	ST	**20**	7 / 9	ST	**20**	8 / 10	ST	**17**	8 / 9	ST	**20**	8 / 9
	BT	**7**	7 / 10	BT	**7**	8 / 9	BT	**7**	5 / 7	BT	**10**	7 / 7	BT	**7**	7 / 8	BT	**10**	7 / 8	BT	**5**	8 / 8	BT	**7**	7 / 8
4. Repeat	S			S			S			S			S			S			S			S		
	V	**5**	10 / 10	V	**5**	9 / 10	V	**5**	7 / 10	V	**5**	10 / 10	V			V			V			V		
	JR			JR			JR			JR			JR	**7**	10 / 10	JR	**7**	10 / 10	JR	**10**	10 / 10	JR	**10**	10 / 10
	TN			TN			TN			TN			TN			TN			TN			TN		
													AW			AW			AW			AW		
													Sch			Sch			Sch			Sch		
	ST	**20**	7 / 8	ST	**20**	7 / 9	ST	**20**	6 / 9	ST	**20**	7 / 9	ST	**15**	7 / 9	ST	**15**	8 / 9	ST	**15**	8 / 10	ST	**15**	8 / 9
	BT	**10**	7 / 8	BT	**10**	7 / 9	BT	**7**	5 / 9	BT	**7**	7 / 9	BT	**7**	7 / 8	BT	**10**	7 / 8	BT	**7**	7 / 9	BT	**7**	8 / 9

Explanation: S = mustard, V = chickweed, JR = annual panicle, T = dead nettle, AW = field bindweed, Sch = horsetail, ST = laterals, BT = lower shoots, Monitored: 1 – 10 (10 = 100 % effectiveness)

5.6 Appearance and control of the corn borer (*Ostrinia nubilalis*) in hops

Extract from a thesis by Stephan Schinagl, FH Weihenstephan.

The corn borer (*Ostrinia nubilalis*) which is classified as a lesser harmful pest is mentioned in specialist hop literature. After its appearance in the 1940s damage to hops was again reported in 2002 particularly in the Jura region.

The mapping of areas where attacks by the corn borer were recorded in Bavaria shows that the Hallertau and Spalt hop production regions are within the areas affected.

Damage:

Damages to hops are mainly caused by the borer larvae eating the marrow inside the shoots. By damaging the supply channels the supply of water and nutrients as well as the assimilation transport are interrupted. When the larvae bore in and out at the nodium laterals are often damaged and then die off with the cones. As a consequence this means that varieties with thin bines such as Perle or Hallertauer Tradition react considerably more sensitively than varieties with strong bines such as Spalter Select or Hallertauer Magnum.

Initial situation:

The monitorings in March 2004 after the hops were pruned mechanically showed, as in the previous year, no sign that corn borer larvae hibernate beneath the soil in the cut rhizomes and/or in the root stock.

Numerous larvae were found hibernating in the maize stubble on the ground in neighbouring fields where maize had been grown in 2003. The following tables show the classification and initial potential of larvae for the expected flight of moths from the monitored areas.

Table 5.7: Classifying the initial potential for the expected flight

Moths expected flight	low	medium	high
No. of larvae/100 m^2	0 – 10	11 – 30	> 31

Table 5.8: Monitoring results of the areas in the Nietenhausen location

Initial-areas	Covered with maize straw or hop stalks %	Stems; Stalks / 100 m^2 n	No. of larvae / 100 m^2 n	Moths flight expected Acc. toTab. 5.
Hops: H.Taurus	4	40	0	low
Hops: Perle	4	40	0	low
Winter wheat (in S. part)	6 – 7	99	37	high
Winter wheat (in N. part)	5 – 6	86	15	medium

Pheromone traps and determining the race:

So as not to affect the various pheromones, the dispensers for the Z-race, E- + Z-races and E-race were set out on 1.06.04 on three different plots at a good distance from one another in the wheat plots where the preceding crop was maize.

The first male moth was caught at the Nietenhausen location (Central Hallertau) on 28.06., and at Ried (Jura) on 14.07. Due to the cool temperatures the flight climax was reached very late between 14.07. and 18.07. (2002 – 5.07., 2003 – 23.06. according to the Agricultural Office in Ingolstadt).

The only catches recorded in the pheromone traps were for the Z-race. At the Ried location 7 and 19 at the Nietenhausen location.

Live moths caught by means of light traps:

The light trap with cage was looked after in cooperation with Herrn Prof. Dr. Schuphan from the Rheinisch-Westfaelisch Technischen Hochschule (Technical University) Aachen .

The first moth was caught on 6.07. at the only location in Nietenhausen. Altogether 24 male and 49 female moths were caught by 30.07. Hop plants were brought into the walkable cage, approx. 2 m high so that the eggs which are very difficult to find out in the open due to the height of 5-7 metres at which they are laid, could be found with specific numbering.

Questions such as: Hatching out and boring through the leaf to the upper side of the leaf, as with maize or out of the egg on the underside of the leaf, initial nourishment, initial boring etc. had not been answered for hops from the references in literature up to now.

Although female moths had already been present in the cage for a long time the first eggs were monitored on 26.07. The monitoring results out in the open produced an explanation for this. There too only strong plants are accepted. The leaves with eggs had a minimum size of 30 cm^2. Only when the strongest young plant in the cage had reached this leaf size, were eggs laid there. Altogether 13 sets of eggs laid only on these strongest hop plants were counted up until the end of the flight phase.

The larvae hatch out the eggs on the underside of the leaves, feed themselves by eating a hole on the underside of the leaves and after 1-2 days bore their way into the protecting basis of the shoot.

Once again a word of thanks is expressed here for the loan of the light trap and for the good cooperation with Professor Dr. Schuphan's team.

Assessing attacks in stands of cultivated hops before the harvest

There is a correlation between the initial potential of hibernating larvae and the following attacks of corn borers from neighbouring maize and hop areas. The initial potential and the frequency of attacks on the maize test areas is shown in Table 5.9.

Table 5.9: Initial potential and frequency of attacks in the maize test areas

	Ried location		Nietenhausen location	
	Initial potential Tab. 5.7	**Frequency of attacks (grains) %**	**Initial potential Tab. 5.7**	**Frequency of attacks (silo maize) %**
North	low	6	medium	75
East	low	8	medium	56
South	low	14	high	5
West	low	9	high	35
Ø total area	**low**	**9,25**	**medium**	**42,75**

At the Ried location the attacks on hops were also lower than at the Nietenhausen location.

In the zero plots (no direct or indirect control measure) at the Ried location only in one of three repeats with 48 plants was an infected trained bine monitored in the variety Perle (PE).

In the variety Spalter Select (SE), the development of which was ideal at the time of the flight climax, each plot (with 72 plants) was affected. All in all 5 infected plants were monitored here. The variety Hallertauer Taurus (TU) showed no attacks at the Nietenhausen location. The monitorings at the time of the flight climax showed small leaves in the upper third part of the plants <30 cm ^{2}. At the time when the eggs were laid, the variety Perle had developed ideally. The monitoring result for this variety before harvesting is shown in Table 5.10 representative for all locations and varieties.

Table 5.10: Attacks and damage to the zero plot (Nr. 1a – c) at the Nietenhausen location, test area (Perle)

Date of monitoring: 23.08.2004 Plants examined / Plot: 84

	Boreholes visible on plant				**Plants with damages**		
Repeat	**No. of plants**	**Boreholes/ plant**	**Boreholes height in m**		**No. of plants**	**Development Habitus**	**Aspect of damage**
			oberstes	**unterstes**			
1 a	1	4	3,5	2			
	2	12	7	4	1	Very good; 3 shoots	Damaged cones eaten by larvae
	3	6	7	4	2	Good: 3 shoots	Lateral died off
	4	7	7	4			
1 b	1	4	4	3,5			
	2	11	7	4	1	Good; 3 shoots	Lateral died off
	3	7	5	4	2	Average; 2 shoots	Lateral died off
	4	3	5	4			
	5	5	6	4			

	Visible boreholes on plant				Plants with damages		
Repeat	**No. of plants**	**Boreholes/ plant**	**Borehole height in m**		**No.of plants**	**Development Habitus**	**Aspect of damage**
			highest	**lowest**			
1c	1	5	5	4,5	1	Very good; 3 shoots	Damaged cones
	2	10	7	4	2	Medium; 3 shoots	Top (20cm) begins to die off
	3	3	5,5	5	3	Gut; 2 Triebe	Lateral died off
	4	4	6,5	5			

Combating the *Ostrinia nubilalis* in hops

In the test at the Ried location work was done with wasps *Trichogramma evanescens* (Trichocap from Messrs. Landi Reba, Schweiz).

The insecticide Baythroid 50 and the *Bacillus thuringiensis* preparation Dipel ES was used in Nietenhausen.

The specific areas were deliberately separated to avoid adverse effects from spray blowing into the sensitive trichogramma areas.

Table 5.11: Combating methods, monitorings and processing costs

Location	**Variety**	**Method**	**Stck /ha l/ha**	**Distribution date**	**Ø Attacks %**	**Degree of effectiveness**	**Product costs**	**Application costs €/ha**	**Cost of method €/ha**
Ried	PE/SE	Untreated	0	-	1.79	-	-		
	PE	Trichocap Trichocap	600 600	02.07. 12.07.	0	100	369.--	182.80	551.80
	SE	Trichocap Trichocap	600 600	02.07. 12.07.	0.46	66.9	369.--	182.80	551.80
Nie-ten-hausen	PE	Untreated	0	-	5.16	-	-	-	-
		Baythroid 50	1,0 1,0	18.07. 30.07	0	100	64.20	39.60	103.80
		Dipel ES	2,0 2,0	18.07. 30.07.	0.40	92.25	159.20	39.60	198.80
	TU	Untreated	0	-	0	-	-	-	-
		Baythroid 50	1,0 1,0	18.07. 30.07.	0	-	64.20	39.60	103.80
		Dipel ES	2,0 2,0	18.07. 30.07.	0	-	159.20	39.60	198.80

The informative value of the monitorings is limited due to the low initial attacks in the hops. It can be clearly seen that the chemical control must be judged more favourably compared with the biological method not only in its effectiveness but also as far as the cost is concerned.

Description of attacks:

In 2004 there were no losses in yield or quality through cones which had died off up until the varieties examined were harvested. Due to the late flight climax and therefore the shorter time for the larvae to cause damage up to the harvest it was decided not to harvest the plants marked as infested in the untreated control plots. These plants were taken down approx. three weeks after the harvest to judge which damages might have occurred if the flight climax had been approx. three weeks earlier.

At this point in time, of the 11 plants monitored there were

- 2 trained bines each of which had a dead top 1.5 m long,
- 3 trained bines had 7 dead laterals,
- 6 trained bines had no signs of anything dying off,
- all were very brittle at the damaged nodium.

The larvae could no longer be found hibernating in the base of the shoots but in the remaining dry stems, as a rule covered up.

The boreholes could be found 7 m – 2.5 metres above the ground. Therefore it can be assumed that hardly any larvae have a chance of surviving technical harvesting.

Conclusion:

The thesis provides answers to many open questions concerning the hops culture and is therefore a valuable aid for further observation of the pest *Ostrinia nubilalis*.

By including the monitorings of the previous year the result obtained is that

- the initial potential in the hibernating material determines the number of sets of eggs laid,
- no variety differences are present in the sets of eggs laid but the development stage of the hop plants is decisive for the flight climax,
- the height of the first borehole generally determines where the eggs are laid,
- the larvae feed on the leaf material after they have hatched,
- the larvae in the shoots eat their way upwards as well as downwards,
- a long period of time between flight climax and harvesting decides on the yield and/or quality losses,
- combating them with biological and chemical methods is possible but the costs are widespread,
- furthermore attention must be paid to hygiene when working in maize straw and when disposing of hop stems.

5.7 Developing an EDP water management model for controlling irrigation in hops

As the yields and the alpha-acid contents drop very considerably in dry years, the irrigation in hop-growing gains more and more in significance. Irrigation is authorized by the water authority if sufficient ground water is available near the surface. However the availability of water is the limiting factor for most farms. For this reason the optimum point of time for watering and the optimum quantities are to be calculated in the future by means of an EDP water management model.

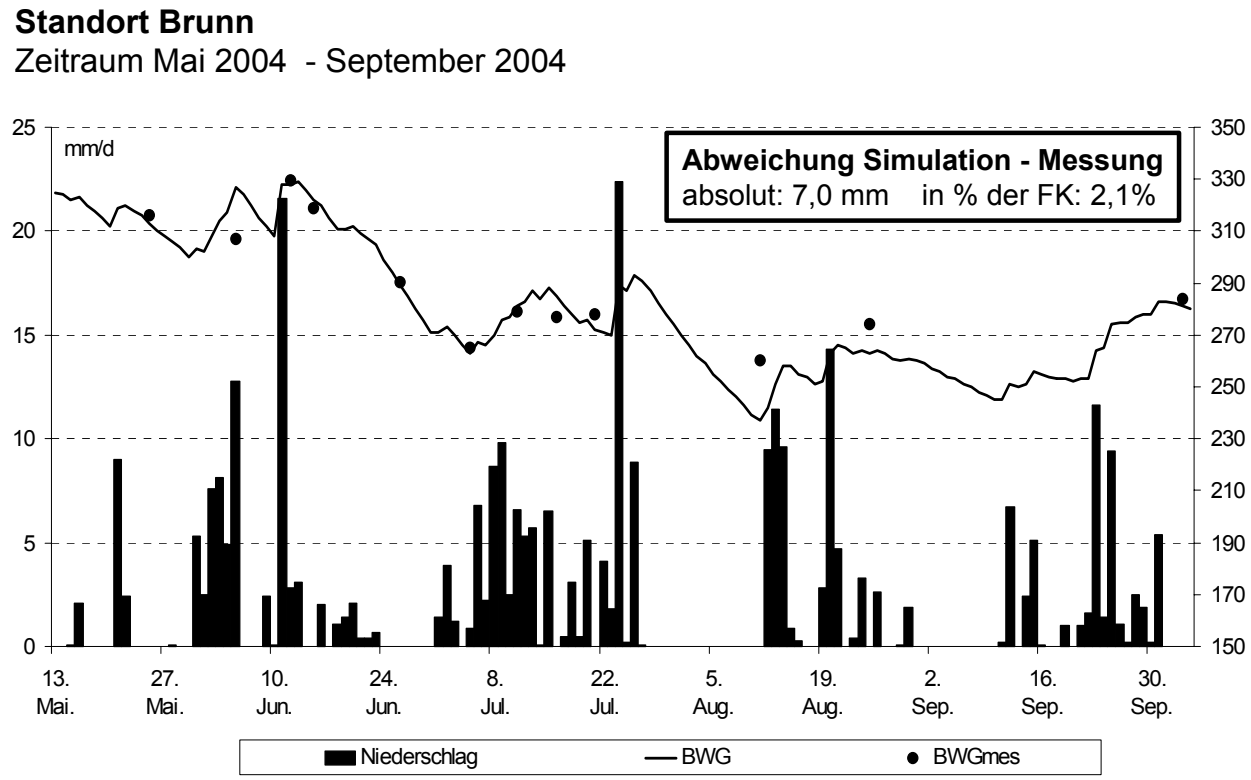
Within the scope of a project supported by the HVG producer group, the EDP water management model evolved by Dr. Rötzer which can assess the water in various cultures during the vegetation period is to be applied to hops. In daily steps the model calculates from meteorological data the potential and actual evaporation, the interception, the ground water balance, the drainage as well as the irrigation necessary. At the same time the type of soil, the phenology of the hops and the optional irrigation is taken into account.

3 different locations with various types of soil were selected to calibrate and validate the model. A sandy soil in Eichelberg, a loess soil in Brunn and a loamy clay soil in Osterwaal. The cardinal values such as type of soil, rooting depth and usable field capacity were ascertained for the test locations at the Institute for Agrar Ecology.

From mid-May onwards the water content of the soils on the hop row and in the tractor path was determined each week at the locations to a depth of 90 cm using the dry box method. When making the calculation the model takes into account the development phases at start of growth, at 50% of trellis height, at the finish of longitudinal growth, full blossom and harvest. Therefore the phenology of the hops in 2004 was recorded in writing as well as in pictures and integrated in the program. The interception, a criterion for the amount of rainfall which remains on foliage and bines, was determined with the aid of rain meters which were set on the hop rows in the hop-yard and outside the hop-yard. The climate data from the Hüll and Stadelhof stations was used to calculate the contents of ground water. Figure 5.5 shows the measured and simulated contents of ground water at the Brunn location. The fluctuations between the measured and simulated values were 2-6 % at the 3 test locations.

Before it is introduced into practice in 2005 another calibration and validation of the model is to be held with new test series and research will be made at 2 locations when the optimal time for irrigation is.

Figure 5.5: Rainfall, measured and simulated contents of ground water at the Brunn location from May 2004 – September 2004



5.8 Trials to train two or three bines with the varieties Hallertauer Taurus and Saphir

The aim of these trials with the hop varieties Hallertauer Taurus and Saphir is to research the influence of two or three trained bines on the yield and alpha-acids. The trials will only be evaluated finally after the results collected over three years.

Figures No. 5.6 and No. 5.7 show a slight increase in the yield (kg/ha) in the 2004 crop result for both varieties taking the mean over three repeats and in the alpha-acids (%) in the case of the three-bine variant. From this the tendency towards a higher alpha-production (kg α/ha) can be calculated with 3 bines per training wire.

The exterior quality was above-average good in all variants with the exception of wind damage in the variety Hall. Taurus.

Figure 5.6: Crop result Hallertauer Taurus / Trial with two or three trained bines

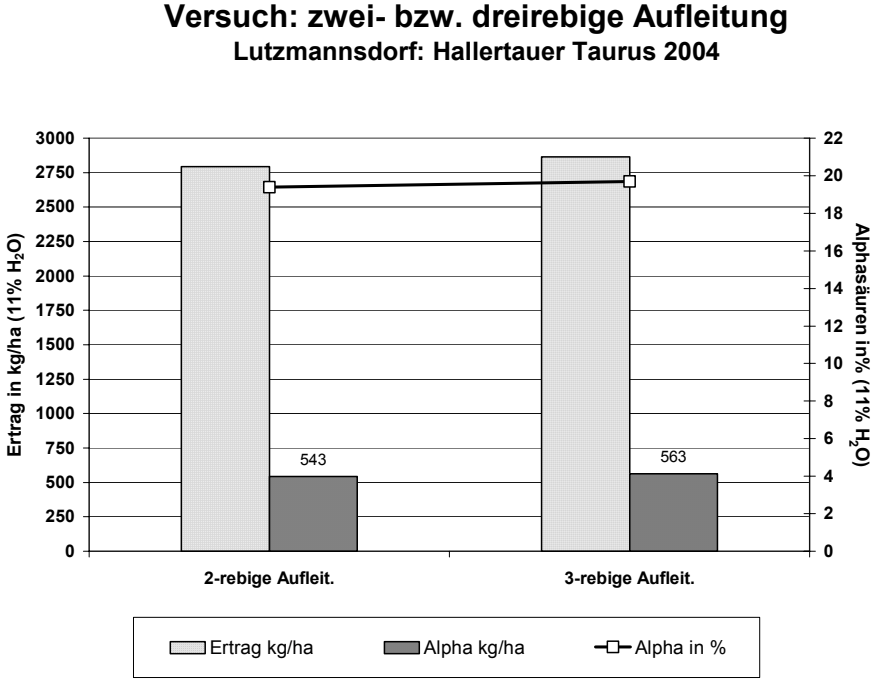
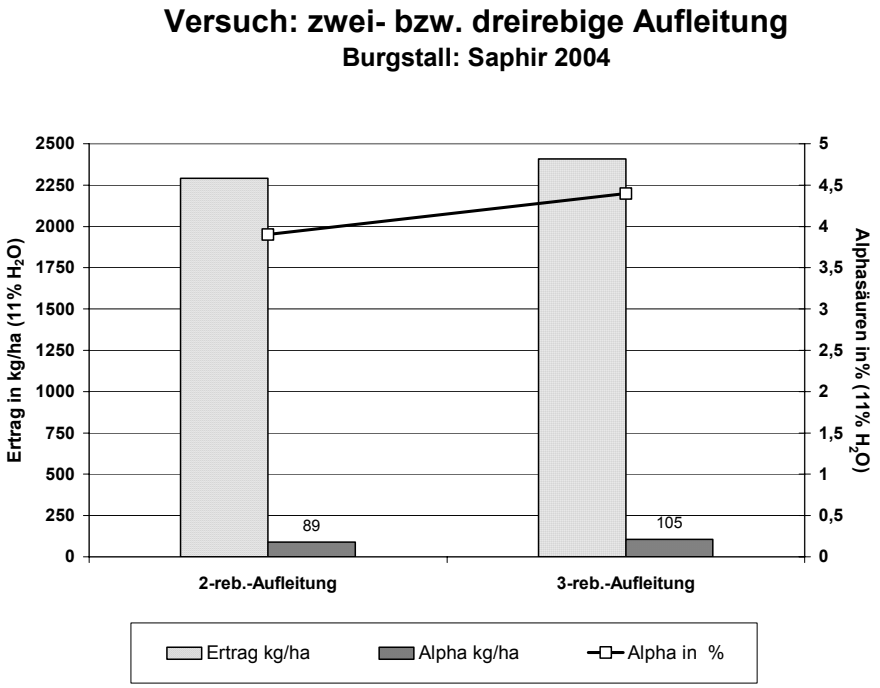


Figure 5.7: Crop result Saphir / Trial with two or three trained bines



5.9 Determining the optimum harvest-time with the varieties Hallertauer Mfr. and Saphir

The optimum harvest-time is important for a high yield and good quality. If harvested too early the yield is given away and the hops are weakened. When harvested too late i.a. the exterior quality and the aroma suffer. The latter characteristics are extremely important particularly as far as the aroma varieties tested are concerned.

In order to determine the optimum time for harvesting, 20 trained bines were harvested from practice yards at intervals of 3-4 days with 4 repeats. Harvesting was carried out with the variety Hallertauer Mfr. on 7, with the variety Saphir on 5 different dates. Evaluation was made with regard to yield, alpha-acid content, aroma and exterior quality (picking, colour and lustre, cone growth and defects).

Hallertauer Mfr.

The harvest-time trial with Hallertauer Mfr. was carried out in a hop yard at the Busch Farm in Hüll during the years 2002-2004. The harvest times for the various years can be seen in Table 5.12.

Table 5.12: Dates for the harvest-time trial with Hallertauer Mfr., Hüll 2002-2004

Termin	2002	2003	2004
T 1	14.08.	07.08.	16.08.
T 2	19.08.	11.08.	19.08.
T 3	22.08.	14.08.	23.08.
T 4	26.08.	18.08.	26.08.
T 5	29.08.	20.08.	30.08.
T 6	02.09.	22.08.	02.09.
T 7	05.09.	25.08.	06.09.

Harvesting was considerably earlier in the dry year 2003. In order to make a comparison between the years, the harvest times (T) were numbered from 1-7 and the results of the various years determined for each time (T).

Figure 5.8: Course of yield Hallertauer Mfr. 2002-2004 / Harvest time trial

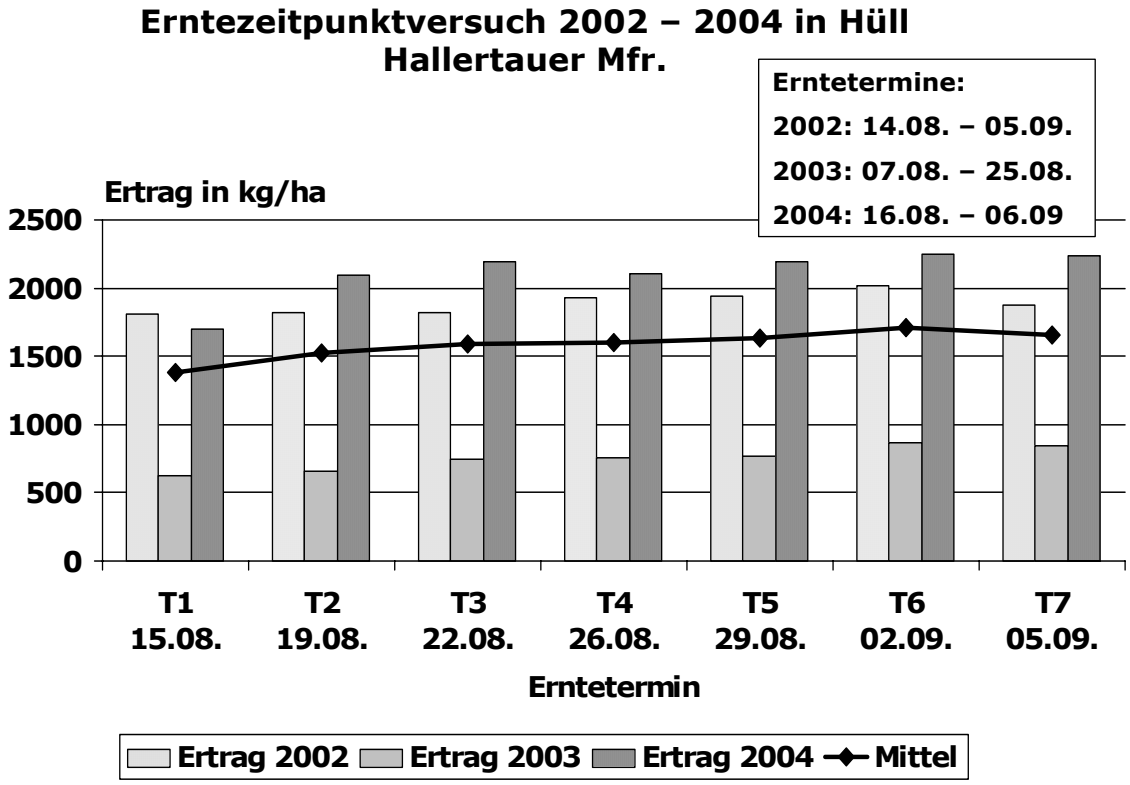


Figure 5.9: Alpha-acid content Hallertauer Mfr. 2002-2004 / Harvest-time trial

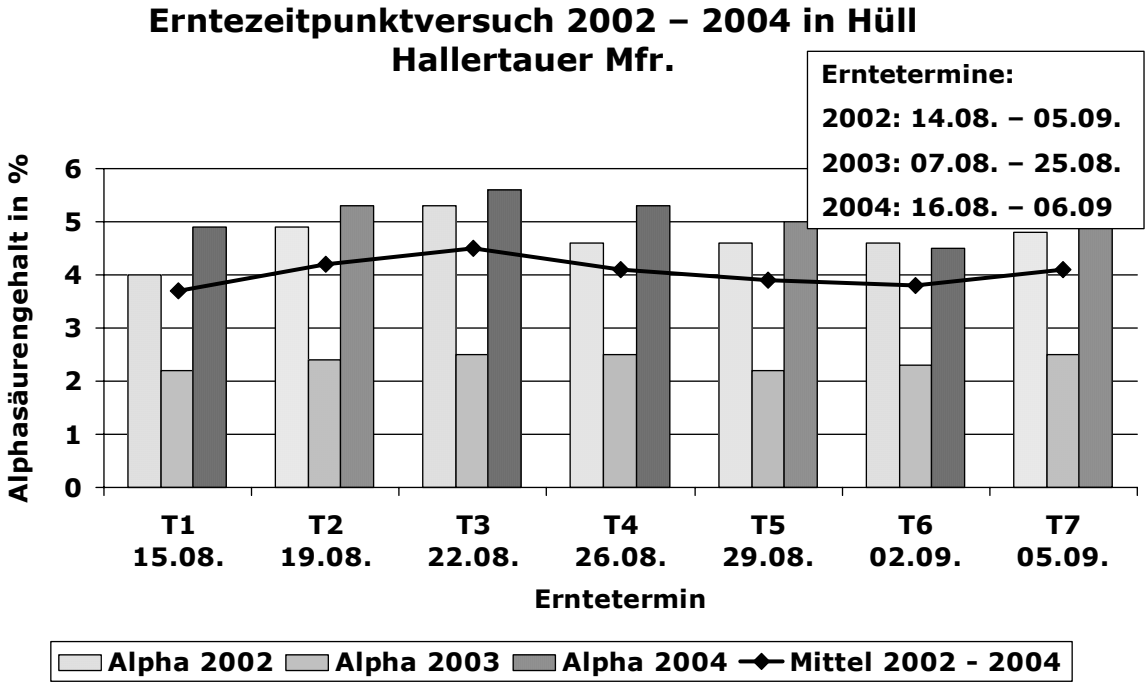


Figure 5.10: Aroma monitoring Hallertauer Mfr. 2002-2004 / Harvest-time trial

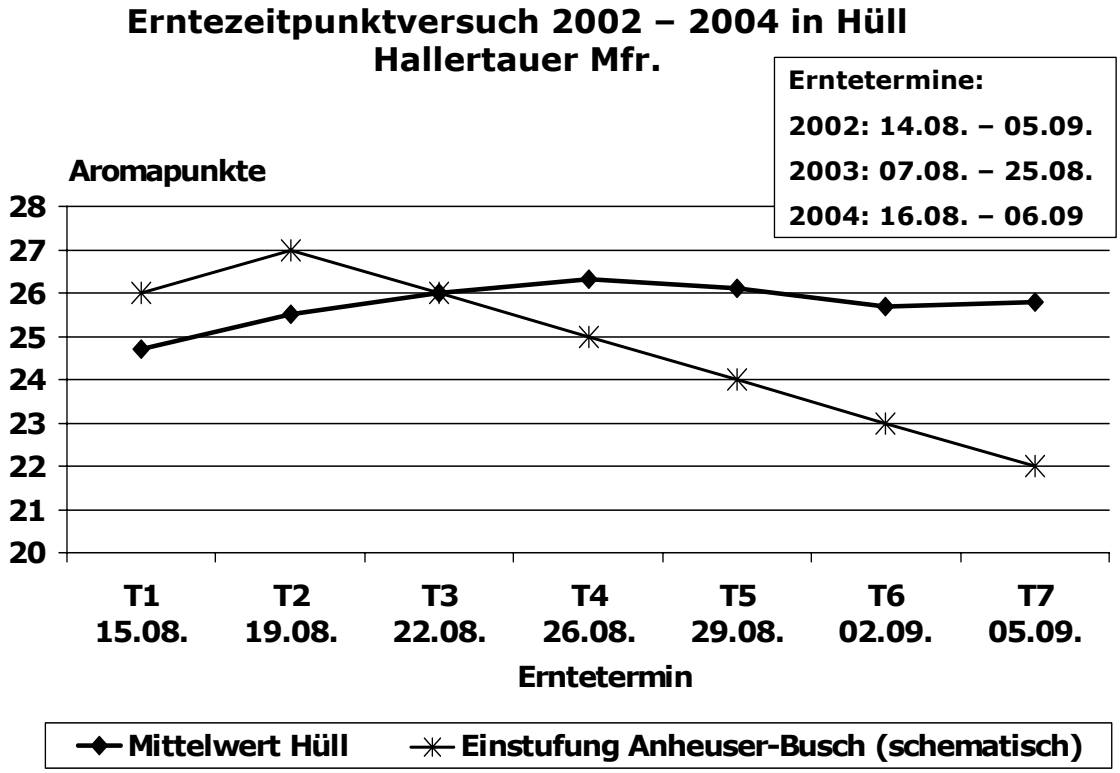
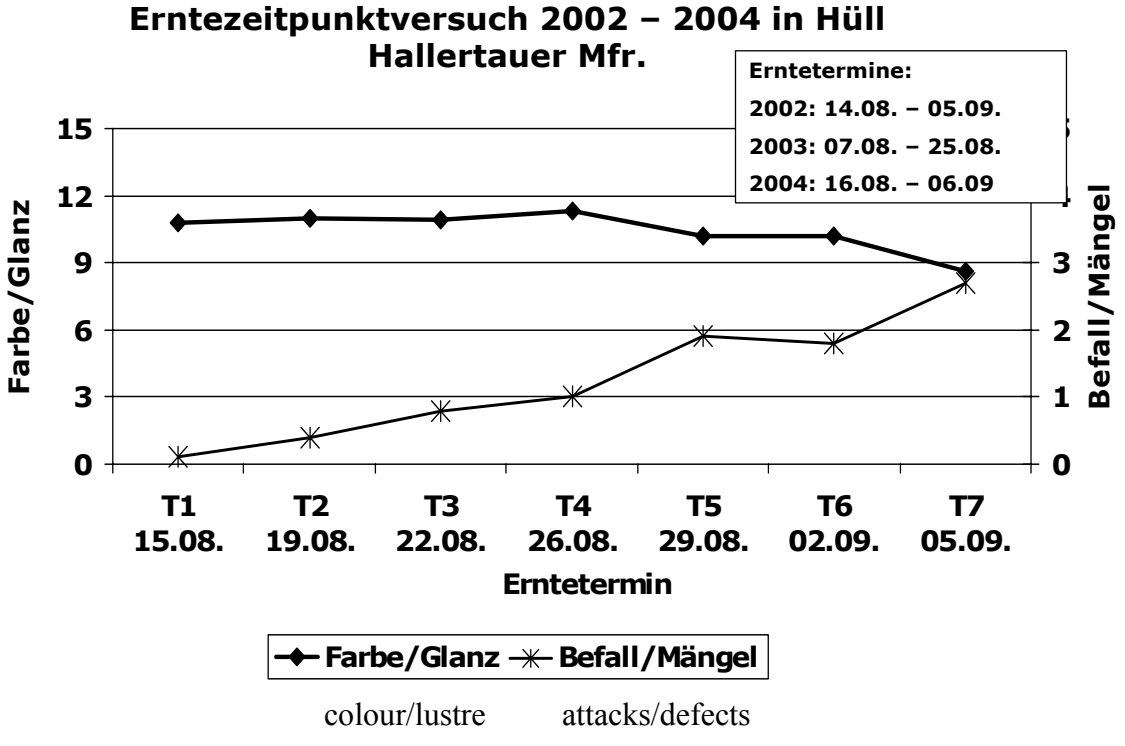


Figure 5.11: Colour and lustre and/or defects Hallertauer Mfr. 2002-2004
Harvest time trial 2002-2004 in Hüll



colour/lustre attacks/defects

As far as the yield is concerned, an increase of approx. 200 kg was recorded from T 1 and T 3. This corresponds to a financial advantage of around € 1,000 / ha. A further increase in yield up to T 6 is accompanied by a deterioration in the exterior quality as well as in aroma. This is not acceptable on the part of marketing in the case of Hallertauer Mfr. The alpha-acid content reaches its optimum at the third harvest-time.

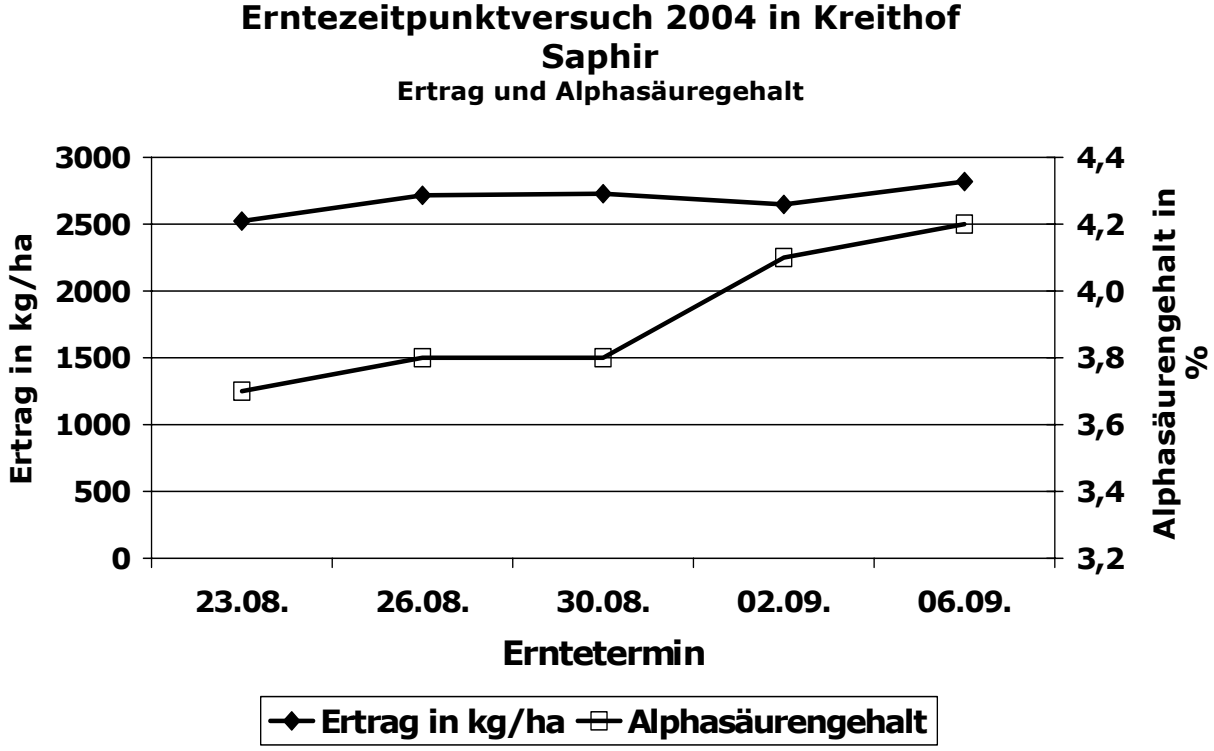
It could be seen in the 3rd harvest year in the experimental yard that there were more attacks of wilt in the plots with the respective early harvest-times.

The middle harvest-times T 3 and T 4 must be seen as a compromise regarding the market requirements, optimum yield and quality as well as maintaining the quality and health of the hops; these times can therefore be recommended as optimum harvest-times. In normal years this should be between 22nd and 26th August (until 29th August).

Saphir

The harvest-time trial with the variety Saphir was carried out in the first year at the Kreithof near Wolnzach.

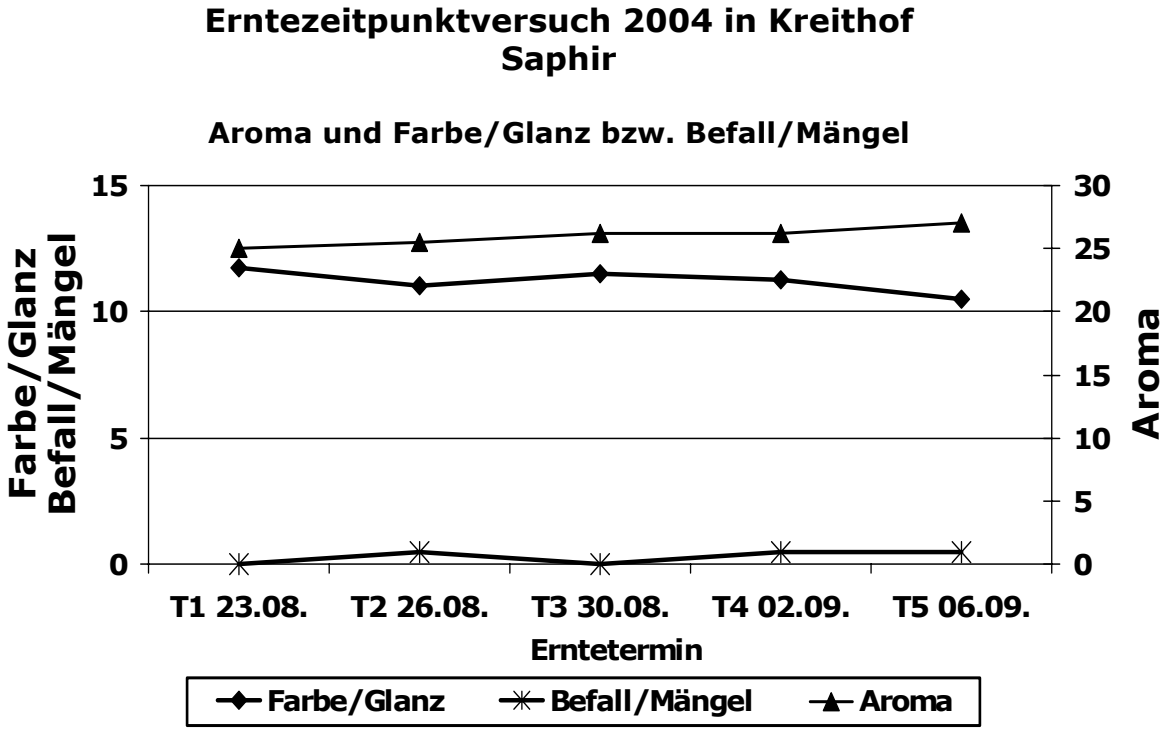
Figure 5.12: Yield and alpha-acid content Saphir 2004 depending on harvest time



Harvest time

Yield in kg/ha **Alpha-acid content**

Figure 5.13: Aroma and exterior quality Saphir 2004



The Figures show that not only the alpha-acid content but also the yield have increased by the last harvest-time. The aroma also increased up to the last harvest-time. The exterior quality deteriorated only slightly by the last harvest-time. The trial will be continued over the next two years.

5.10 Optimum conditioning of hops

Due to further numerous trials and intensive measurements it was possible to prove and optimize the instructions for controlling conditioning systems, as already described in the Annual Report 2002.

Only evenly dried and not over-dried hops can be optimum conditioned

The optimum moisture content of the hops fresh from the kiln is to 9-10%. In this state the moisture content of the spindle is between 25-35% and only 4-7% in the case of the bracteoles. When the hops are stored on the hop floor and/or during aerating in conditioning chambers the differing moisture content of the inhomogeneous hops and the big difference in moisture content between spindles and bracteoles are balanced out.

The relative humidity of the air influences the drawing-in behaviour

According to the sorption isotherms and the hops draw in a moisture content of 9-12% during storage or during ventilation with a 58-65% relative humidity of air. Therefore the drawing-in behaviour of the hops must be judged directly after drying. With a relative humidity of air below 50 % hops fresh from the kiln will still dry off during the storage until ventilation and with a relative air humidity over 55 % will draw-in to reach a higher moisture content.

Mixing well when filling the chamber reduces the airing time

Although the hops were dried evenly and at a constant drying temperature of 65°C, fluctuations in the moisture content of the dry hops were measured in the floor before it was emptied. If efforts are made to dry the last more damp area to 9-10 % then as a rule the total amount of hops in the drawer are over-dried as these more damp areas only make up a low percentage proportion of the entire quantity of hops. On the other hand if hops with a water content of over 10 % are always tipped into the chamber at the same place there is a risk that the hops will collapse during a lengthy storage and the ventilating air can no longer penetrate these layers of hops. The result is hop lots with different moisture contents. If the hops are mixed before or when the conditioning chamber is filled, the dampness in the inhomogeneous hops already begins to balance out before ventilation. Above all the big differences in moisture contents between the spindles and bracteoles are then balanced out during ventilation.

There is a close connection between the moisture content of the air and the moisture in the hops.

The obtainable moisture content can be assessed with the aid of the ventilation Figure (Annual Report 2002). The optimum ventilation time, measured in the air supply channel or in the air-diffusing space in the conditioning chamber, is 18-24 °C with a relative humidity of 58-65%. In the practice manual measuring equipment or already integrated stationary temperature and moisture sensors over which the mixed air regulator can be controlled, are used to measure the ventilating air.

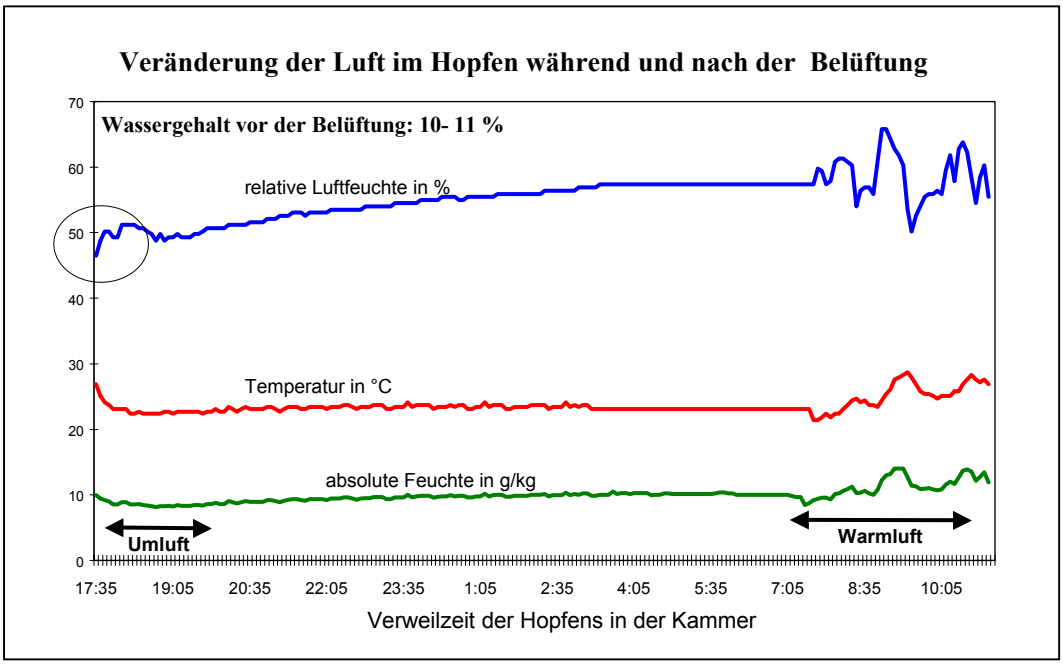
It is important that the temperature and the humidity of the ventilating air during ventilation in the supply channel or in the air-diffusing space can be followed via a digital display or on a computer screen. Numerous measuring devices can show the absolute humidity calculated in grams water/kg air. With this value a change in the mixed air can be determined very quickly and it can also judged whether due to this change the hops in the chamber will be compensated by the ventilation, dampened or dried a second time.

Judging the moisture of the hops in the chamber is very important!

Before ventilating the hops the moisture content of the hops for conditioning must be assessed so that the ventilating air can be set properly via the mixed air control. The aim should be to dry the hops to such an extent that the required moisture content is obtained by ventilating with circulating air. If the hops are too dry or too damp the ventilation air from circulating air is mixed as required with air containing more or less moisture until the mixed air has reached the required relative humidity. At the same time the optimum temperature range for the ventilation air from 18-24 °C should not be left.

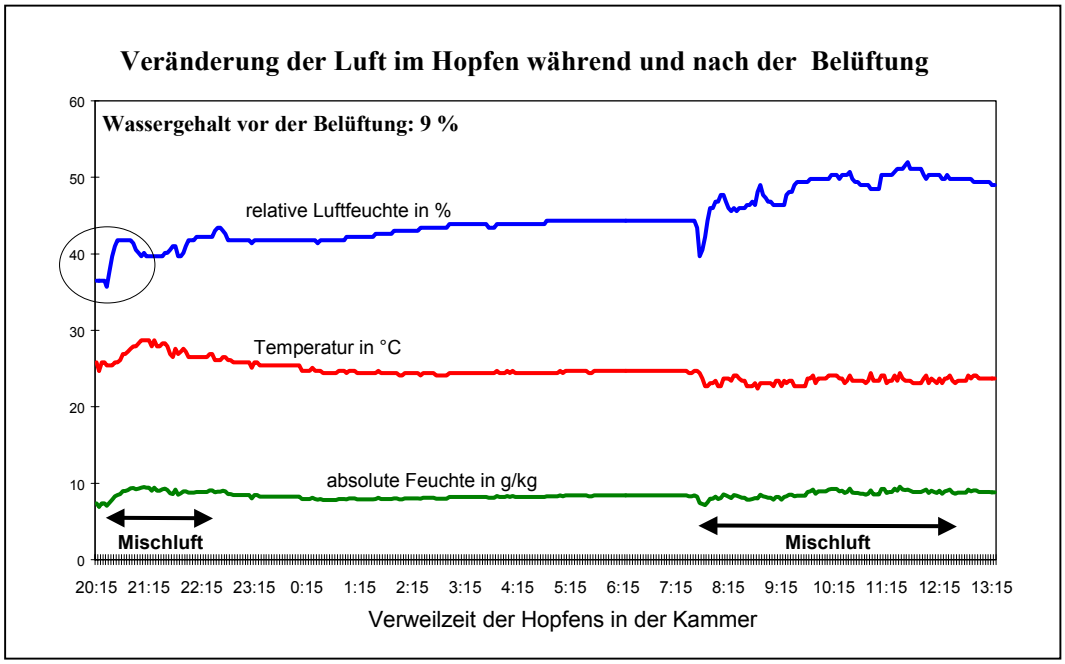
So that the initial dampness in the hops is assessed before the ventilation and the effects of the ventilation on the hops could be determined, the temperature, the relative and absolute air humidity in the hop floor were measured, recorded and evaluated during the time spent in the conditioning chambers.

Figure 5.14: Measurements in the conditioning chamber



As the hops in the chamber already had a moisture content of 10-11 % before ventilation they were aerated with circulating air. Before aerating a relative moisture of only 50% was measured in the hops as the still high moisture content of the spindle moisture is only partly recorded via the relative humidity of air. After switching off the ventilation the relative humidity of air increased with a constant temperature due to the beginning of the moisture balancing between spindles and bracteoles. Already after approx. 6 hours the relative humidity of air in %, the temperature and the absolute humidity in g moisture/kg air calculated from it, which is closely linked with the moisture content of the hops, no longer changed. The hops were completely homogenised.

Figure 5.15: Measurements in the conditioning chamber



As the hops for conditioning showed a moisture content of 9 % before ventilation, they were aerated with mixed air by adding the more damp kiln air into the circulating air. Before ventilation only a relative humidity of air below 40% could be measured in the hops with this moisture content as the spindle moisture of the not yet compensated cones had not been recorded yet. If these hops were aerated too long with circulating air in this high temperature area of 25°C, the result would be a second drying. After switching off the ventilation with mixed air in the evening, the hops in this temperature area were likewise homogenised by approx. 6 hours.

The further course of the curves in both Figures shows that ventilation after homogenising has already occurred is no longer practical. If in spite of this they are ventilated and the ventilation temperature is lower than the temperature in the conditioning chamber, it was possible to prove an increase in the proportion of bracteoles in the tests.. A ventilation with temperatures over 20 °C and observing a pause of at least 6 hours until the hops collapse, resulted in the reduction of the bracteoles by up to 50%.

5.11 Documentation and evaluation of the Bavarian Hop Card Index (HSK)

950 hop files were recorded and evaluated with the EDP programme HSK for the crop year 2004. So that the data from the hop-growers could also be recorded and evaluated along with it, which the card index conducted with the EDVP programme "HR – Product Pass" of the Hallertau Hop Ring, an interface for reading in the data was programmed by Mr. Baumgartner (StMLF). At four regional evaluation meetings the total evaluation was presented to those farms filed in the Hop Card Index. The evaluation was made with the emphasis on economic, farming aspects. At the same time it was shown that the contribution margin ascertained via the Hop Index is prerequisite for planning individual farm budgets.

5.12 Advisory and Training activities

Besides the applied research in the field of hop cultivation it is the task of the Hop Cultivation Work Group, Production Techniques (IPZ 5a) to prepare the test results for the practice and advise the Agricultural Offices (LwÄ) as well as the hop-farmers directly through special consultations, training facilities, talks as well as being accessible via the internet. The organisation of the peronospora (downy mildew) warning service and updating the warning instructions also belong to their duties just as much as the specialist service for the hop producer rings. Training was increased for the specialists supporting the producer rings as they are multiplicators for advice on the spot.

The training and advisory activities are summarized as follows:

5.12.1 Information in written form

- The "Green Pamphlet" Hops 2004 – Cultivation, Varieties, Fertilization, Plant Protection, Harvesting – 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 with a circulation of 3100 pamphlets by the

LfL distributed to the agricultural offices and research facilities and distributed 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 hop ring fax (in 2004: 52 faxes to 923 participants).
- Up-to-date information was likewise made available at weekly intervals for the weather fax.
- Within the bounds of the DSN soil test 4029 results were inspected for plausibility and released for despatch to the hop-growers.
- Advisory notes and specialist articles were published for the hop-growers in 3 ER circulars of the Hopfenring and published in 9 monthly issues of the Hopfenrundschau.
- Hop Index evaluations were carried out with the HSK data collection and evaluation programme for 305 hop-growers on 950 plots and returned to the farmers in written form.

5.12.2 Internet und Intranet

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

5.12.3 Telephone consulting and announcement services

- The peronospora (downy mildew) warning service was drawn up during the period 07.05.–24.08.2004 by the Work Group - Hop Cultivation, Production Techniques in Wolnzach in collaboration with the Work Group - Plant Protection in Hüll and updated 75 times so that it can be accessed via the answer-phone (Tel. 08442/9257-60) or via the internet.
- Tips on hop cultivation with up-to-date notes on pest and diseases as well as fertilizer and soil-working measures can be heard via the answer-phone in Wolnzach (Tel. 08442/957-401).
- The trade consultants of the Work Group Hop Cultivation, Production Techniques gave advice on special questions concerning hop cultivation per telephone or in individual discussions or on the spot in approx. 4,000 cases.

5.12.4 Tours, training facilities and meetings

- Two work discussions and a test inspection for the consultants of the agricultural office
- 7 training courses for the hop ring consultants
- 9 hop cultivation meetings in collaboration with the LwÄ (665 participants)
- 44 specialist talks at meetings held by other organisers
- 9 trial tours for the hop-growers and the hop industry
- 2 EDP training courses on Hop Card Index with 24 participants.
- 6 hop cultivation seminars on drying and conditioning hops with 175 participants
- 1 school day for the summer term students at the Agricultural College in Pfaffenhofen

6 Plant protection in the cultivation of hops

Bernhard Engelhard, Dipl. Ing. agr.

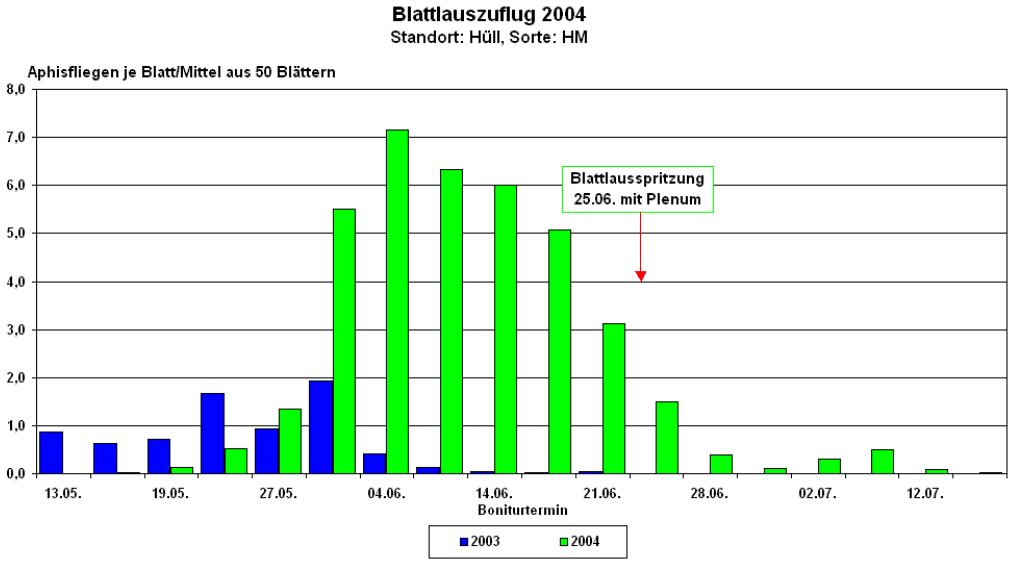
6.1 Pests and diseases in hops

Alfalfa weevil (*Othiorhynchus ligustici* L.) and wire worm

There were big problems in some areas with these pests. There were several areas on which the larvae eat the hops in the soil therefore causing long-term damage. The wire worm also caused permanent damage to the stand on several acreages.
In experimental tests on chemicals there was no active ingredient which obtained a real breakthrough on the search for an effective insecticide. In some cases a considerable reduction of the feeding spots was attained (BASF-insecticide from 119 to 1); however only a few dead beetles were found which allow a proper assessment of the effect.

Hop aphid [*Phorodon humuli* (SCHRANK)]

Figure 6.1: Aphid migration 2003/2004



The migration began punctually in mid-May and developed up to the beginning of June to a much greater extent than has been known since 1993. It was not unusual to find up to 200 winged aphids on the little hop leaves at the top of the plants. Besides the strong migration the length of migration up to mid-July was unusual.
It was a hard test for the products licensed to control the aphids. Although the weather conditions were not optimum many of the hops had to be treated during the first ten days in June, as otherwise the hops would have been damaged already. The time from spraying until the effect was reached was up to 14 days in the case of Plenum. Generally a second spraying was necessary, in the odd case a third spraying was necessary.

Common spider mite (*Tetranychus urticae* KOCH)

Attacks to the usual extent. The use of the control threshold as a deciding tool for spraying is still not sufficiently taken into consideration.

Downy mildew [*Pseudoperonospora humuli* (MIY. et TAK.) WILSON]

During the youthful development of the hops primary attacks of downy mildew occurred more intensively and lasted longer. The cool weather with a lot of rainy days, even if they only brought little precipitation, resulted in a considerable spread of attacks through secondary infections of downy mildew. The warning service gave almost twice as many warnings than in the previous year. However, at the harvest the cones were only infested in the case of susceptible varieties which had not been treated early enough.

Powdery mildew (*Sphaerotheca humuli* BURR.), Botrytis (*Botrytis cinerea* PERS.)

Both diseases were not worth mentioning up until the harvest. Pustules only occurred occasionally during the season..

The best conditions for infection with mildew in the entire Hallertau were on 21st August. With very little infection material only late ripening varieties were attacked.

Wilt (*Verticillium alboatrum*)

There were considerable losses through hop wilt due to slow development in the youth especially in the case of the Hallertauer Mittelfrüher variety. In one test it could be shown that the wilt attack was stronger in the previous years especially when the hops were harvested too early.

Viroids

As in the case of virus diseases the viroid attacks cannot be controlled with chemicals. The Hop-Latent-Viroid (HLVd) appears in almost all hop-growing regions all over the world, in Germany virtually to 100 %. In eastern European countries they are trying to produce plants free from viroids and plant them out.

Within the scope of a propagation development with the Hallertauer Merkur variety besides virus-free plants also viroid-free plants could be won. These plants which were proved to be free of viroids were planted out in two rows. A control in the 3rd year following planting showed that all the plants were already re-infected! Therefore from our point of view it does not make much sense to invest great efforts in viroid-free plant material; there is a difference to virus-free plant material. Crop examinations showed no advantage for the viroid-free plants.

6.2 Investigating the epidemiology of the powdery mildew (*Sphaerotheca humuli*) and on the development of a forecasting model

6.2.1 Requirements for the weather parameters to set off a spray warning

Following the 2004 season the requirements were reworked based on the weather parameters for the forecasting model and the certainly positive experience made with this data. The individual weather parameters were integrated to a different extent in the model, in order to test the effect on the number of "spray warnings" zu testen. The value which applies to the majority of the occurrences from 1997 – 2004 was used as a "provisional value".

Sunshine intensity

3500 watt-hours/m^2 = 21 warnings
4000 watt-hours/m^2 = 33 warnings
4500 watt-hours/m^2 = 37 warnings

Rain intensity:

> 1 mm (20.01 – 5.00 hrs.) and > 5 mm on the previous day = 32 warnings
> 0,1 mm (20.01 – 5.00 hrs.) and > 1 mm on the previous day = 41 warnings

It is well-known that **no** rain is necessary for the multiplication and new infection as e.g. in the greenhouse the infection is extremely successful without the leaves becoming wet. Presumably rain has an indirect effect out in the open:

- when it rains the sky is cloudy = no/little sunshine,
- when it rains the humidity is high and this is necessary for the survival of the spores.

Temperature:

The separate evaluation of the average temperatures between day and night has so far proved to be useful. Although the growth and the formation of spores of the fungus is also possible below 10 °C the limit around or above 10 °C seems to be of special importance for the mass growth and the widespread new infection. In the periods when infections are probably the minimum temperatures in the night are not below 10 °C.

Locational influence:

When comparing the seven agro-meteorological stations in the Hallertau there are clear concentrations on specific days. It is applicable in about half of the warnings that the conditions are fulfilled simultaneously in all locations,. Small area differentiation is still difficult at present. If three or more stations fulfil the conditions therefore there is a spray warning for the 2005 season.

Under these conditions the weather parameters mentioned on page 10 were laid down to set off a spray warning for 2005.

6.2.2 Spray warning according to "4er model", "5er model", or "6er model", adjoining sections of the day for susceptible varieties

Table 6.1:

Infection in the respective year and spraying frequency required after predefining the provisional forecasting model			
Year	5 > = x	additional to 4 x	
1997	5	4	For the first time bad infection with late mildew
1998	1	4	No problems
1999	4	2	So far earliest and worst infection
2000	3	2	No special problems
2001	3	3	Big problems in some areas (June!)
2002	2	3	Bad infection
2003	-	1	No infection
2004	4	-	Very little infection

The provisional forecasting model assumes that the weather conditions must apply over a certain, adjoining period of time .

The number of spray warnings is summarized in Table 6.1 according to the "5er model" (5 > = x) and the **additional** spray warnings (additional to 4 x) according to the "4er model" for the years 1997 – 2004.

The number of spray warnings according to the "5er model" and the actual attacks of mildew in the practice has a logical correlation. Among the changed requirements for the weather parameters compared with 2003 according to the "4er model" there were too many spray warnings even for susceptible varieties – e.g. nine in 1997 and six in 2001.
For 2005 the other tests for susceptible varieties will therefore be held according to the "5er model".

6.2.3 Spray warning according to "six" (6er model) adjoining sections of the day for less susceptible varieties

In the years 1997 – 2004 following six adjoining sections of the day the provisional model would have set off a spray warning on the following days:

1997 – 20th July

1998 – -

1999 – 22nd May, 10th July, 11th August

2000 – -

2001 – 10th June, 18th June

2002 – 18th July, 12th August

2003 – -

2004 – 21st August

These dates also produce a logical correlation with the actual attacks.

In a test in 2002 the variety Hersbrucker Spät was sprayed for the last time against powdery mildew. At this time inspections showed a completely healthy state. The "6er model" set off a spray warning on 12th August. At the first harvesting date on 6th September the cones were still free from attacks of mildew; at the harvesting date on 11th September up to 10% of the cones were infected to varying extents. A spraying between 13th and 18th August would have been useful and would have prevented attacks of late mildew in this less susceptible variety.

6.2.4 Comparison of results from tests on plots and the "5er model"

Key to symbols for the Tables 6.2 - 6.5

- In the main column "Hüll" the grey boxes on the left are for filling in the weather parameters from 5.01 – 20.00 hrs.; in the Center for filling in from 20.01 – 5.00 hrs.

  The black boxes on the right stand for five adjoining times of day and consequently for a spray warning according to the "5er model".

- In the column "Hofen" or "Buch" are the spraying times at this location and year. The times were laid down based on previous experience and weather conditions.

- The assessment data is in the main column on the right "% attacks" – on the left in treated plots, on the right in untreated plots.

  Up until the end of July attacks on leaves and flowers, attacks on cones from August onwards.

- The final result and the attacks on cones as a criterion for the spread of infection due to the year and the effectiveness of the sprayings show the data for the "attacks on cones" at bottom right.

Table 6.2: Correlation between spray warning and monitoring

Zusammenhang zwischen "Spritzaufruf" und "Bonitur"
Agrarmeteorologische Meßstation Hüll; Standort Hofen; Sorte HM; 1997

	1997 Hüll	Hofen Spritz-T	Hofen % Befall		1997 Hüll	Hofen Spritz-T	Hofen % Befall		1997 Hüll	Hofen Spritz-T	Hofen % Befall		1997 Hüll	Hofen Spritz-T	Hofen % Befall
01. Mai				01. Jun.				01. Jul.			0,7 /0,5	01. Aug.			
02. Mai				02. Jun.				02. Jul.				02. Aug.			
03. Mai				03. Jun.				03. Jul.				03. Aug.			
04. Mai				04. Jun.				04. Jul.				04. Aug.			
05. Mai				05. Jun.				05. Jul.				05. Aug.			
06. Mai				06. Jun.				06. Jul.				06. Aug.			
07. Mai				07. Jun.				07. Jul.				07. Aug.			
08. Mai				08. Jun.				08. Jul.				08. Aug.			
09. Mai				09. Jun.				09. Jul.				09. Aug.			
10. Mai				10. Jun.				10. Jul.				10. Aug.			
11. Mai				11. Jun.				11. Jul.				11. Aug.			0,1 / 31
12. Mai				12. Jun.				12. Jul.				12. Aug.			
13. Mai				13. Jun.				13. Jul.				13. Aug.			
14. Mai				14. Jun.				14. Jul.				14. Aug.			
15. Mai				15. Jun.				15. Jul.				15. Aug.			
16. Mai				16. Jun.				16. Jul.			0,0 / 0,7	16. Aug.			
17. Mai				17. Jun.				17. Jul.				17. Aug.			
18. Mai				18. Jun.				18. Jul.				18. Aug.			
19. Mai				19. Jun.				19. Jul.				19. Aug.			
20. Mai				20. Jun.			0,2 / 0,1	20. Jul.				20. Aug.			
21. Mai				21. Jun.				21. Jul.				21. Aug.			
22. Mai				22. Jun.				22. Jul.				22. Aug.			
23. Mai				23. Jun.				23. Jul.				23. Aug.			
24. Mai				24. Jun.				24. Jul.				24. Aug.			
25. Mai				25. Jun.				25. Jul.				25. Aug.			
26. Mai				26. Jun.				26. Jul.				26. Aug.			0 / 92
27. Mai				27. Jun.				27. Jul.				27. Aug.			
28. Mai				28. Jun.				28. Jul.			0 / 0,7	28. Aug.			
29. Mai				29. Jun.				29. Jul.				29. Aug.			Doldenbefall: unbehandelt= 91 % 3x behandelt= 1,7 %
30. Mai				30. Jun.				30. Jul.				30. Aug.			
31. Mai								31. Jul.				31. Aug.			

Table 6.3:

Zusammenhang zwischen "Spritzaufruf" und "Befallsbonitur"
Agrarmeteorologische Meßstation Hüll; Standort Buch; Sorte HM; 1999

	Hüll	Buch Spritz-T	Buch Befall		Hüll	Buch Spritz-T	Buch Befall		Hüll	Buch Spritz-T	Buch Befall		Hüll	Buch Spritz-T	Buch Befall
01. Mai				01. Jun.				01. Jul.				01. Aug.			
02. Mai				02. Jun.				02. Jul.				02. Aug.			
03. Mai				03. Jun.				03. Jul.				03. Aug.			70 / 97
04. Mai				04. Jun.				04. Jul.				04. Aug.			
05. Mai				05. Jun.				05. Jul.				05. Aug.			
06. Mai				06. Jun.				06. Jul.				06. Aug.			
07. Mai				07. Jun.				07. Jul.				07. Aug.			
08. Mai				08. Jun.				08. Jul.				08. Aug.			
09. Mai				09. Jun.				09. Jul.				09. Aug.			
10. Mai				10. Jun.				10. Jul.				10. Aug.			
11. Mai				11. Jun.			7,0 / 8,5	11. Jul.			7,0 / 8,5	11. Aug.			
12. Mai				12. Jun.				12. Jul.				12. Aug.			
13. Mai				13. Jun.				13. Jul.				13. Aug.			
14. Mai				14. Jun.				14. Jul.				14. Aug.			
15. Mai				15. Jun.				15. Jul.				15. Aug.			
16. Mai				16. Jun.				16. Jul.				16. Aug.			
17. Mai				17. Jun.				17. Jul.				17. Aug.			
18. Mai				18. Jun.				18. Jul.				18. Aug.			
19. Mai				19. Jun.				19. Jul.				19. Aug.			
20. Mai				20. Jun.				20. Jul.			9 / 66	20. Aug.			
21. Mai				21. Jun.				21. Jul.				21. Aug.			
22. Mai				22. Jun.				22. Jul.				22. Aug.			
23. Mai				23. Jun.				23. Jul.				23. Aug.			
24. Mai				24. Jun.				24. Jul.				24. Aug.			
25. Mai				25. Jun.				25. Jul.				25. Aug.			
26. Mai				26. Jun.				26. Jul.				26. Aug.			
27. Mai				27. Jun.				27. Jul.				27. Aug.			
28. Mai				28. Jun.				28. Jul.				28. Aug.			
29. Mai				29. Jun.			14 / 46	29. Jul.				29. Aug.			Dodenbonitur: unbehandelt = 100 % 4x behandelt = 100%
30. Mai				30. Jun.				30. Jul.				30. Aug.			
31. Mai								31. Jul.				31. Aug.			

Table 6.4: Correlation between spray warning and attacks monitored

Zusammenhang zwischen "Spritzaufruf" und "Befallsbonitur"
Agrarmeteorologische Meßstation Hüll; Standort Hofen; Sorte HM; 2001

	2001 Hüll	Hofen Spritz-T	Hofen %Befall		2001 Hüll	Hofen Spritz-T	Hofen %Befall		2001 Hüll	Hofen Spritz-T	Hofen %Befall		2001 Hüll	Hofen Spritz-T	Hofen %Befall
01. Mai				01. Jun.				01. Jul.				01. Aug.			1,3 / 4,8
02. Mai				02. Jun.				02. Jul.				02. Aug.			
03. Mai				03. Jun.				03. Jul.				03. Aug.			
04. Mai				04. Jun.				04. Jul.				04. Aug.			
05. Mai				05. Jun.				05. Jul.				05. Aug.			
06. Mai				06. Jun.				06. Jul.				06. Aug.			
07. Mai				07. Jun.				07. Jul.				07. Aug.			
08. Mai				08. Jun.				08. Jul.				08. Aug.			
09. Mai				09. Jun.				09. Jul.				09. Aug.			
10. Mai				10. Jun.				10. Jul.				10. Aug.			
11. Mai				11. Jun.				11. Jul.				11. Aug.			
12. Mai				12. Jun.				12. Jul.				12. Aug.			
13. Mai				13. Jun.			0 / 0,2	13. Jul.				13. Aug.			
14. Mai				14. Jun.				14. Jul.				14. Aug.			10 / 53
15. Mai				15. Jun.				15. Jul.				15. Aug.			
16. Mai				16. Jun.				16. Jul.				16. Aug.			
17. Mai				17. Jun.				17. Jul.				17. Aug.			
18. Mai				18. Jun.				18. Jul.				18. Aug.			
19. Mai				19. Jun.				19. Jul.			0 / 0,1	19. Aug.			
20. Mai				20. Jun.				20. Jul.				20. Aug.			
21. Mai				21. Jun.				21. Jul.				21. Aug.			
22. Mai				22. Jun.				22. Jul.				22. Aug.			22 / 88
23. Mai				23. Jun.				23. Jul.				23. Aug.			
24. Mai				24. Jun.				24. Jul.				24. Aug.			
25. Mai				25. Jun.				25. Jul.				25. Aug.			
26. Mai				26. Jun.				26. Jul.				26. Aug.			
27. Mai				27. Jun.				27. Jul.				27. Aug.			19 / 94
28. Mai				28. Jun.			0,1 / 1,6	28. Jul.				28. Aug.			
29. Mai				29. Jun.				29. Jul.				29. Aug.			Doldenbonitur: unbehandelt = 92 % 6x behandelt = 17 %
30. Mai				30. Jun.				30. Jul.				30. Aug.			
31. Mai								31. Jul.				31. Aug.			

Table 6.5:

Zusammenhang zwischen "Spritzaufruf" und "Befallsbonitur" bzw Praxisbeobachtungen
Agrarmeteorologische Meßstation Hüll; Standort Hofen; Sorte HM; 2003

	Hüll	Hofen Spritz-T	Hofen %Befall		Hüll	Hofen Spritz-T	Hofen %Befall		Hüll	Hofen Spritz-T	Hofen %Befall		Hüll	Hofen Spritz-T	Hofen %Befall
01. Mai				01. Jun.				01. Jul.				01. Aug.			
02. Mai				02. Jun.				02. Jul.				02. Aug.			
03. Mai				03. Jun.				03. Jul.				03. Aug.			
04. Mai				04. Jun.				04. Jul.				04. Aug.			
05. Mai				05. Jun.				05. Jul.				05. Aug.			
06. Mai				06. Jun.				06. Jul.				06. Aug.			
07. Mai				07. Jun.				07. Jul.				07. Aug.			
08. Mai				08. Jun.				08. Jul.				08. Aug.			
09. Mai				09. Jun.				09. Jul.				09. Aug.			
10. Mai				10. Jun.				10. Jul.				10. Aug.			
11. Mai				11. Jun.				11. Jul.				11. Aug.			
12. Mai				12. Jun.				12. Jul.				12. Aug.			
13. Mai				13. Jun.				13. Jul.				13. Aug.			
14. Mai				14. Jun.				14. Jul.				14. Aug.			
15. Mai				15. Jun.				15. Jul.				15. Aug.			
16. Mai				16. Jun.				16. Jul.				16. Aug.			
17. Mai				17. Jun.				17. Jul.				17. Aug.			
18. Mai				18. Jun.				18. Jul.				18. Aug.			
19. Mai				19. Jun.				19. Jul.				19. Aug.			
20. Mai				20. Jun.				20. Jul.				20. Aug.			
21. Mai				21. Jun.				21. Jul.				21. Aug.			
22. Mai				22. Jun.				22. Jul.				22. Aug.			
23. Mai				23. Jun.				23. Jul.				23. Aug.			
24. Mai				24. Jun.				24. Jul.				24. Aug.			
25. Mai				25. Jun.				25. Jul.				25. Aug.			
26. Mai				26. Jun.				26. Jul.				26. Aug.			
27. Mai				27. Jun.				27. Jul.				27. Aug.			
28. Mai				28. Jun.				28. Jul.				28. Aug.			
29. Mai				29. Jun.				29. Jul.				29. Aug.			Doldenbonitur: unbehandelt = 0 % 4x behandelt = 0 %
30. Mai				30. Jun.				30. Jul.				30. Aug.			
31. Mai								31. Jul.				31. Aug.			

Discussion relating to Tables 6.2. - 6.5

In 1997 the spray warnings and spraying dates (coincidental) were close together.

Spraying was carried out after a warning at intervals of max. 5 days. Optimum success was achieved with three sprayings.

In 1999 there had already been two spray warnings in May. Until the first spraying had been carried out, the infection was already present to a great extent and could no longer be effectively controlled with the licensed products. Four spraying dates around the 15th May, 24th May, 12th July und 13th August would quite probably have produced effective control.

In 2001 the two spraying dates were well timed in June. The two sprayings in July would not have been necessary. The spraying on 6th August was probably two to four days too early – during this time the very sensitive young cones were formed (strong growth), which were no longer protected by the plant protective. Then by the time of the spraying on 16th August the infection had already taken place.

There were no attacks in 2003 and also no spray warning according to the "5er model".

Summary

The provisional forecasting model supplies logical correlations of spray warnings and the actual infection. Thanks to the agro-meteorological measuring station altogether eight years could be checked with extremely different infection situations. Due to limited space only four years are shown as examples here.

6.2.5 Practice tests 2005

In 2004 28 hop-growers already declared they were prepared to test the provisional forecasting model in one hop yard each. In addition, within the scope of a dissertation partial areas were also defined which were not sprayed against mildew. The hop-growers' readiness to take risks on the one hand showed great confidence in the model, but on the other hand also showed how important it is to solve this "mildew problem".

In addition to this practice trials were planned with another eight hop-growers and the advisors of the plant protective firms. Six rows each were treated with various products in one spraying series. The spraying according to the "warning from Hüll" and one untreated plot served as a comparison.

Evaluation:

In 2004 the spread of infection was altogether low. Infection was only assessed at three locations. According to the forecasting model four spray warnings were given; however not always at the right time. An attempt was made to combine the weather forecast and spray warnings for downy mildew. As this was the wrong way, there may only be one spray warning in 2005 if the model sets it off. At the trial stage combinations have to be oriented solely to the model for mildew.

6.3 Research project "Evaluation of production measures in organic hop growing"

6.3.1 Object

This three-year project (duration: 01.04.2002 – 31.03.2005) first and foremost only included testing methods for the support of beneficial arthropods in the organic cultivation of hops, particularly by creating hibernating shelters. In concrete terms, the use and establishment of predatory mites in hops was assessed in this point as well as the suitability of specially designed "lacewing hotels" as overwintering quarters for lacewings hibernating in hops. Furthermore methods to attract lacewings were tested. Besides, a test was also carried out on plant protectives which correspond to the production guidelines for organic hop growing, and the method already developed for controlling the common spider mite by insect glue barriers on the hop bines was developed further.

6.3.2 Use and establishment of predatory mites in hop yards

6.3.2.1 Study site and methods

All trials relating to this point were conducted at the location Buch near Aiglsbach, Kelheim district. For the trial a garden planted with cv. "Perle" was selected in 2002, which due to its unusual size with comparatively homogeneous soil conditions seemed to be optimum for the wide-scale trial planned. However, as this yard had to be cleared in spring 2003 for farming reasons, the 2003 trial was moved to an equally large garden planted with cv. "Hallertauer Tradition" where it was also carried out in 2004.

In each of the three trial years four plots were set up on about 1 ha, each replicated four times. The size of the individual plots was approx. 250 m^2 with 210 training wires, respectively. The plots of the trial in 2002 and 2003 were:

- Predatory mites (*Typhlodromus pyri*) with stripped bines
- Predatory mites (*T. pyri*) with unstripped bines
- Glue applied to the bines
- Untreated control.

In 2004 the variant "predatory mites (*T. pyri*) with unstripped bines" was replaced by a variant using another species of predatory mite (*Phytoseiulus persimilis*).

The predatory mites were purchased from a commercial breeder in bags containing 100 mites each, which were released punctually on every seventh hop-plant in two waves after the first spider mites (*Tetranychus urticae*) appeared. The development of predatory and spider mites on hops were monitored weekly from the beginning of June until harvest. The number of predatory mites released on an average per plant was 30 in 2002, 20 in 2003 and 40 in 2004.

Prior to the harvest, in all three years felt bands were exposed at the hop poles as potential hibernating quarters for predatory mites, and one bine was left hanging at each pole until the winter. The felt bands were removed in late winter and examined for hibernating arthropods.

6.3.2.2 Results and discussion

The predatory mite trials in 2002 and 2003 must be interpreted as a failure. In 2002 the spider mite infestation situation was very low and in no plot of the trial was it possible to

obtain a control effect compared with the untreated variant – there was no damage from spider mites in the entire hop-yard. Contrary to this, the "summer of the century" in 2003 led to a spider mite infestation that no plot of the trial could stand up to, which is why half of the plots had to be re-sprayed on 30.07.2003 in order to keep the damage by *T. urticae* as low as possible. Also the re-catching rates for predatory mites at the monitoring was extremely unsatisfactory in both these years. (Table 6.6 and 6.7).

However in 2004, contrary to the two previous years, the desired effect of the spider mite control could be proved for the first time, as it was seen that until harvest the predatory mite plots differed considerably in spider mite infestation from the untreated plots. Besides, with 1,632 predatory mites more than twelve times as many could be encountered again in the monitorings than in 2003 (Table 6.6). An experimental harvest carried out on 28.08.2004 showed no significant differences in yield in the predatory mite plots, compared to the remaining garden that was treated with acaricide as usual in practice. With regard to alpha-acid contents, the values in the experimental plots were even significantly higher than those in practice, which is a further proof for the fact that moderate infestation of two-spotted spider mites up to the damage threshold stimulates the hop to increased alpha-acid production (Fig. 6.2).

The results determined in the three years for the dispersion of predatory mites released on hops are very promising. The distribution of the predators happened very quickly not only in the vertical direction, however in which the upper part of the bines was only reached by about 10% of the predatory mites (Table 6.6), but also in the horizontal direction right out to the boundaries of the plot. (Table 6.7)

Table 6.6:

Vertical distribution of predatory mites found on hops during the three trial years

Rebenabschnitt: (Höhe über Grund)	Unten (1-2 m)	Mitte (3-5 m)	Oben (6-7 m)
2002 (n = 45)	62,2%	28,9%	8,9%
2003 (n = 127)	52,8%	31,5%	15,7%
2004 (n = 1632)	41,4%	48,5%	10,1%

Table 6.7:

Horizontal distribution of predatory mites re-encountered on hops during the three trial years on release plants (0), neighbouring plants in the rows (-1, -2, -3) and outside the release plots.

Freilassungspflanze:	0	-1	-2	-3	außerhalb
2002 (n = 45)	53,3%	11,1%	13,3%	6,7%	15,6%
2003 (n = 127)	19,7%	12,6%	26,0%	15,7%	26,0%
2004 (n = 1597)	14,9%	24,2%	18,3%	24,4%	18,2%

During the evaluation of felt bands no hibernating predatory mites could be proved in all three years, whereas on the other hand great numbers of common spider mites had definitely used the quarters, e.g., in 2003 on an average over 230 insects per felt band. Nevertheless, in spring 2004 during the monitoring in predatory mite plots that were identical to the previous year the predators were recorded on the plants in little abundance even before the dates of their release – so far this is the first proof for the overwintering of predatory mites in a high-trellis hop garden of the Hallertau.

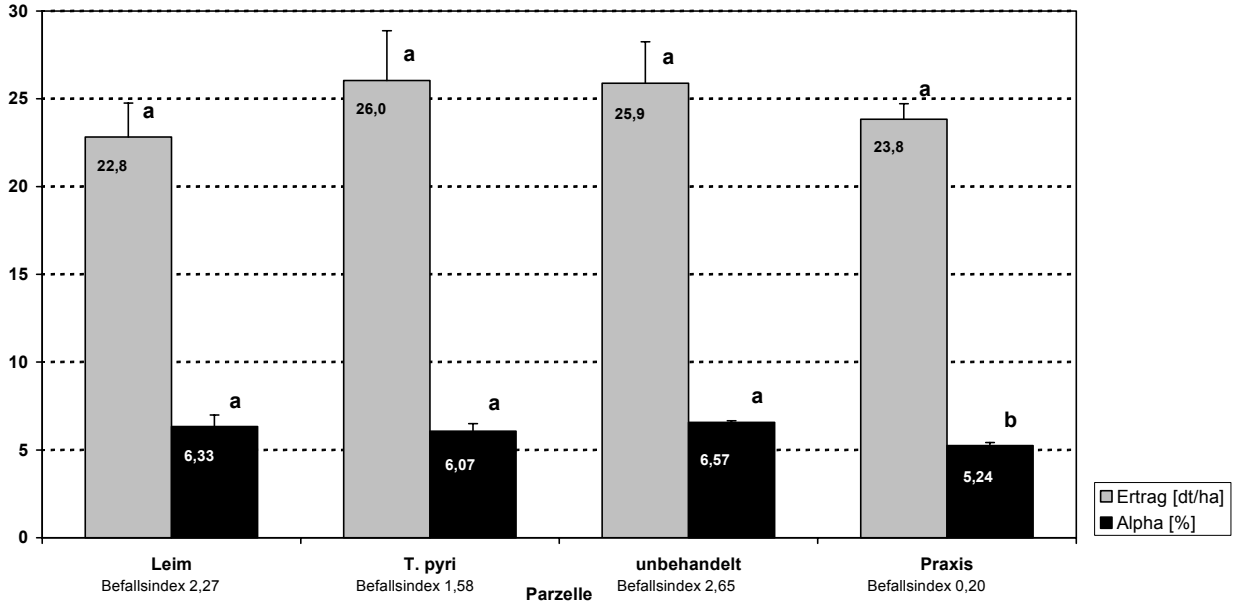
6.3.3 Further development of a method to control two-spotted spider mites by insect glue barriers

The trials to further develop a method to control spider mites by insect glue barriers on the hop bines were carried out annually in the predatory mite trial as a fourth plot of the trial. The results of the glue variant with regard to spider mite infestation was always considerably below that of the untreated variant. However, the glue did not stand up to the extreme infestation of spider mites in 2003 – for the first time since the start of respective trials in 1994 - and there was considerable damage. In the experimental harvest in 2004 the glue variant however did not differ significantly from yield in the practice and likewise had significantly higher alpha-acid values (Fig. 6.2). The use of a tractor-drawn and -heated application apparatus to apply the glue to the bines was successful in all three years without any technical problems even on a wider scale.

Figure 6.2:

Experimental harvest"Grünbrunn", Buch, 25.08.2004; cv. HT; yield and alpha using various methods to control two-spotted spider mites.

a, b = significant differences according to ANOVA ($P < 0,05$)



6.3.4 Provisiob of hibernaton shelters for lacewings in hops

In the scope of this investigation each year at the end of August in the experimental gardens of the locations Ursbach and Buch 32 specially designed "lacewing hotels", made by ourselves were exposed before the harvest at the hop poles or in the vicinity of the hop yard (in hedges, in a small glade, on the edge of woods, on top of hills) erected on wooden posts 150 cm high. The hotels consisted of light plywood boards made into cube-shaped boxes 30 cm long that were open at the bottom and at the gable. At the gable five and at the bottom six 4 cm wide strips made out of the same material were placed with diagonally cut long sides in the form of slats to ensure unhindered access to the hotel for the lacewings. The upper side was screwed on the box as a lid and overhung 4 cms at the front like a canopy to provide a certain amount of protection from precipitation. At the rear a chair hinge was screwed on to fix the hotel out in the field. Finally all the hotels were painted with matt, reddish brown dispersion paint for wood (Lucite Wetterschutz plus®) and before they were exposed filled fairly densely with dry straw from oats.

The hotels were dismantled each year in December and stored in a cool, dark barn. In January/February the arthropods in them were determined, counted and, in the case of lacewings, sexed.

During all the trial years three species of the genus *Chrysoperla* were determined in the hotels which – contrary to almost all the other indigenous species of lacewing – hibernate as imagines. The total number of insects caught was surprisingly high and in 2003 reached a total of 2,251 individuals in the 15 hotels opened. Among these insects *Chrysoperla carnea* was clearly the dominant species and accounted for between 84% and 98% of the individuals in those three years. *Chrysoperla pallida* reached 2% - 15%, and only a few individuals of *C. lucasina* were found (0,2% bis 0,5%) each year in the hotels.

With regard to the location of the hotel there was a significant preference in all three years by *Chrysoperla* spp. for hotels fixed to the hop poles, while there was generally no significant difference in the colonizing between the other locations of the hotels. Only the location "on the edge of woods" showed the significantly lowest number of lacewings in 2003 (Fig. 6.3).

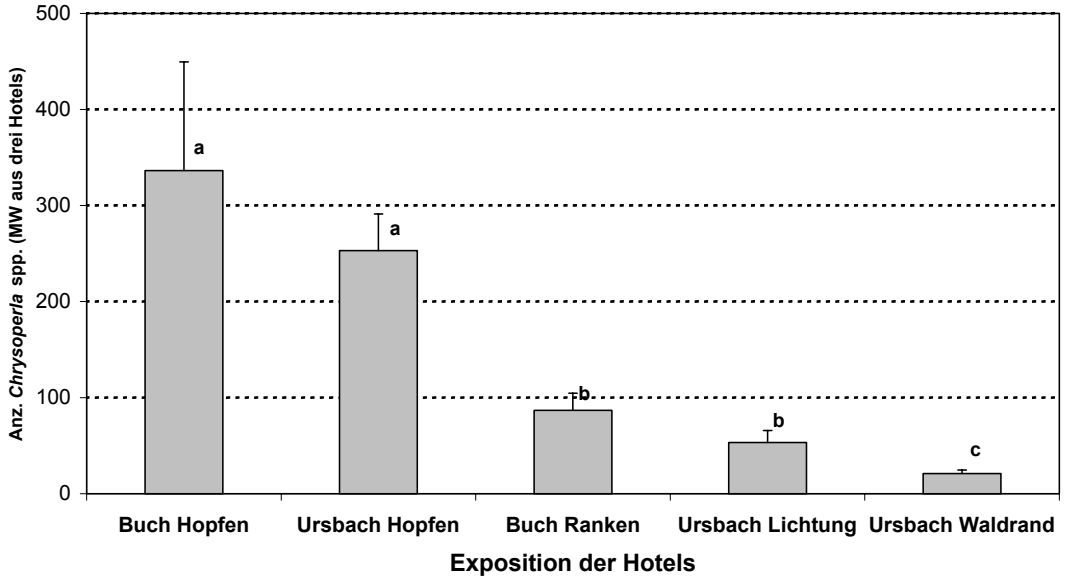
The absolute numbers of hibernating lacewings per hotel were quite remarkable on the hop poles and generally reached considerably higher figures than stated in literature on comparable research: The by far greatest number of hibernating lacewings could be found in 2003 with a maximum of 396 insects in one hotel on the hop poles, and of the three trial years this exposure site was colonized on an average by 280 lacewings per hotel. The hibernation rates at the other exposition sites was always considerably below this (Fig. 6.3). The antagonistic potential of an hotel is quite amazing: With (according to the data of all three trial years) about 130 - 150 hibernating female lacewings, each of which produce 300 eggs in the spring from which larvae hatch each of which eat about 300 hop aphids in the course of their development, it is over twelve million hop aphids.

However, when the hotels were opened in the trial yard in May 2003 and 2004 the specific use of this potential produced no increased rate of eggs laid by the female lacewings on the hops. Although at least in 2004 a lot of insects were still diapausing in the hotels during the coolest and darkest storage possible, when released they seem to disperse freely in the surrounding areas and obviously do not remain in the stand.

Figure 6.3:

Hibernating rates 2003/2004 of *Chrysoperla* spp. in lacewing hotels in the hop region near Ursbach and Buch (n total/15 hotels = 2251);

a, b, c = significant differences according to ANOVA ($P < 0,05$)



6.3.5 Attraction of lacewings for the control of hop aphids

In the first two trial years efforts were made within the scope of this investigation to stimulate the lacewings to lay their eggs on the hops with our own "artificial honeydew". The mixture consisted of 1000 g honey and 50 g brewers yeast, which was diluted with tap water to make 5 litres and then it was well stirred. To avoid the formation of black mould fungus on the leaves, an additional 5 g of the fungicide "Funguran" approved according to the Bioland guidelines was stirred in. In 2002 and 2003 the artificial honeydew was applied using a projection sprayer at the Ursbach location in four lacewing plots on two dates (beginning of June and mid-August) on every second plant in the row. A week later the number of the lacewing eggs were monitored on treated and untreated plants, and no differences could be found, i.e., this method proved to be not successful to attract lacewings for oviposition.

Due to these poor results the application of artificial honeydew was omitted in 2004. For this insect traps were established at five locations in the spring, which had various scents (kairomones) as baits. As far as the locations are concerned, in each case there were the outer rows of the poles of the trellis system of hop yards in Ursbach (2), Buch and Hüll (2), in which series of eight traps were exposed on eight poles in a row at a height of about 1.5 m. The traps hung for 16 weeks until harvest, were emptied weekly and were evaluated for lacewings and hoverflies. A highly significant attraction effect for the lacewing species *Peyerimhoffina gracilis* was evidenced by the substances (1*R*,4*S*,4a*R*,7*S*,7a*R*)-dihydronepetalactol and nepetalactone (Table 6.8). However, so far no kairomone could be found as an attractant for the actual object of these trials, the wide-spread, common predator *Chrysoperla carnea.*

Table 6.8:

Lacewing species (Chrysopidae) attracted by various kairomones at five locations in the Hallertau in 2004. The numbers represent the total catch at five locations in the Hallertau in 16 weeks (males,females).

		Lockstoff							
Florfliegenart	Gesamtfang	G1	G2	G3	G4	G5	Nepetalactol	Nepetalacton	Kontrolle
Hypochrysa elegans	2,0			2,0					
Chrysopidia ciliata	0,1					0,1			
Chrysopa perla	7,1						7,1		
Chrysopa dorsalis	0,1						0,1		
Chrysopa pallens	1,0						1,0		
Peyerimhoffina gracilis	593,210						364,118	229,92	
Chrysoperla carnea s.str.	1,3	0,2					1,1		
Chrysoperla pallida	1,1	0,1			1,0				

6.3.6 Testing of plant protectives that comply with the production guidelines for organic hop growing

Trials relating to this topic were held in the three trial years at various locations, partly integrated in trial rows for the Official Assessment of Plant Protectives. Special investigations on plant protectives that comply with the Bioland guidelines were mainly carried out in two hop yards at the Ursbach location.
In 2002 first and foremost the effectiveness of a quassia extract was examined in Ursbach which had been produced by the farmer himself by boiling of the chippings. The degree of effectiveness of the quassia treatment could be assessed as very good. As the aphid population (*Phorodon humuli*) completely broke down in all plots by the end of July, in the trial harvest however neither qualitative nor quantitative differences could be ascertained at the untreated plots, i.e., the infestation of aphids from mid-June up to mid-July had no influence on yield or alpha-acids. In the weekly monitorings which encompassed all other arthropods on the hops, a significant side effect from the quassia solution could be determined on non-target organisms (in this case cicades). In addition, in 2002 the *Bacillus subtilis* preparation "Serenade" was tested against powdery mildew and two low copper preparations ("Solucuivre", "SPU-00910-F-0-WD") against downy mildew. "Serenade" showed no improvement against untreated plots. The effect of "Solucuivre" could not be finally judged as no attacks were observed during the testing period. Tests with"SPU-00910-F-0-WD" had to be broken off due to lack of effectiveness.

In 2003 two big trials each with three replicates per trial section were set up in Ursbach to control hop aphids. In one trial the quassia extract which was very effective in 2002 was analysed and the effectiveness of three different NeemAzal formulations incl. a granulate were examined in another garden. Unfortunately both trials produced no results due to the extreme weather conditions which made the aphid populations in all plots completely break down early at the end of June. In another aphid trial at the Buch location (three replicates,

cv. HM) in 2003 "Spruzit Neu" produced extremely positive results and with effective grades up to 98.2% was considerably better than the comparative insecticide.

Trials to control *P. humuli* were set up in 2004 in an experimental hop-yard in Herpersdorf/Hersbruck (cv. PE) and in two yards in Ursbach (cvs HE, SE). In Herpersdorf the following variants were tested: untreated, "Spruzit Neu" (comparative insecticide); "NeemAzal T/S" (sprayed and painted), quassia extract (sprayed) and "TRF-002" (quassia preparation, painted in four-fold concentration). The best effect on the aphids was shown by "TRF-002". After the last counting on 17.07.2004 to minimize the damage the largest part of the plots was uniformly painted over with "TRF-002" in three-fold concentration, only two rows of each test section remained untreated until a trial harvest on 01.09.2004. Striking in this trial harvest was the fact that the systemic variant "TRF-002" actually produced the best yield, but there were significant losses in alpha-acid contents (Fig. 6.4).

Another comparable trial to control aphids in Ursbach (cv. HE) was entirely sprayed on 11.07.2004 with a quassia-soft soap mixture as there were signs of a total loss due to the extreme attacks of aphids in all plots in 2004. Only in the third yard (cv. SE) the trial sections remained unrestricted up until the harvest; here the self-produced quassia extract again had the best effect on aphids, whereas "Spruzit Neu" showed very poor degrees of effectiveness in 2004. The main reason for this was probably the extremely cool spring weather from mid-May to Mid-June that virtually never guaranteed optimum conditions for aphid sprayings.

In a trial hop yard (cv. HA) in Herpersdorf apart from an untreated variant and the comparative product "Funguran" (copper oxychloride) the test products "Cuprozin flüssig" (copper hydroxide), "Kanne Brottrunk", whey and "Frutogard" (plant restorative) were tested to control downy mildew *Pseudoperonospora humuli*. The spread of infection through primary infection, the so-called "spikes", was very high. The diseased shoots were broken out twice by hand. Despite three treatments simultaneously with the test products, the infestation in the test variants was so heavy that the trial had to be broken off. Only "Frutogard" showed a good effect. With an experimental harvest on 01.09.2004 in this test section the yields of the practice variant however could not be reached anywhere near at all (Fig. 6.5). However, "Frutogard" has to be be listed in the future as a plant protective as it contains phosphoric acid and can therefore no longer be used in organic hop growing.

In 2004 to control the powdery mildew *Sphaerotheca humuli* in another garden in Ursbach (cv. PE) potassium bicarbonate with interlacing agent, whey and "hipocre" (natural microorganisms, fermented plant extracts and micronutrients) were used. As no powdery mildew occurred even in untreated plots, no result could be gained.

Figure 6.4: Experimental harvest "Flöz", Herpersdorf, 01.09.2004, cv. PE

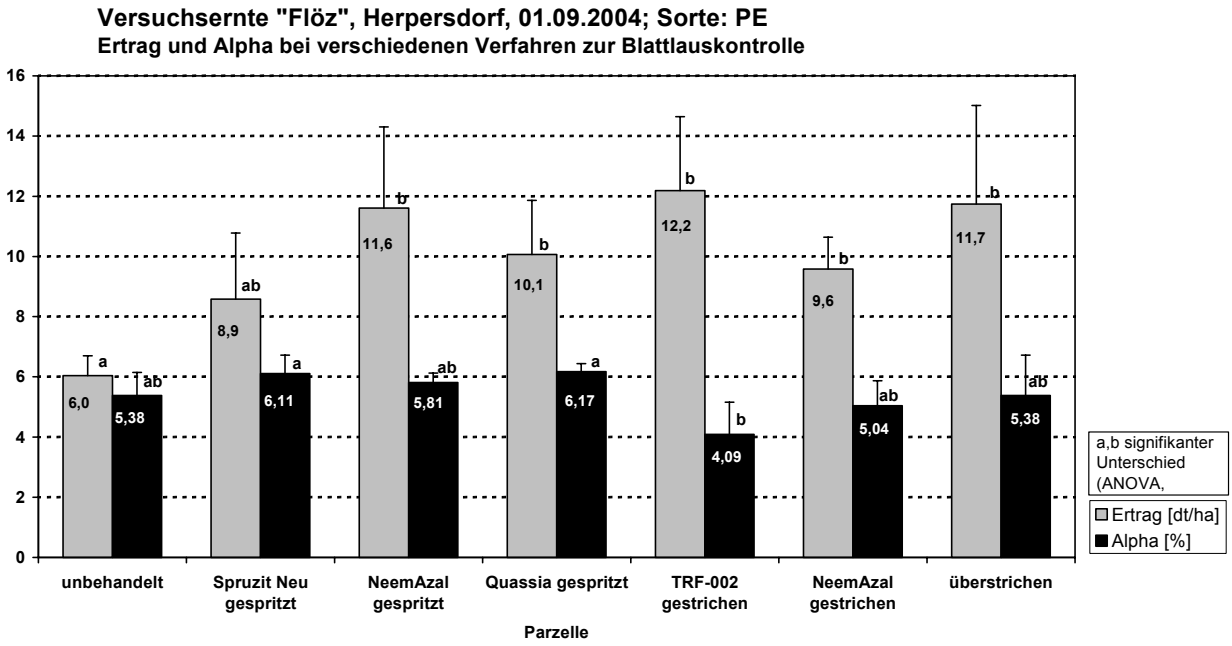
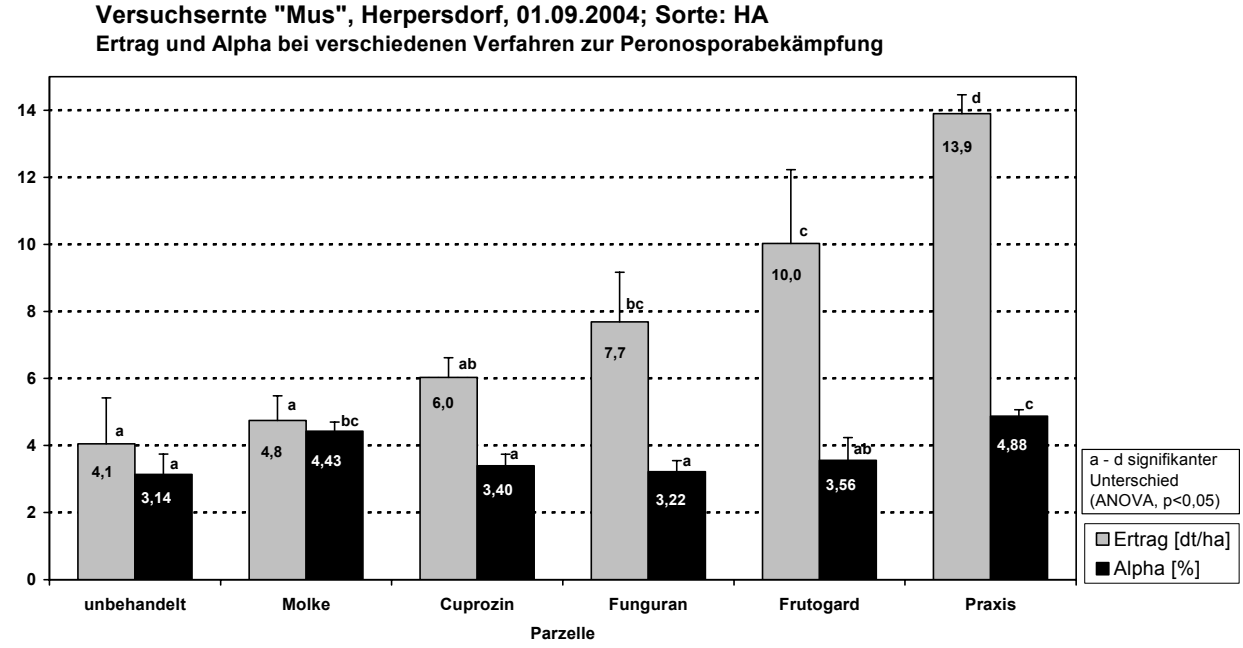


Figure 6.5: Experimental harvest "Mus", Herpersdorf, 01.09.2004, cv. HA



6.4 Developing a sprayer for individual bines for the Official Insecticide Test in hops

Figure 6.6 : Sprayer for single hop bines

Objective

In the special culture of hops the farmers only have a limited number of licensed plant protectives available. Eight trials for effectiveness and eight trials for residue are needed to be authorized for hops. These trials out in the open have so far been carried out with a blower-sprayer as normally used in the practice. The size of the plots is around 500 m², only 10 wires at the heart of the plot are assessed. With the development of a sprayer for individual bines the trial areas and consequently the compensatory costs should also be reduced. This creates an incentive for the plant protective companies to test new substances in hop-growing very early on. Therefore the authorization for use in hop production can already take place in the time frame of the main cultures and the maximum amount of residue must not be laid down for hops at a later date..

Method

This prototype was developed at the Institute for Agrarian Techniques, Building & Environmental Technology in close cooperation with IPZ 5b and IPS. The equipment concerned is a front attachment with hydraulic lift masts. The spray basket is fastened on the lift masts and travels evenly up the bine. By using three binary jets and three additional air jets it is possible to obtain a spraying similar to the practice with only 300 - 800 ml of water per wire. The spray liquid is filled into a pressure pump and this is fastened directly on the spray basket. In the spraying procedure the pressure pump also travels upwards. Therefore the wires to the jets can be kept very short and very little is left over. By using pressure pumps the very small amounts of test substances can also be weighed in at the laboratory. There is no drop in pressure while spraying as it is operated with compressed air and compressor. If a new test substance is to be sprayed, the pressure pump is replaced. The wires and jets are cleaned with water and compressed air. The spray basket can be cleaned with a hand gun with water. In the rear-mounted part of the tractor there is its own oil motor, compressor and two water tanks. The technical development of the equipment is for the most part completed.

Test to measure coating

So that the test results of spraying the individual bines can later be transferred into the practice, comparative trials must be carried out with the practice equipment and the individual bine sprayer. Therefore in August 2004 a test to measure the deposit was carried out in cooperation with Mr. Schenk IPS and the FA Geisenheim. By applying a dye the precise amount of deposit could be defined when taking samples of the leaves and by washing off the sprayed deposit. 5 wires each were treated with the blower-spray used in the practice and the individual bine sprayer. 400 leaves pro variant were taken from four levels (bottom, midway, top outside and top inside). Of these, 200 leaves were washed off on the upper sides and 200 leaves were washed off on lower sides. The leaves were washed with prepared glasses with a defined content, which were covered with the leaf and then shaken. Through the uniform openings in the glasses the tested leaf surface was always the same.

Results

This test enables a quantitative definition of the sprayed deposit. This method is backed up statistically. However, the droplet spectrum on the leaf was not acquired. With the individual bine sprayer the build-up of active substances is quantatively similar or even higher than with the equipment used in the practice. Further comparative tests for effectiveness must still be carried out over the new few years.

Project Manager: Engelhard B.

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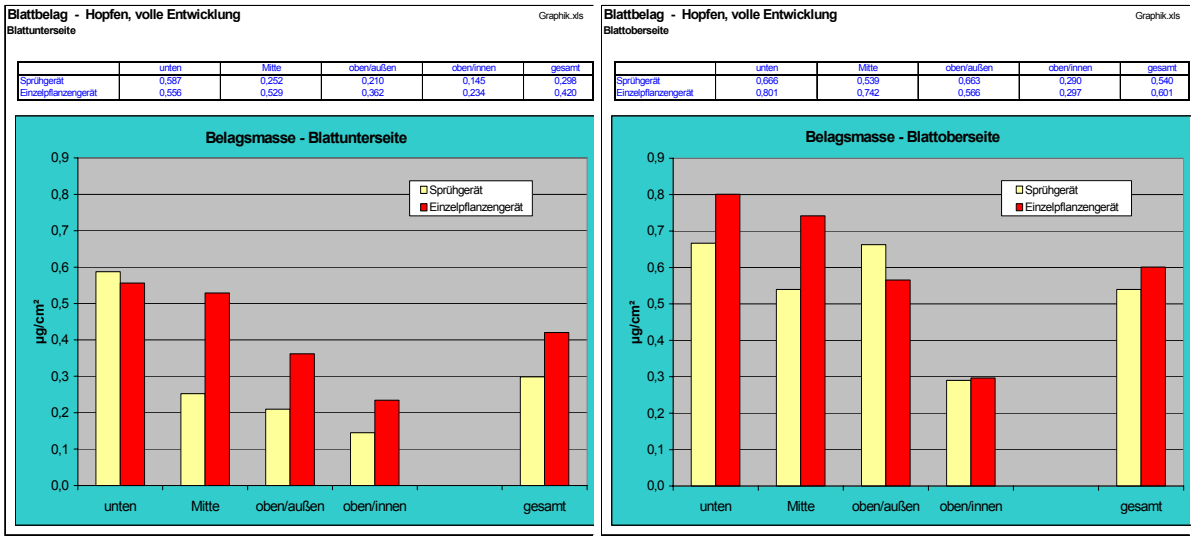
Duration: 2003-2005

Promoted by: Firmen BASF, Bayer CropScience, DOW AgroScience GmbH, Spiess-Urania Chemicals GmbH, Stähler and SyngentaAgro GmbH

Figure 6.7 : Test to measure deposit 2004



6.5 Virus-free plant material

11,256 plants were examined for viruses in 2004.

- **Work Sector - Breeding**
  5,544 mother plants for ApMV and HMV
  560 young plants for ApMV

- **Propagation facility Eickelmann**
  309 mother plants for ApMV und HMV
  including: 34 Hallertauer Mittelfrüher
  4 Select
  4 Hersbrucker
  40 Saphir
  43 Hallertauer Merkur
  46 Perle
  36 Taurus
  45 Hallertauer Magnum
  57 Hallertauer Tradition

- **Ring Hallertau**
  56 ApMV for confirmation

- **Own examinations**
  126 ApMV
  574 HMV

- **Professor Schildbach – samples from Turkey**
  80 ApMV
  80 HMV

7 Hop Quality and Analytics

Dr. Klaus Kammhuber, Dipl. Chemiker

7.1 Introduction

It is the task of the Work Group IPZ 5d to carry out all the analytical tests, which are necessary to support test problems of the work sector IPZ 5 Hops. The bitter compounds, essential oils and polyphenols are regarded as the valuable hop components. Particularly the content of alpha-acids is considered to be the primary quality feature of hops from an economic aspect as it represents a criterion for the bitter potential. The essential oils ensure the hop aroma in the beer. The polyphenols possess a lot of positive characteristics with regard to health as they have an antioxidant effect and can catch free radicals. Especially the substance xanthohumol recently aroused great interest by the general public due to its anti-carcinogenic potential. It was proved through a lot of brewing trials that by selecting different hop varieties from various hop-growing regions it is possible to give the beer various characters. However this cannot yet be allotted analytically to a specific spectrum of hop components.

7.2 Breeding programmes

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

7.2.1 Breeding program: aroma varieties

Table 7.2 shows analysis results for the 2003 crop with criteria of the Saaz group compared with the varieties Saazer, Spalter, Spalter Select and Tettnanger. Some varieties are marked by a high linalool and farnesene content and at the same time low cohumulone contents.

7.2.2 Breeding program: bitter varieties

As far as the bitter varieties are concerned, on the one hand bitter hops are desired without qualitative requirements with the highest possible alpha-acid content and on the other hand bitter varieties with qualitative requirements like “Hallertauer Magnum” and “Hallertauer Taurus” should be breeded. The table 7.1 shows a selection of some breeding lines in comparison to “Hallertauer Magnum”, “Hallertauer Merkur” and “Hallertauer Taurus” of the 2003 crop.

The breeding line 95/094/816 was applied for the name “Herkules” at the Federal Classification Office. This breeding line brings considerable breeding progress regarding ripening time, resistance, yield and alpha-acid content. Even in 2003 which was marked by extremely low alpha-acid values many Hüll breeding lines still showed quite good alpha-acid contents.

Table 7.1 Breeding program: bitter varieties, 2003 crop

Variety/Breeding line	a-acids	ß-acids	ß/a	Cohumulone	Colupulone
Hallertauer Magnum	12.44	6.52	0.52	19.9	36.3
Hallertauer Magnum	12.18	5.51	0.45	20.8	38.9
Hallertauer Merkur	11.24	5.06	0.45	16.0	38.5
Hallertauer Merkur	11.23	4.02	0.36	14.7	38.4
Hallertauer Taurus	12.94	4.10	0.32	19.1	41.3
Hallertauer Taurus	13.48	4.21	0.31	19.8	42.5
95/094/816 (Herkules)	13.49	4.36	0.32	30.4	51.6
95/094/816 (Herkules)	14.29	4.09	0.29	29.5	51.2
89/089/059	12.80	4.27	0.33	21.2	44.9
93/010/034	12.13	4.78	0.39	18.1	39.6
93/010/063	12.63	4.77	0.38	28.0	48.7
94/075/761	13.49	4.95	0.37	14.3	30.0
95/083/769	13.43	3.42	0.25	21.7	46.3
95/094/721	13.69	4.20	0.31	30.5	55.3
95/094/834	13.33	4.18	0.31	30.5	52.4
95/094/850	12.49	4.02	0.32	20.1	40.4
97/065/753	12.73	4.26	0.34	19.1	46.6
99/061/009	12.44	3.08	0.25	18.7	35.2
2000/066/011	12.74	4.05	0.32	24.1	42.5
2000/070/006	12.87	4.94	0.38	22.5	37.9
2000/108/715	14.11	4.26	0.30	26.1	48.1
2000/109/727	12.91	5.52	0.43	18.2	46.9
2000/109/728	16.54	3.71	0.22	20.8	42.4
2001/093/010	12.28	3.77	0.31	20.8	40.4
2001/093/714	12.63	4.24	0.34	22.9	44.0
2001/093/715	12.48	5.18	0.42	19.7	40.4
2001/103/710	12.45	3.20	0.26	17.0	35.2
2001/109/010	14.86	4.62	0.31	19.9	42.3
2002/061/007	15.06	5.98	0.40	22.0	44.2
2002/061/011	14.59	3.91	0.27	24.7	49.3
2002/061/725	13.76	4.49	0.33	27.3	51.9
2002/061/735	12.64	3.48	0.27	26.1	48.7
2002/061/748	13.37	4.68	0.35	22.3	46.5
2002/061/754	13.54	4.71	0.35	22.0	46.3
2002/069/026	12.32	3.42	0.28	26.9	49.6

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

Table 7.2: Breeding lines with criteria of the Saazer group and with low cohumulone contents, 2003 crop

Variety/ Breeding line	Myr-cene	2-M.-iso-butyrate	Sub. 14b	Sub. 15b	Lina-lool	Aroma-dendren	Unde-canon	Humu-lene	Farne-sene	γ-Muu -rolen	ß-Se-linen	α -Se-linene	Cadi-nene	Seli-nadiene	Gera-niol	α-acids	ß-acids	ß/a	Cohu-mulone	Colu-pulone
Saazer	2167	21	5	3	35	0	15	302	30	11	6	4	22	0	0	3.00	4.37	1.45	23.1	41.0
Spalter	2828	20	4	2	40	0	16	303	40	10	3	2	17	0	0	2.43	4.62	1.90	24.8	42.6
Spalter Select	7362	40	8	4	69	19	15	201	123	9	27	24	11	44	0	2.47	2.70	1.09	20.6	40.9
Tettnanger	3058	18	3	4	43	0	15	293	39	10	4	0	21	0	0	2.62	4.63	1.77	23.2	40.7
89/002/025	1755	36	5	9	35	0	9	210	26	6	4	0	11	0	0	4.03	3.62	0.90	19.8	52.7
91/033/015	2777	7	6	4	22	0	6	242	66	7	3	2	13	0	0	2.64	1.44	0.54	16.0	32.3
93/053/033	1803	32	3	2	21	0	15	291	41	9	4	3	16	0	0	4.22	4.51	1.07	19.7	37.0
97/010/023	3717	5	3	4	24	0	10	235	57	8	6	3	15	0	0	4.69	4.47	0.95	20.9	36.6
99/096/712	2004	66	2	5	17	0	10	183	26	6	41	50	14	2	0	6.15	2.71	0.44	23.6	44.3
2001/016/705	3056	39	3	22	26	0	17	217	34	7	34	39	16	0	0	5.53	2.29	0.41	22.4	44.7
2001/016/713	2746	72	4	30	12	0	24	274	24	7	4	4	15	0	0	4.93	2.42	0.49	21.8	42.2
2001/018/726	4348	54	5	5	40	0	22	179	21	8	11	11	17	16	0	6.99	3.67	0.52	21.0	49.5
2001/019/E62	2265	25	5	5	25	0	16	177	32	6	7	3	12	0	0	5.16	2.67	0.52	21.7	43.2
2001/032/702	979	7	6	3	28	0	7	271	24	11	6	3	22	0	0	4.34	2.86	0.66	17.7	46.9
2001/035/021	4310	44	5	4	36	0	14	264	64	7	4	3	15	0	0	4.42	2.17	0.49	21.4	42.9
2001/059/B08	1726	50	1	1	28	0	9	179	27	11	4	3	19	0	0	3.54	4.19	1.18	21.1	43.4
2001/059/B23	1562	53	1	4	8	0	5	174	40	8	3	2	14	0	0	4.13	1.81	0.44	21.0	43.9
2001/059/B35	2210	54	3	4	14	0	10	167	34	8	3	2	16	0	0	6.17	2.62	0.43	18.2	40.3
2001/059/B99	1766	14	1	5	12	0	7	255	89	9	3	3	17	0	0	3.93	1.27	0.32	24.7	44.7
2001/059/B113	2369	58	2	1	22	0	9	215	42	9	4	3	18	0	0	3.48	1.56	0.45	23.8	46.2
2001/059/B105	963	89	3	0	19	0	14	169	35	23	14	9	40	7	0	4.53	2.31	0.51	23.4	48.8
2001/059/B118	1365	41	2	1	10	0	4	203	35	7	3	3	15	0	0	4.39	1.68	0.38	23.5	43.7
2001/059/B119	2400	24	3	1	42	0	9	182	45	15	9	8	28	5	0	3.68	1.44	0.39	26.2	52.6

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

7.3 World hop range

This research program is carried out every year. The aim is to determine the quality and variety specific components of the available domestic and foreign hop varieties when produced under the conditions prevailing in Hüll. Table 7.3 shows the results of the crop year 2003. It can serve as an aid to allocate unknown hop varieties to a specific variety type.

Table 7.3: Word Hop Range 2003 Crop

Variety	Myr-cene	2-M.-iso-butyrate	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendren	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/a	Cohu-mulone	Colu-pulon
Admiral	3893	670	3	14	31	0	10	276	0	7	6	3	16	0	0	12.57	5.01	0.40	44.4	66.2
Agnus	4369	12	1	4	10	0	2	89	0	4	6	5	12	0	0	11.79	5.50	0.47	26.4	50.5
Alpharoma	2757	155	27	11	14	0	15	263	27	9	7	5	18	0	0	4.84	2.23	0.46	27.8	55.8
Apolon	7439	30	21	12	21	0	5	196	123	8	7	6	14	0	0	6.69	3.46	0.52	21.3	43.0
Aurora	9035	68	0	26	47	0	16	245	52	6	6	2	15	0	0	7.42	3.37	0.45	21.5	49.8
Backa	1106	153	6	3	12	0	5	247	20	8	6	3	18	0	0	5.13	3.31	0.64	37.3	62.3
Belgischer Spalter	1756	36	0	4	17	7	4	153	0	8	27	28	14	43	0	3.48	2.72	0.78	23.9	45.5
Blisk	3971	98	8	2	20	0	3	230	117	9	9	6	16	0	0	4.96	2.38	0.48	34.4	59.6
Bobek	13047	108	4	52	94	0	18	274	56	7	7	3	14	0	0	2.81	3.99	1.42	28.8	48.3
Bor	3837	29	0	24	9	0	3	269	0	6	3	3	13	0	0	4.85	3.63	0.75	22.5	43.0
Brewers Gold	5277	248	10	29	16	0	1	177	0	7	8	6	15	0	0	5.88	4.21	0.72	37.2	64.7
Bullion	5942	199	16	29	20	0	2	176	0	5	6	5	15	0	0	5.70	5.09	0.89	34.5	60.7
Cascade	5540	97	12	6	21	0	4	224	29	8	8	6	18	0	0	4.68	6.13	1.31	30.9	46.8
Chang bei no 1	5328	24	3	2	44	0	8	212	36	8	20	21	15	23	0	1.65	3.08	1.87	21.8	39.7
College Cluster	2619	36	11	28	7	0	2	139	0	4	6	5	10	0	0	4.42	1.69	0.38	24.7	46.9
Columbus	5391	85	10	7	9	0	2	133	0	2	8	8	26	9	0	13.34	4.10	0.31	27.2	50.3
Comet	1710	40	2	37	9	0	2	8	6	1	31	37	5	9	2	5.36	2.58	0.48	37.3	58.8
Crystal	2714	12	4	3	35	34	14	214	0	10	30	30	17	35	0	2.47	3.74	1.52	18.5	36.8
Density	1858	40	0	0	15	0	4	221	0	6	0	3	14	0	0	2.42	2.56	1.06	35.6	61.4
Dunav	3222	36	1	98	7	0	3	154	21	5	2	2	14	1	0	4.74	5.07	1.07	26.5	58.2
Early Choice	1303	31	0	9	5	0	2	205	0	5	32	41	15	0	0	1.62	1.43	0.88	33.1	51.7
Eastern Gold	1345	3	1	4	11	0	6	203	14	18	9	7	36	8	0	7.92	4.78	0.60	25.2	42.6
Eastwell Golding	2933	27	1	5	19	0	5	256	0	6	4	3	14	0	0	3.37	2.43	0.72	26.9	47.1

Table 7.3 continued

Variety	Myr-cene	2-M.-iso-butyrate	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendren	Unde-canon	Humu-lene	Farne-sene	γ-Muu-rolene	ß-Se-linene	α -Se-linene	Cadi-nene	Seli-nadien	Gera-niol	α -acids	ß-acids	ß/a	Cohu-mulone	Colu-pulon
Emerald	594	8	3	4	3	0	4	271	0	5	3	3	13	0	0	2.63	2.59	0.98	27.6	42.3
Eroica	3981	354	32	70	7	0	13	157	0	5	8	7	13	0	0	9.97	8.18	0.82	37.9	63.0
First Gold	5117	331	4	39	22	0	14	214	13	6	45	51	16	0	0	7.07	3.22	0.46	32.8	56.2
Fuggle	1886	60	0	2	14	0	4	268	21	7	4	3	18	0	0	3.13	2.28	0.73	28.6	48.5
Galena	5165	420	33	108	6	0	16	184	0	7	8	6	14	0	2	11.60	8.38	0.72	37.7	62.4
Ging dao do hua	4262	460	3	2	21	0	8	245	0	16	31	27	33	0	0	2.61	2.74	1.05	47.4	70.7
Glacier	1421	9	3	1	12	0	5	258	0	7	4	3	17	0	0	1.99	4.05	2.03	14.6	37.8
Golden Star	3798	500	0	5	17	0	7	256	0	18	31	26	36	0	0	2.52	2.65	1.05	46.8	70.5
Granit	4267	45	2	6	12	0	5	184	0	4	6	5	11	0	0	4.76	3.16	0.66	22.6	43.3
Green Bullet	2211	69	10	3	14	0	5	221	0	7	3	3	14	0	0	6.15	4.43	0.72	40.5	67.3
Hallertauer Gold	1691	11	12	2	16	0	4	239	0	6	5	3	14	0	0	4.86	4.22	0.87	22.2	39.7
Hallertauer Magnum	3840	19	18	10	8	0	4	262	0	7	3	3	14	0	0	12.88	5.85	0.45	18.3	35.7
Hallertauer Merkur	3018	112	11	4	23	0	4	246	0	6	4	3	15	0	0	11.02	4.79	0.43	15.7	39.2
Hallertauer Mfr.	1008	31	2	1	30	0	7	301	0	10	5	4	20	0	0	2.98	4.01	1.34	19.9	39.4
Hallertauer Taurus	5496	13	9	10	34	0	7	223	0	6	42	53	16	0	0	12.69	4.34	0.34	19.6	41.0
Hallertauer Tradition	1346	27	4	0	23	0	4	274	0	7	6	3	16	0	0	4.27	3.21	0.75	25.9	45.9
Herald	6007	303	3	83	15	0	18	188	0	5	22	22	14	0	0	9.27	3.22	0.35	34.4	59.0
Hersbrucker Pure	7135	41	0	13	35	12	8	176	0	8	30	32	16	49	0	2.69	1.74	0.65	25.2	46.3
Hersbrucker Spät	2068	7	4	3	46	38	10	199	0	11	42	43	17	54	0	2.30	3.94	1.72	17.7	35.8
Horizon	3455	57	3	10	23	0	4	134	14	4	11	10	11	0	0	6.20	3.86	0.62	18.7	39.4
Hüller	2636	68	16	3	29	22	9	165	0	28	48	46	50	71	0	5.65	3.24	0.57	26.3	45.0
Hüller Anfang	795	32	5	0	15	0	5	302	0	10	5	4	19	0	0	2.36	3.99	1.69	22.7	39.0
Hüller Aroma	959	17	2	0	21	0	4	251	0	8	3	3	16	0	0	2.97	4.45	1.50	24.7	43.9

Table 7.3 continued

Variety	Myr-cene	2-M.-iso-butyrate	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendren	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/a	Cohu-mulone	Colu-pulon
Hüller Fortschritt	986	10	4	0	17	0	5	245	0	7	4	3	14	0	0	2.21	4.42	2.00	26.0	42.0
Hüller Start	637	12	1	1	8	0	6	266	0	8	6	3	17	0	0	2.16	3.80	1.76	23.5	42.6
Japan C 730	2217	14	21	37	8	0	6	103	90	4	6	5	9	0	0	1.84	1.48	0.80	35.1	59.7
Japan C 827	1890	17	8	7	5	0	4	273	33	8	8	6	17	25	0	2.96	1.81	0.61	27.2	53.4
Japan C 845	1438	4	3	23	4	0	3	275	24	8	3	3	15	0	0	5.54	4.34	0.78	20.0	39.2
Kirin 1	3685	433	3	3	15	0	6	228	0	13	24	21	28	0	0	2.91	3.03	1.04	46.3	70.4
Kitomidori	1547	6	3	21	5	0	2	248	15	8	3	3	14	0	0	5.58	4.61	0.83	19.8	38.5
Kumir	2974	24	0	13	27	0	4	297	10	8	6	3	16	0	0	7.05	4.70	0.67	19.1	39.8
Late Cluster	18514	226	24	25	67	26	16	43	12	33	74	74	66	98	7	7.00	3.57	0.51	20.6	41.8
Liberty	4381	80	2	7	42	0	9	258	0	7	5	4	17	1	0	2.65	2.57	0.97	27.5	47.0
Marynka	9989	176	4	30	16	0	5	124	163	8	8	7	14	1	0	8.44	3.63	0.43	23.2	49.1
Mount Hood	1274	39	7	1	26	0	4	218	0	11	5	3	21	0	0	1.95	3.41	1.75	21.9	41.1
Neoplanta	3902	71	0	26	13	0	4	179	35	5	2	2	12	0	0	4.90	2.58	0.53	28.3	59.0
Northern Brewer	1536	42	0	16	6	0	3	209	0	6	3	3	12	0	0	5.73	4.62	0.81	27.4	48.1
Nugget	2372	90	2	11	15	0	6	177	0	6	8	6	12	0	0	8.49	3.05	0.36	24.3	48.8
Olympic	1907	91	2	8	15	0	6	180	0	5	8	6	12	0	0	8.74	3.11	0.36	24.8	49.5
Omega	2607	113	6	5	14	0	6	306	0	6	46	58	18	0	0	4.51	2.95	0.65	31.8	45.7
Orion	1042	39	1	2	14	0	3	165	0	7	2	2	16	0	0	5.45	3.96	0.73	27.5	48.3
OT 48	1979	60	3	1	24	0	8	225	0	7	2	4	16	0	0	2.18	2.68	1.23	36.2	60.7
Pacific Gem	3697	315	15	15	17	0	13	263	0	7	3	2	16	0	0	9.32	5.72	0.61	39.6	66.7
PCU 280	1092	18	0	7	3	0	2	234	0	5	3	3	13	0	0	5.28	2.54	0.48	25.6	47.4
Perle	911	21	1	7	3	0	2	206	0	5	2	2	12	0	0	3.34	2.45	0.73	32.8	51.4

Table 7.3 continued

Variety	Myr-cene	2-M.-iso-butyrat	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendren	Unde-canon	Humu-lene	Farne-sene	γ-Muu-rolene	ß-Se-linen	α -Se-linen	Cadi-nene	Seli-nadiene	Gera-niol	α -acids	ß-acids	ß/a	Cohu-mulone	Colu-pulon
Phoenix	888	99	1	3	4	0	2	225	18	6	42	53	15	0	0	9.27	3.97	0.43	22.8	45.0
Pilgrim	6109	351	3	116	12	0	22	247	0	6	52	62	17	0	0	5.24	2.34	0.45	38.8	62.8
Pilot	4271	207	3	18	59	0	46	65	0	9	305	363	30	0	3	6.07	2.26	0.37	34.9	61.9
Pioneer	3513	471	3	62	13	0	31	205	0	6	19	18	15	0	0	7.17	2.53	0.35	38.7	64.6
Premiant	3404	36	2	11	26	0	5	248	10	7	4	3	15	0	0	6.54	4.57	0.70	19.3	41.7
Pride of Ringwood	2866	18	3	1	7	0	10	18	0	7	194	205	21	0	1	3.45	4.37	1.27	35.2	56.9
Progress	14818	194	24	25	63	33	17	55	0	37	78	75	70	99	6	5.92	3.62	0.61	21.1	41.6
Record	2147	28	2	5	26	0	15	295	0	10	9	5	20	0	0	1.55	3.56	2.30	24.1	42.3
Saazer	2167	21	5	3	35	0	15	302	30	11	6	4	22	0	0	3.00	4.37	1.45	23.1	41.0
Saphir	3777	9	4	16	22	5	16	196	0	7	22	20	15	28	0	1.75	3.29	1.88	11.6	40.3
Serebrianca	817	24	1	2	21	0	3	142	0	12	26	22	21	0	0	1.22	4.88	4.01	19.4	36.5
Sladek	5240	44	0	16	31	0	4	281	0	6	3	3	15	0	0	5.52	4.09	0.74	21.0	41.9
Spalter	1914	22	6	3	41	0	15	302	27	11	5	0	21	0	0	2.82	4.59	1.63	23.2	40.9
Spalter Select	7207	35	13	12	38	6	7	228	81	7	18	17	15	22	0	2.66	2.51	0.94	22.1	41.5
Sterling	1516	59	2	10	12	0	5	169	0	5	6	4	12	0	0	7.22	2.65	0.37	24.0	48.9
Sticklebract	4895	334	27	10	14	0	13	176	35	7	44	46	17	0	3	8.12	5.00	0.62	41.4	67.7
Strisselspalter	1743	4	4	4	38	35	11	224	0	10	32	35	16	39	0	2.02	4.31	2.14	15.9	32.7
Super Alpha	7540	274	16	16	44	0	7	266	0	5	3	3	13	0	0	5.07	4.39	0.87	40.1	63.7
Talisman	4014	41	0	37	7	0	2	202	0	5	2	2	13	0	0	5.49	4.79	0.87	27.8	47.8
Tettnanger	3058	18	3	4	43	0	15	293	39	10	4	0	21	0	0	2.62	4.63	1.77	23.2	40.7
Toyomidori	4009	436	14	171	16	0	8	208	0	17	8	7	33	7	0	10.68	4.42	0.41	39.5	60.0
USDA 21055	3678	291	3	179	8	0	3	120	38	5	11	12	14	0	0	8.69	2.92	0.34	42.2	65.4

Table 7.3 continued

Variety	Myr-cene	2-M.-iso-butyrate	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendren	Unde-canon	Humu-lene	Farne-sene	γ-Muu-rolene	ß-Se-linen	α -Se-linen	Cadi-nene	Seli-nadiene	Gera-niol	α -acids	ß-acids	ß/a	Cohu-mulone	Colu-pulon
WFG	2935	18	0	10	32	0	10	296	45	9	7	3	19	0	0	2.64	4.27	1.62	23.9	40.8
Willamette	2379	52	0	4	13	0	2	250	32	6	5	4	13	0	0	2.22	2.49	1.12	32.4	53.2
Wye Challenger	5180	149	0	16	17	0	7	244	0	5	36	42	15	0	0	2.73	3.47	1.27	31.4	47.4
Wye Saxon	2603	38	0	71	11	0	5	163	30	6	26	25	15	0	0	5.45	5.70	1.05	18.6	38.8
Wye Target	4050	197	4	16	27	0	6	167	0	12	10	8	26	7	0	9.16	4.03	0.44	34.2	60.5
Wye Viking	4737	102	7	42	18	0	9	197	71	7	30	29	16	0	0	6.56	5.87	0.89	21.1	39.9
Yeoman	1321	95	0	3	5	0	2	201	0	5	32	39	13	0	0	9.24	4.09	0.44	23.1	44.2
Zatecki	1151	29	0	2	10	0	2	205	14	5	2	2	12	0	0	1.65	2.09	1.26	28.9	47.8
Zenith	5889	36	0	14	34	0	8	234	0	5	48	60	15	0	0	4.33	2.19	0.51	27.2	48.6
Zeus	6431	119	14	9	12	0	3	147	0	14	10	10	30	10	0	12.31	3.70	0.30	26.9	50.5
Zitic	3724	7	1	6	9	0	6	254	0	5	4	2	12	0	0	2.58	2.66	1.03	20.9	41.8

Esssential oils = relative values, ß-caryophyllene = 100; **α** - and beta -acids in % as is.; analoga in % of the **α** - or ß-acids

7.4 Collaborative trials for the 2004 crop

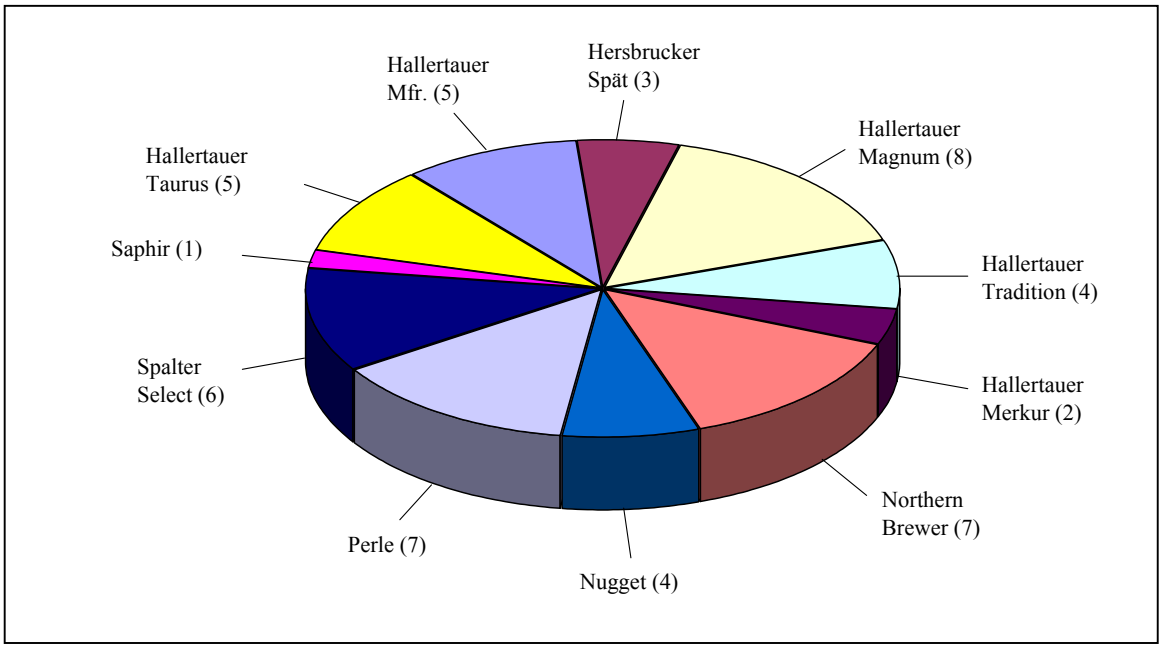
Since the year 2000 there has been a supplementary agreement to the hop supply contracts, in which the alpha-acid contents are taken into consideration. The price agreed in the contract applies if the alpha-acid content is within a neutral range. If this neutral range is exceeded or fallen short of there is either a surcharge or a price reduction. It is precisely laid down in the duties record book of the Work Group for Hop Analytics how the samples are to be treated (dividing samples, storage), which laboratories carry out further analyses and which tolerance ranges are permitted for the results of the analyses. In 2004 it was again the task of the Work Group IPZ 5d to organise collaborative trials and evaluate them in order to ensure the accuracy of the alpha-acid analyses.

In 2004 the following laboratories participated in the collaborative trials

- 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
- Agrolab GmbH, Oberhummel
- Agrar- und Umweltanalytik GmbH (AUA), Jena
- Bavarian Research Center for Agriculture, Dept. Hops, Hüll

The collaborative trial was started on 30.08.2004 and ended on 26.11.2004 as the majority of the 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 homogeneity. Each time on a Monday the samples were ground in Hüll with a hammer mill, divided using a sample divider, vacuum-packed and brought to the individual laboratories. On the following weekdays one sample was always analyzed per day. The results of the analyses were sent back to Hüll a week later and evaluated there. Altogether 52 samples were analyzed in 2004. Figure 7.1 shows the composition of the varieties.

Figure 7.1: Composition of the varieties for the collaborative trials 2004



The evaluations were passed on as quickly as possible to the individual laboratories. As examples Figures 7.2 and 7.3 show the collaborative trials with the lowest and highest deviations.

Figure 7.2: Collaborative trial with the lowest standard deviation

Nr. 1: HHA (31.08.2004)

Labor	KW		mittel	s	cvr
1	4,33	4,29	4,31	0,028	0,7
2	4,40	4,40	4,40	0,000	0,0
3	4,43	4,44	4,44	0,007	0,2
4	4,40	4,40	4,40	0,000	0,0
5	4,33	4,44	4,39	0,078	1,8
6	4,33	4,27	4,30	0,042	1,0
7	4,49	4,49	4,49	0,000	0,0

mean	4,39
sr	0,035
vkr	0,8
sR	0,069
vkR	1,6
r	0,10
R	0,19
Min	4,30
Max	4,49

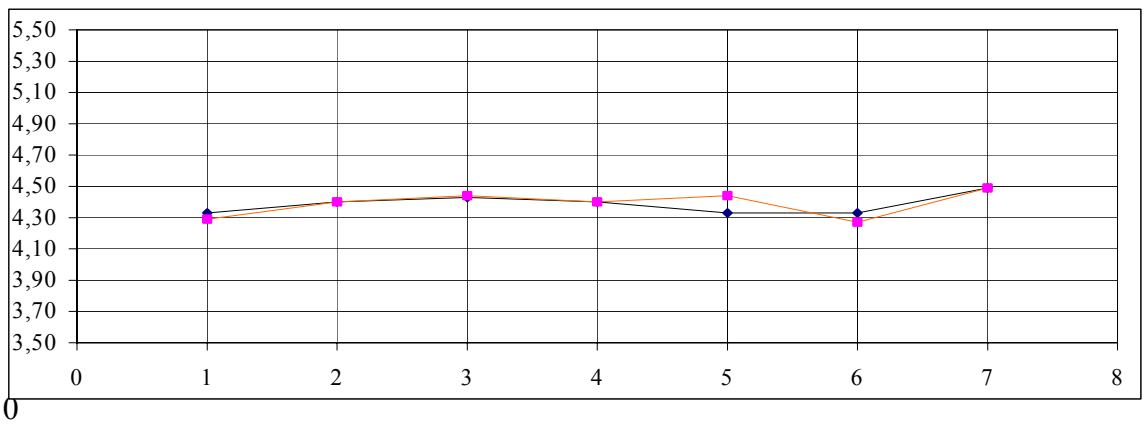
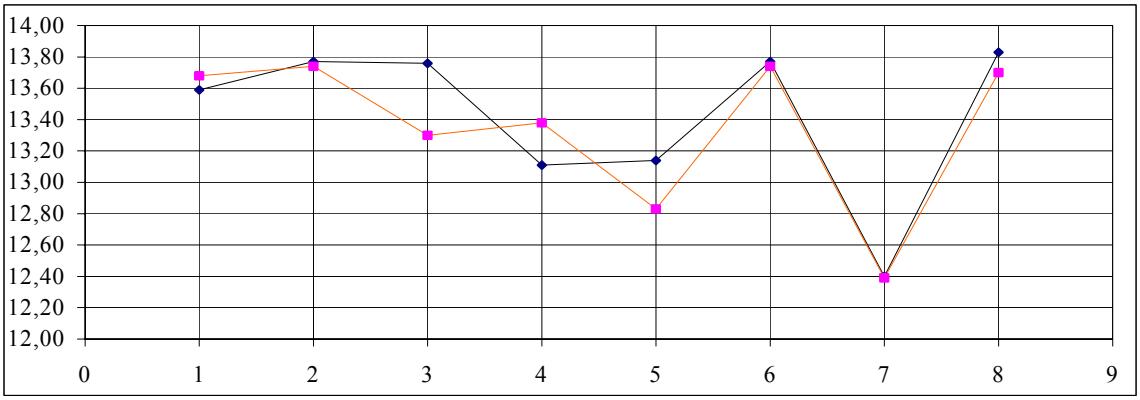


Figure 7.3: Collaborative trial with the highest standard deviation

Nr. 28: MR (15.10.2004)

Labor	KW		mittel	s	cvr
1	13,59	13,68	13,64	0,064	0,5
2	13,77	13,74	13,76	0,021	0,2
3	13,76	13,30	13,53	0,325	2,4
4	13,11	13,38	13,25	0,191	1,4
5	13,14	12,83	12,99	0,219	1,7
6	13,77	13,74	13,76	0,021	0,2
7	12,40	12,39	12,40	0,007	0,1
8	13,83	13,70	13,77	0,092	0,7

mean	13,38
sr	0,160
vkr	1,2
sR	0,485
vkR	3,6
r	0,45
R	1,36
Min	12,40
Max	13,77



As a outlier test between the laboratories the Grubbs Test was calculated according to DIN ISO 5725. 4 outliers were recorded in 2004. Table 7.4 shows the tolerance limits (d critical, Schmidt, R., NATECO$_2$, Wolnzach) deduced from the methods collected by the European Brewery Convention (EBC 7.4, conductometric titration) and their exceedings in the years 2000, 2001, 2002, 2003 and 2004.

Table 7.4: Tolerance limits of the EBC method 7.4 and their exceedings in the years 2000, 2001, 2002, 2003 and 2004

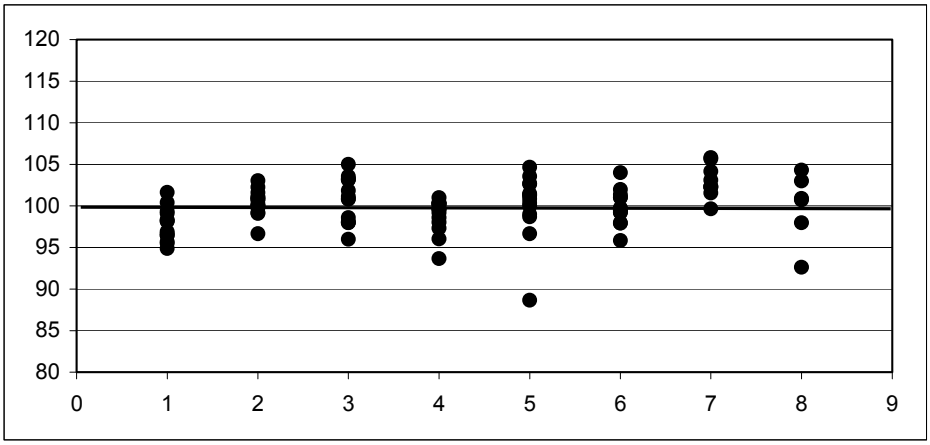
	Up to 6.2 % α-acids	6.3 % - 9.4 % α-acids	9.5 % - 11.3 % α-acids	As from 11.4 % α-acids
d critical	+/-0.3	+/-0.4	+/-0.5	+/-0.6
range	0.6	0.8	1.0	1.2
exceedings in 2000	0	3	0	3
exceedings In 2001	2	1	0	2
exceedings In 2002	4	4	2	4
exceedings In 2003	1	1	1	0
exceedings in 2004	0	0	0	4

In 2004 there were 4 exceedings in the tolerance range greater than 11.4 % consequently the 2004 collaborative trial was not as good as in 2003.

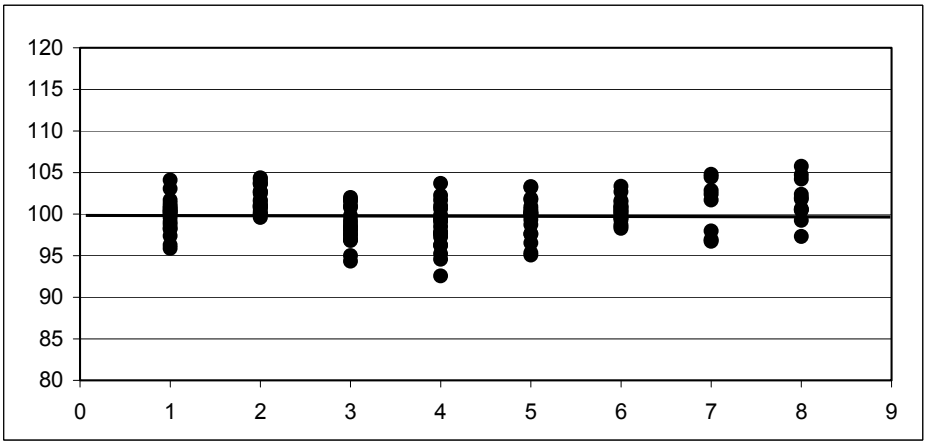
All the analysis results for each laboratory are listed in Figure 7.4 as relative deviations from the mean average (= 100 %) differentiated according to alpha-acid content < 5 %, > = 5 % and < 10 %, > = 10 %.

Figure 7.4: Analysis results of the laboratories relative to the mean average

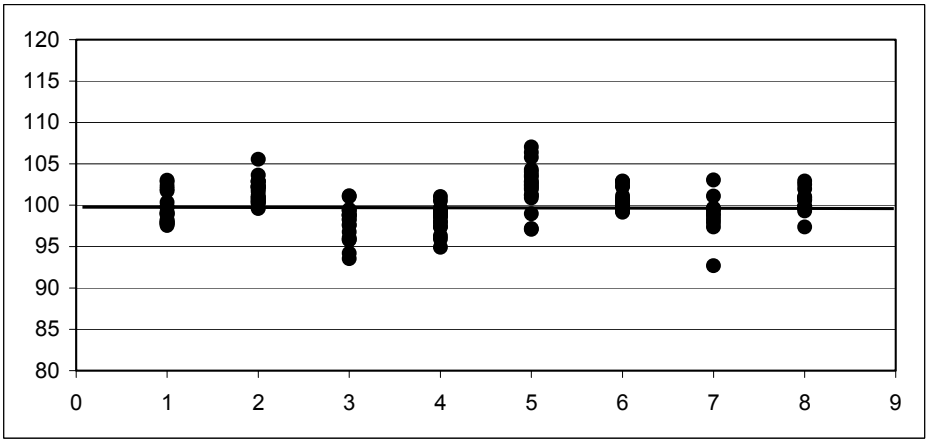
Proben < 5 %



Proben >= 5 % und < 10 %



Proben >= 10 %



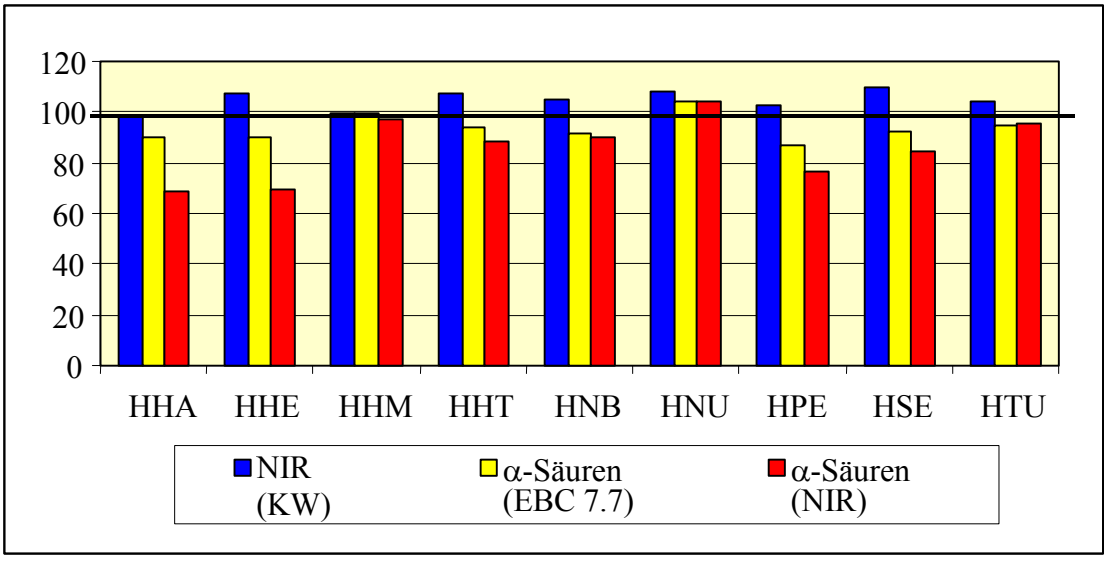
7.5 NIR – Near Infrared Reflection Spectroscopy

KW (EBC 7.4)	=	conductometer value according to EBC 7.4
NIR (KW)	=	conductometer value determined with NIR based on KW (EBC 7.4) calibration
α-acids (EBC 7.7)	=	alpha-acids determined with HPLC (high performance liquid chromatography) according to EBC 7.7
α -acids (NIR)	=	alpha-acids determined with NIR based on HPLC (EBC 7.7) calibration

In the Work Group for Hop Analytics it was decided that the present NIR calibration based on the conductometer values according to EBC 7.4 can no longer be improved and it is not suitable as a method for the hop supply contracts. Nevertheless the calibration will be amended and extended each year through new data records.

Since the year 2000 a calibration based on HPLC data is being built up by the laboratories of the hop processing firms and the Bavarian Research Center (LfL) in Hüll. In 2003 this calibration was proved to be not good. Figure 7.5 shows the mean values NIR (CV), alpha-acids (EBC 7.7) and alpha-acids (NIR) relative to the CV (EBC 7.4) = 100 % of the 2003 collaborative trial. It shows that with the varieties Hallertauer Mfr. and Hersbrucker Spät the alpha-acids (NIR) are obviously too low. This can be attributed to the fact that such extreme samples as in the 2003 crop had not yet existed in the calibration so far and the calibration up to 2002 was not yet stable enough to pick up such fluctuations in the crop years. Then all the available data records for 2003 were added to the existing calibration and this was used for the 2004 crop. A first validation for this calibration showed a definite improvement. However, the 2004 collaborative trial is not yet quite completed.

Figure 7.5: Mean values in the 2003 ring test, NIR (KW), alpha-acids (EBC 7.7), alpha-acids (NIR) relative to the (EBC 7.4) = 100%



R (reproducibility) und r (repeatability) are criteria for the accuracy of an analysis method. Figures 7.6 und 7.7 show the r and R values of the various methods of analysis. Not only from the r and R values can it be seen that as far as accuracy is concerned the NIR methods are inferior to the wet chemical methods. The NIR calibration based on HPLC should only be released for the practice if it is at least as good as the conductometer method according to EBC 7.4.

Figure 7.6: r values, 2003 ring test, CV (EBC 7.4), NIR (KW), alpha-acids (EBC 7.7), alpha-acids (NIR)

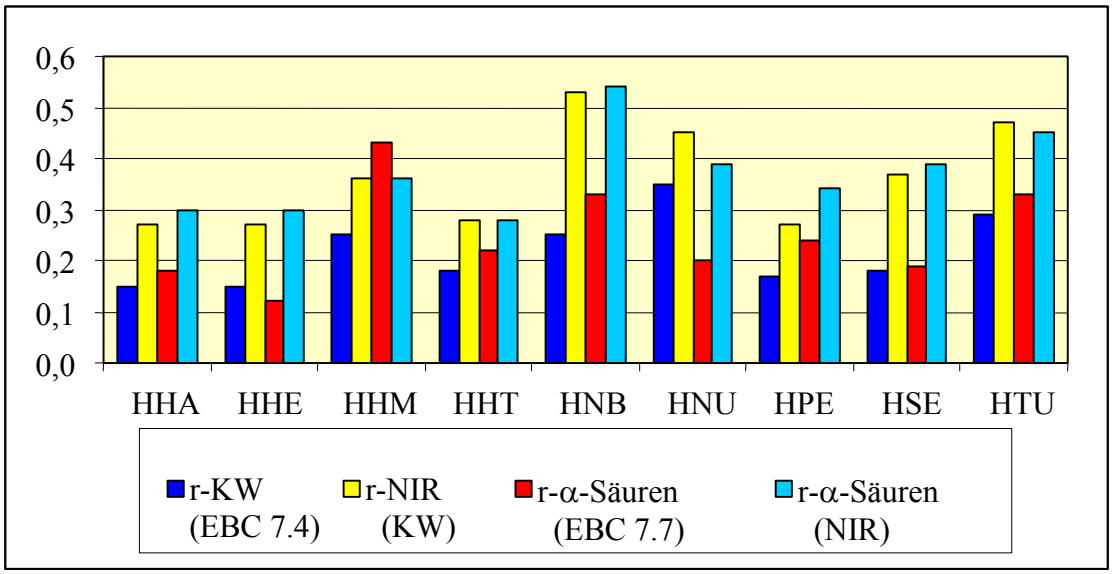
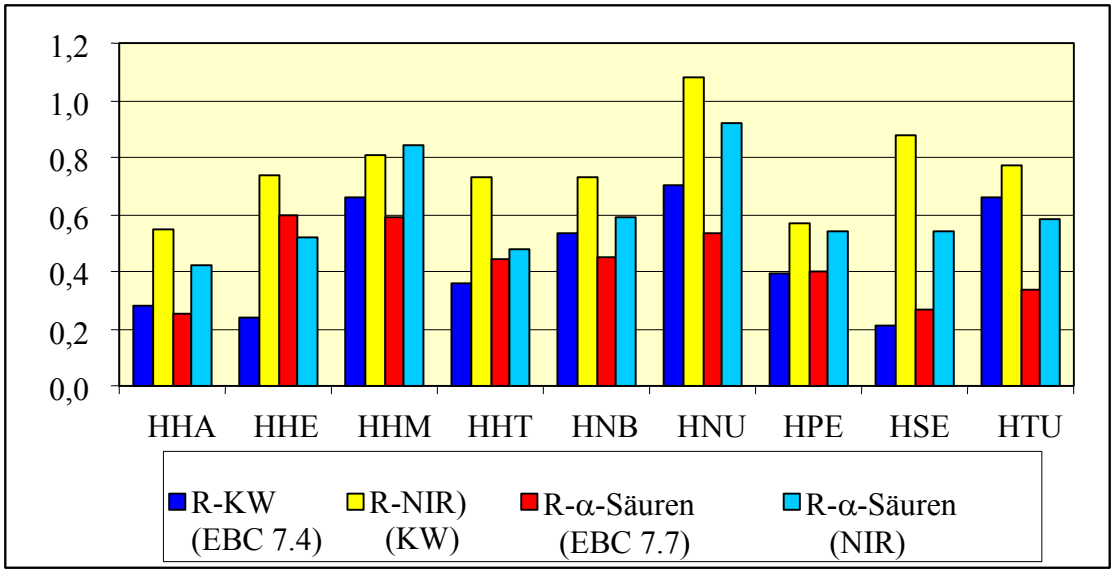


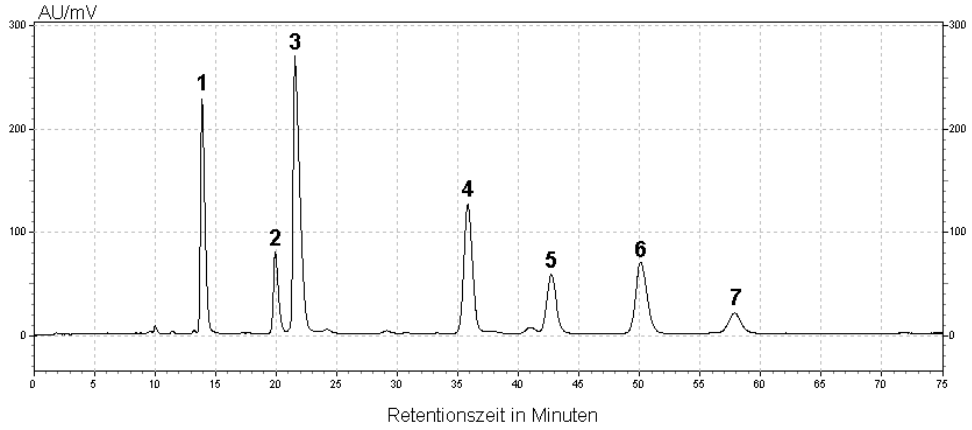
Figure 7.7: R values, 2003 ring test, CV (EBC 7.4), NIR (KW), alpha-acids (EBC 7.7), alpha-acids (NIR)



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

The aim of this project is to find out whether varieties with extremely different 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. (figure. 7.8). Using this method the whole world range of hops available in Hüll (118 samples) was examined.

Figure 7.8: 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

As other analytical parameters the whole polyphenol and total flavanoid content was measured with two spectral-photometric methods. The statistical indexes of the analyses are summarized in Table 7.5.

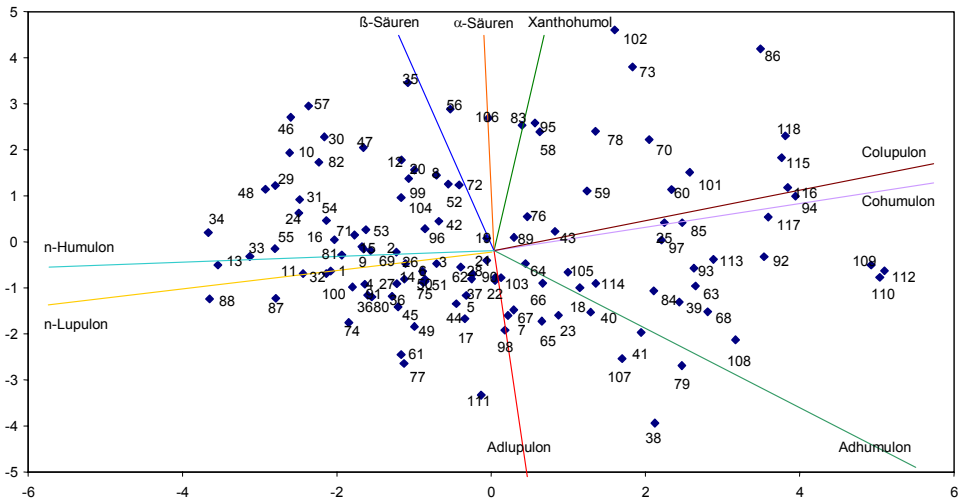
Table 7.5: Statistical indexes for the analysis parameters of the 2003 world hop range of varieties

Substance	Mean value	Standard deviation	Minimum	Maximum
α-acids	5.39	3.24	0.66	15.82
ß-acids	3.60	1.22	1.37	8.35
Cohumulone	27.03	7.81	11.82	47.44
Adhumulone	14.98	3.41	6.56	26.52
n-Humulone	57.99	10.04	31.43	79.07
Colupulone	48.61	9.72	29.58	70.69
Adlupulone	12.74	2.16	8.01	20.72
n-Lupulone	38.65	9.62	18.54	60.04
Xanthohumol	0.37	0.19	0.11	1.08
Polyphenols	4.95	1.19	2.16	8.63
Flavanoids	0.93	0.22	0.32	1.64

α -, ß-acids, xanthohumol, polyphenole, flavanoids in % as is.; analoga in % of the α - or ß-acids

Figure 7.9 shows the projection of the HPLC data according to an analysis of main components on a two-dimensional level.

Figure 7.9: Graph of the HPLC data according to an analysis of the main components on a two-dimensional level



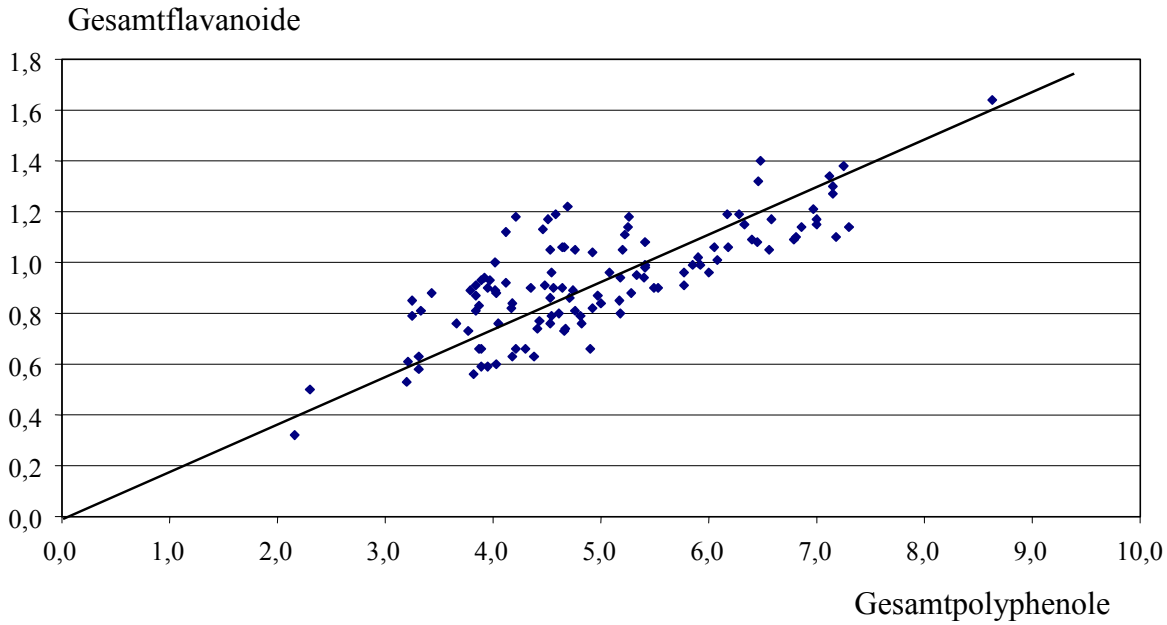
Varieties shown in Figure 7.9

No.	Variety	No.	Variety	No.	Variety	No.	Variety
1	Hallertauer Mfr.	31	Premiant	61	Hersbrucker Spät	91	Japan C-845
2	Spalter	32	83/069/008	62	Hüller	92	Brewers Gold
3	Tettnanger	33	Saphir	63	Blisk	93	Comet
4	Hüller Anfang	34	Opal	64	Bobek	94	USDA 21055
5	Hüller Aroma	35	Agnus	65	Zenith	95	Columbus
6	Hüller Fortschritt	36	93/053/033	66	Omega	96	Marynka
7	Zatecki	37	89/002/025	67	Eastwell Golding	97	Bullion
8	Northern Brewer	38	03/063/051	68	OT 48	98	Liberty
9	WFG	39	Density	69	Progress	99	Eastern Gold
10	Wye Viking	40	Wye Challenger	70	Wye Target	100	Kitamidori
11	Serebrianca	41	Willamette	71	Late Cluster	101	Toyomidori
12	Phoenix	42	Aurora	72	Cascade	102	Galena
13	87/024/003	43	Neoplanta	73	Eroical	103	Sterling
14	Hüller Start	44	Hersbrucker Pure	74	Crystal	104	95/094/730
15	Saazer	45	Spalter Select	75	Apolon	105	93/010/063
16	Hallertauer Gold	46	Hall. Magnum	76	Dunav	106	Zeus
17	Emerald	47	Hall. Taurus	77	Strisselspalter	107	Japan C-827
18	Perle	48	Hall. Merkur	78	Herald	108	Japan C-730
19	Orion	49	Zitic	79	NZ Hallertauer	109	Kirin 1
20	Yeoman	50	Granit	80	Mount Hood	110	Golden Star
21	PCU 280	51	College Cluster	81	Horizon	111	Chang bei no 1
22	Fuggle	52	Talisman	82	85/059/001	112	Ging dao do hua
23	Early Choice	53	Bor	83	Herkules	113	Pride of Ringw.
24	Wye Saxon	54	Sladek	84	First Gold	114	Alpharoma
25	Backa	55	91/059/025	85	Pioneer	115	Sticklebract
26	Belg. Spalter	56	93/010/036	86	Admiral	116	Green Bullet
27	Record	57	94/075/758	87	Glacier	117	Super Alpha
28	Hall. Tradition	58	95/094/721	88	Smaragd	118	Pacific Gem
29	Kumir	59	Pilot	89	Olympic		
30	93/010/034	60	Pilgrim	90	Nugget		

From the graph it is easy to see that the components n-humulone, n-lupulone as well as cohumulone and colupulone are very well correlated. There is also a tendency to an easy correlation with the alpha-acids, xanthohumol and the beta-acids.

Figure 7.10 shows the correlation of the total polyphenol content for the total flavanoid content, here too there is a good correlation.

Figure 7.10: Correlation between total flavanoid content and total polyphenol content



Varieties which differ very extremely in their components were then selected for brewing trials. Table 7.6 shows the varieties and breeding lines selected.

Table 7.6: List of the varieties and breeding lines which were selected for the brewing Trials

Selection criteria	Variety/Breeding line
Low cohumulone content	Saphir, Smaragd, Merkur
High cohumulone content	Admiral, Pilgrim
Low adhumulone content	Agnus, Premiant
High adhumulone content	03/63/51, Pride of Ringwood
High polyphenol content	Saazer, Pride of Ringwood
Low polyphenol content	95/094/816 (Herkules), Zitic

The brewing trials were carried out at the Experimental Brewery in St. Johann. The first tasting of the beers has already taken place. Considerable differences are apparent between the beers. When the tastings are completed, it is to be checked whether there is a correlation between the results of the beer-tastings and the criteria of the components selected. A closing report and a publication in a brewing trade magazine are planned. The results of the research project are bound to produce important findings regarding the breeding aims for new varieties from Hüll

7.7 Tests for residues of plant protectives in hops of the 2004 crop

The annual inspections for residues of plant protectives in hops give a very good oversight on the actual situation regarding the use of plant protectives. Contrary to widespread supposition hops are free from harmful residues of plant protectives.

With the licensing of new products to control downy mildew (peronospora) the selection available increases. This is obvious in the increasing number of low values in "cupric compounds". The values for "phosphoric acids" are attributed to the systemic effects of the product "Aliette" which controls the disease even if the infection has already occurred. In Hallertauer Hops the very low values of "Folpet" are good news, a sign that this contact preparation is only used up to the formation of the cones.

Surprisingly often (although fairly expensive) products of the new group of strobilurins (azoxystrobin, trifloxystrobin) are used. This development can be judged positively with respect to a change in the active ingredients and to the resistance management.

The increased amounts of residues in the insecticides clearly point to extremely bad attacks of hop aphids. The last time similar bad attacks were observed was in 1993. As only "Imidacloprid" and "Pymetrozin" were licensed and remaining quantities of "Cyflutrin" had to be used up, the chemical agents had to be used over wide areas partly at a very late stage at the limit to the prescribed waiting time. In the advisory activities the increase in amounts of residues should be clearly pointed out (although still well below the officially permitted maximum amounts).

Due to the high costs for the total analyses (approx. € 1.600 per sample) the extent of the analyses also had to be restricted to six samples this year. However, a great number of analyses will be carried out additionally in the company-own residue laboratories of the hop-refining facilities.

7.7.1 Selecting the samples

Spread out over the weighing-in and certifying season 2004 altogether 110 hop samples of all the important varieties of the Hallertau production region were delivered to the Hops Dept. of the Bavarian State Research Center for Agriculture (LfL) by the Hopfenring Hallertau e.V. The samples were only marked with the name of the variety and the bale number. Consequently the Bavarian Research Center (Lfl) does not know the names of the hop farms concerned.

At the Research Center (LfL) **two** hop samples were selected from these samples for each of five hop varieties listed in the table and a mixed sample was made for each variety. The extensive

residue analyses of a mixed sample from two individual samples are justified as the lots delivered to the buyers (breweries) are generally put together from more than two individual lots. During the hop harvest the sample "R1/04 HM" was drawn from a hop-grower without advance warning and analyzed as an individual sample.

The analyses were carried out at the Bioanalytik Weihenstephan (formerly Principal Agricultural Research Institute HVA) of the Technical University (TUM) in Freising-Weihenstephan. Table 7.7 shows the results of the 2004 harvest.

Table 7.7: Analyses for residues of plant protectives – 2004 crop

Chemicals listed According to pests	Max. permitted ppm	Milligram per kilogram = ppm					
		R 1/04 HM	R 2/04 HE	R 3/04 HT	R 4/04 TU	R 5/04 PE	R 6/04 HA
Downy mildew							
Azoxystrobin	20	n.n.	8.1	1.3	n.n.	n.n.	0.45
Captafol	0,1	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Cymoxanil	2,0	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Dimetomorph	50	n.n.	n.n.	n.n.	n.n.	0.89	n.n.
Dithiocarbamate	25	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Fentin-acetate	0,5	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Folpet	120	0.54	<0.20)	<0.20)	<0.20)	n.n.	<0.20)
Fosethyl	100	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Cupric compounds	1000	4.8	321.0	80.1	392.0	83.4	451.0
Metalaxyl	10	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Phosphoric acid	*)	n.n.	10.0	5.7	n.n.	n.n.	7.1
Tolyfluanide	30	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Mildew							
Fenarimol	5.0	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Fenpropymorph	0.1	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Myclobutanil	2.0	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Quinoxyfen	1	0.10	n.n.	0.15	n.n.	n.n.	n.n.
Triadimefon	10	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Triadimenol	10	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Trifloxystrobin	30	0.27	0.63	0.05)	1.9	7.1	0.41
Botrytis							
Dichlofluanid	150	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Procymidon	0.1	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Vinclozolin	40	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.

Table 7.7 continued

Chemicals listed According to pests	Max. permitted ppm	Milligram per kilogram = ppm					
		R 1/04 HM	R 2/04 HE	R 3/04 HT	R 4/04 TU	R 5/04 PE	R 6/04 HA
Hop aphids							
Bifenthrin	10	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
3-Hydroxy-Carbofuran	10	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Cyfluthrin	20	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Lambda-Cyhalothrin	10	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Cypermethrin	30	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Deltamethrin	5	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Diazinon	0.05	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Endosulfan	0.1	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Imidacloprid	2.0	0.12	<0.10	<0.10	0.13	0.21	0.10
Mevinphos	0.5	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Omethoat	0.05	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Parathion-methyl	0.1	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Permethrin	0.1	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Pirimicarb	0.05	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Propoxur	0.1	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Pymetrozin	5	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Common spider mite							
Abamectin	0.05	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Amitraz	20	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Azocyclotin/Cyhexatin	0.1	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Brompropylate	5	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Dicofol	50	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Fenbutatinoxide	0.1	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Fenpyroximate	10	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Hexythiazox	3	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Propargit	30	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Alfalfa weevil							
Acephate	0.1	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Carbofuran	10	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Methamidophos	2	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Methidathion	3	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Herbicides							
Cinidon-ethyl	0.1	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Fluazifop-butyl	0.1	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.
Monolinuron	0.05	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.

Explanations to Table 7.7:

) below the determining limit

*) no maximum amounts of residue laid down

n.n. = not detectable

HM = Hallertauer Magnum TU = Hallertauer Taurus

HE = Hersbrucker Spät PE = Perle

HT = Hallertauer Tradition HA = Hallertauer Mfr.

7.7.2 Judging the results

As in past years despite a to some extent extreme spread of infection only few active ingredients were found in hops through analyses even in the residue tests of the 2004 crop. The values are in all cases below the legally permitted maximum amounts in accordance with the current regulation on maximum amounts in the version valid at the present time (Table 7.8).

In a preliminary report in Dec. 2004 higher values were quoted for the active ingredient "Imadocloprid". According to a letter from Bioanalytik dated 23.02.2005 these values in the preliminary report are not correct due to a miscalculation. The values shown in Table 7.7 have been rectified and are now correct.

7.7.3 Resumé

This year the long term program for determining residues of plant protectives in hops again confirmed that hops are free from harmful residues. There is not the slightest suspicion that the legally set maximum amounts have been exceeded. Consequently it can be ruled out that plant protectives have an adverse effect on the beer.

Table 7.8: Residue situation in hops of the 2004 crop

Insecticide (trade name)	Frequ-ency	ppm min.- max.			ppm max. residue	ppm US Tole-rance
Azoxystrobin Ortiva	2	0.45	-	8.1	20	20
Captan (Folpet)	5	0.20	-	0.54	120	120
Kupferverbindungen (z.B. Funguran)	6	4.8	-	451.0	1000	ex.
Phosphorige Säure (Aliette)	3	5.7		10.0	100	45
Quinoxyfen (Fortress)	2	0.1		0.15	1	3
Trifloxystrobin (Flint)	6	0.05	-	7.1	30	11
Imidacloprid (Confidor)	6	0.10	-	0.21	2.0	6

ex. = exempt

7.8 Checking the purity of variety

Checking the purity of variety for food controlling authorities is a duty of the work sector.

Varieties checked for the food monitoring authorities (district administration)	16
Number of complaints	0

8 Publications

Engelhard, B. (2004): The impact of weather conditions on the behavior of powdery mildew in infecting hops (*Humulus*). -Proceedings, 1st ISHS International *Humulus* Symposium, Corvallis, USA, August 2004, 13.

Engelhard, B., Huber, R. (2004): Kapitel Pflanzenschutz. -In: Hopfen 2004 („Grünes Heft", Hrsg.: Bayer. Landesanstalt für Landwirtschaft, Institut für Pflanzenbau und Pflanzenzüchtung, Arbeitsbereich Hopfen, Wolnzach).

Engelhard, B., Huber, R. (2004): Zulassungssituation für Pflanzenschutzmittel im Hopfen für das Vegetationsjahr 2004. -Hopfen-Rundschau 55(3), 49.

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Niedermeier, E. (2004): Pflanzenstandsbericht. -Hopfen-Rundschau 55(5), 108.

Niedermeier, E. (2004): Pflanzenstandsbericht. -Hopfen-Rundschau 55(6), 129.

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Niedermeier, E. (2004): Pflanzenstandsbericht. -Hopfen-Rundschau 55(9), 201.

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Portner, J. (2004): Neu: Prüfbericht für alle PS-Geräte im Hopfen. -Hopfen-Rundschau 55(3), 48

Portner, J. (2004): Pflichtüberprüfung der Hopfengebläsespritzen. Hopfen-Rundschau 55(3), 52.

Portner, J. (2004) Neu: Prüfpflicht für Unterstockspritzgeräte im Hopfenbau. -Hopfen-Rundschau 55(4), 83.

Portner, J. (2004): Rodung stillgelegter Hopfengärten. -Hopfen-Rundschau 55(6), 122.

Portner, J. (2004): Peronosporabekämpfung. -Hopfen-Rundschau 55(6), 130.

Portner, J. (2004): Vermeidung von Gewässerverunreinigung beim Befüllen und Reinigen von Pflanzenschutzgeräten. -Hopfen-Rundschau 55(7), 147.

Portner, J. (2004): Pflanzenstandsbericht. -Hopfen-Rundschau 55(7), 150.

Portner, J. (2004): Kostenfreie Rücknahme von Pflanzenschutz-Verpackungen PAMIRA 2004. -Hopfen-Rundschau 55(8), 158.

Portner, J. (2004): Optimale Trocknung und Konditionierung. -Hopfen-Rundschau 55(8), 172.

Portner, J. (2004): Rebenhäcksel baldmöglichst ausbringen! -Hopfen-Rundschau 55(8), 178.

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