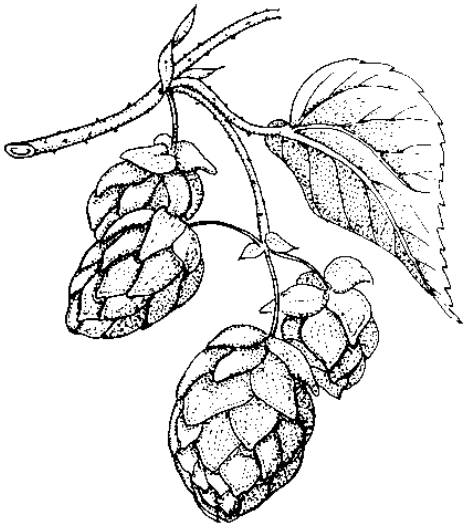
**Bavarian State
Research Centre
for Agronomy**

Hop Research and
Hop Advisory Centre

**Bavarian State Research Centre for Agronomy
and
Society of Hop Research**

Report 2002



Special Edition for Hops

March 2003

**Bayerisches
Staatsministerium
für Landwirtschaft
und Forsten**

P r e f a c e

The test results and research findings of the Hop Research Institute in Hüll have been published in a special information sheet since the 1973 Annual Report, "BLBP Special Issue 1“ dated 29th March, 1974.
Until that time the research results presented at the AGM of the German Society for Hop Research had been published as a special print of the "Deutsche Brauwirtschaft" (until 1972) or of the " Hopfen-Rundschau" (1973).
This short look back should be the basis for a look ahead to the future:

In the future it will also be possible to publish an "Annual Report on the Special Cultivar Hops", as even after the reorganisation of the state institutes, hop research has remained an organisational unit in the department of the Bavarian Ministry for Agriculture & Forestry.

The work groups so far:

- Hop-growing, Production Techniques
- Plant Protection in Hop Production
- Breeding Research in Hops and
- Hop Quality and Analytica

will continue to exist in the same structure as before. This is certainly a sign that the Research and Consultancy for the special cultivar hops is very well organised and has worked effectively and target-oriented.

The preservation of this research facility which is so important for the Bavarian hop-growers as well as the whole hop industry was not a foregone conclusion. Considering the area under hops, after all a quarter of the world acreage, as well as the economic significance for the hop regions by investing in research an important decision is made to secure competitive strength. Hearty thanks to all those who have actively taken part in this development.

In the future too the Bavarian State, represented by the Landesanstalt für Landwirtschaft and the Gesellschaft für Hopfenforschung e.V.,, will jointly support the work to the benefit of the hop and brewing industry at the Hops Sections in Hüll, Wolnzach and Freising.
The test and research reports "Special cultivar hops“ will in future be published annually in German and English. Like all reports and advisory notes issued by the Hop Research Centre both variants can be found in the internet under

"www.landwirtschaft.bayern.de/lbp/info/hopfen.html"

The Annual Report will also be distributed in printed form in the German language.

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

Dr. Friedrich Keydel
Vice-President of the State
Research Centre of
Agronomy

T A B L E O F C O N T E N T S

Preface
Dr. F. Keydel, Vice-President

1 Research projects and main research areas of the Hops Dept. at the LBP 5

1.1 Current research projects 5

1.2 Main research areas 12
1.2.1 Main research areas in breeding 12
1.2.2 Main research areas in hop cultivation 13
1.2.3 Main research areas in plant protection 14
1.2.4 Main research areas in quality, chemistry and technology of hops 15

2 Weather conditions in 2002 16

3 Statistical data on hop production 18

3.1 Production data 18
3.1.1 Structure of hop production 18
3.1.2 Hop varieties 23

3.2 Crop situation in 2002 24
3.2.1 Hop marketing in 2002 28
3.2.2 World hop market 28

4 Hop breeding 31

4.1 Practical hop breeding 31
4.1.1 Crossings 2002 31
4.1.2 Results of the seedling tests 31
4.1.2.1 Seedlings 2000 31
4.1.2.2 Seedlings 99 32
4.1.3 Results of the parentage tests 34
4.1.3.1 Parentage test 2001 in Hüll and Rohrbach 34
4.1.3.2 Parentage test 2000/2 in Hüll and Rohrbach 35
4.1.3.3 Parentage test 2000 in Hüll and Rohrbach 36
4.1.3.4 Parentage test 99 in Hüll and Rohrbach 37
4.1.3.5 Parentage test 98 in Hüll and Rohrbach 38
4.1.4 Results of the principal trials 39
4.1.4.1 Principal trial 2000 in Rohrbach 39
4.1.4.2 Principal trial 2001 in Rohrbach 40

4.1.5 Results of the practical hop-growing trials 41
4.1.5.1 Aroma and bitter lines on the Schwarzmeier farm in Rohrbach 41
4.1.5.2 Testing Hüll breeding lines with low cohumulone values on the Busch farm in Hüll 42
4.1.5.3 Aroma and bitter lines on the Pichlmeyer farm in Grafendorf..... 43
4.1.5.4 Testing Hüll breeding lines and varieties at the Thuringian State Institute for agriculture 44
4.1.6 Gathering and testing wild hops 44
4.1.6.1 Collecting wild hops..... 44
4.1.6.2 Testing the wild hops 2002..... 44
4.1.7 Breeding for mildew resistance 45
4.1.7.1 Improved mildew resistance testing of the seedlings in the greenhouse 45
4.1.7.2 Extensive tests for mildew resistance in the Hüll breeding material - Tests in the greenhouse and in the laboratory..... 45
4.1.7.3 Wild hops as a very promising resource for new mildew resistances 47
4.1.7.4 Use of the mildew testing system in the Petri dish combined with mildew isolates of defined virulence 47
4.1.8 Infection behaviour of the powdery mildew (*Sphaerotheca humuli*) towards hops in various development stages 48

4.2 Biotechnology and genome analysis 51
4.2.1 Working out an effective method to produce fungus-resistant hops via gene transfer 51
4.2.2 Genome analysis 52
4.2.2.1 Identification of mildew resistance markers 52
4.2.2.2 Use of sex-specific DNA-markers 53
4.2.2.3 Verification of hop genotypes(trueness-to-type analyses) 54

5 Hop production and advisory service 55

5.1 Fertilizer 55
5.1.1 Nmin analyses 2002 55
5.1.2 Trial with green compost 57
5.1.3 Nutrient potential trial Eschelbach: Effects of various P-, K- Mg-, S-fertilizer on optimum tended soils 58

5.2 Corn borers in hops..... 60

5.3 Low-trellis yards 61

5.4 Tests with various harvesting times as per Hallertauer Mfr.. 65

5.5 Optimum conditioning of hops..... 67

5.6 Advisory service and training facilities 70

6. Plant protection in hops 2002 71

6.1 Pests and diseases in hops 71
6.1.1 Alfalfa weevil *(Otiorrhynchus ligustici L.)* 71
6.1.2 Hop aphid [*Phorodon humuli* (SCHRANK)] 71
6.1.3 Two-spotted spider mite (*Tetranychus urticae* KOCH)..... 72
6.1.4 Minor pests 72
6.1.5 Peronospora [*Pseudoperonospora humuli* (MIY. et TAK.) WILSON] 72
6.1.6 Powdery mildew (*Sphaerotheca humuli* BURR.) 73
6.1.7 Botrytis (*Botrytis cinerea* PERS.)..... 74

6.2 Mycological tests 74

6.3 Virus-free plants 75

7 Quality, chemistry and technology of hops 76

7.1 General 76

7.2 Breeding programmes 76
7.2.1 Breeding programme - aroma varieties 76
7.2.2 Breeding programme - bitter varieties 78

7.3 Range of world hop varieties 78

7.4 Xanthohumol 85

7.5 Ring analyses on the 2002 crop 87

7.6 NIR calibration 90

7.7 Dissertation "Analysing the ageing components in the hops essential oil by means of SPME“ 92

7.8 Analyses for plant protective residues in hops of the 2002 crop 93
7.8.1 Selecting samples 93
7.8.2 Evaluation of the results 95
7.8.3 Resumé 95

7.9 Checking the varieties for authenticity 96

8 Publications 97

1 Research project and main research areas of the Hops Section at the LBP

Bernhard Engelhard, Dipl. Ing. agr.

1.1 Current research projects

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

Sponsored by: Bayerische Landesanstalt für Bodenkultur und Pflanzenbau (Bavarian State Research Centre for Agronomy)

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

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

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

Working on project: Dr. S. Seefelder, P. Bauer, V. Mayer, A. Lutz, Dr. E. Seigner

Duration of project: 01.05.2002- 31.06.2005

Findings:

- Based on six mapping populations, from crossings of the resistance carrier "Buket" (RBu gene) or "Wye Target" (R2 gene) each with one susceptible parent or two parents with different resistance (RBu x R2), various powdery mildew resistance markers with different quality could be worked out and verified with the AFLP method.
  Altogether 240 AFLP primer combinations were used.

- For the RBu gene three markers could be identified:
  RBu-279, RBu-284 and RBu-319
  Their reliability in the selection of powdery mildew-resistant seedlings varied according to the mapping population between 91.7 and 97 %.

- For the R2 gene so far one marker has been worked out which depending on the various mapping populations makes it possible to differentiate between susceptible and powdery mildew-resistant seedlings with a hit rate between 92.5 and 96.9 %.

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

Sponsored by: Bayerische Landesanstalt für Bodenkultur und Pflanzenbau
(Bavarian State Research Centre for Agronomy)

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

Project Manager: Dr. E. Seigner

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

Duration of project: 01.11.2001-30.09.2004

Aim:

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

Findings:

- After creating diverse strains of agro-bacteria and plasmids with selectable markers and the desired reporter genes (GUS, Bar) *Escherichia coli* strains (for the plasmid multiplication) as well as agro-bacteria strains (for infecting the plants) were transformed with the GUS and Bar reporter genes.

- Simultaneously all the strains of bacteria (grown on diverse antibiotica) as well as the most important plasmids (restriction and gel electrophoresis) were examined for their genetic composition.

- Several transformations of hop internodia were successfully carried out with the GUS reporter gene system.

- The first transgene Saazer plants could be selected and regenerated.

- The successful insertion of the GUS marker gene into the hop genetic material is detected by the GUS colouring and confirmed by the PCR (= polymerase chain reaction).

- The most diverse induction and regeneration media were tested, i.a. mixed with antibiotics in order to improve the ability to regenerate. The regeneration took place solely via indirect organogenesis. The best regeneration rates were obtained with internodia of the "Saaz" variety .

Supporting the powdery mildew resistance breeding by compiling sound findings on the infection potential of powdery mildew in hops depending on the developmental phase of the hops (Project No. Wifö-Nr. B 52 b)

Sponsored by: Bayerische Landesanstalt für Bodenkultur und Pflanzenbau
(Bavarian State Research Centre for Agronomy)

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

Project Manager: Dr. E. Seigner

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

Working on project: Dr. F. Felsenstein, S. Hasyn, EpiLogic
Dr. E. Seigner, Dr. S. Seefelder, B. Haugg, LBP

Duration of project: 01.05.2001 – 31.05.2003

In the battle against powdery mildew considerable costs for fungicides could be saved, if there was more precise information available on the first infection or age resistance of foliage, flowers and cones. In order to compile more accurate information, every week from May onwards leaves and later on flowers and cones of the highly susceptible varieties "Northern Brewer" and "Hallertauer Magnum" were picked from out in the open and artificially infected with powdery mildew in the Petri dish in the laboratory. Afterwards the tissues were examined under the binoculars for conidia chains and powdery mildew pustules. According to our examinations over two vegetation periods the following findings can be reported:

Findings:

- Particularly young leaves which have just unfolded show an extremely high susceptibility towards powdery mildew. With increasing age and stagnating growth of the leaves this sensitivity decreases considerably.
- Flowers just like cones can be infected with powdery mildew at any stage. The insides of the bracteoles react particularly sensitively. However previous infections with other pathogens in the flowers and cones make it difficult to report accurately on the potential first infection with powdery mildew.
- These sensitivity studies basically confirm the strategic use of fungicides so far applied in the practice to combat powdery mildew. At the latest when the first infection can be seen on the leaves, fungicides must be used to control it. The consequent use of plant protectives is advisable particularly during the flowering stage right up to the cone development.

Development of improved methods in the production of low-trellis hops

Sponsored by: Bayerische Landesanstalt für Bodenkultur und Pflanzenbau
(Bavarian State Research Institute for Agronomy)

Financed by: Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft über die Bundesanstalt für Landwirtschaft und Ernährung
(Federal Ministry for Consumer Protection, Food & Forestry via The Federal Institute for Food & Agriculture)

Project Manager: Georg Roßbauer

Working on project: Dipl. Ing. (FH) Thomas Janscheck

Duration of project: 01.12.1999 – 30.11.2002
This research project planned for 3 years was concluded on 30.11.2002.

Findings:

With this research project the production of hops in low-trellis yards has come a considerable step closer to the aim of economical efficiency. A number of findings from this research project have been directly adopted for the production of hops in low-trellis yards.
The problem is finding suitable varieties. The research project has again shown that the traditional varieties bred for high-trellis yards are not suitable for low-trellis production, because the lower yields do not allow economic production. English dwarf varieties have shown that a yield necessary for economic efficiency can be reached in low-trellis yards; but the quality is not adequate enough to attain an appropriate price on the market.

The **cutter** developed by the Landtechnik Weihenstephan is ready to be put into practice and can be used in low-trellis yards. Its use in high-trellis yards is still being tested. Particular emphasis should be put on the direction it razes.

Concrete poles, 4 m long, for the construction of the **trellis,** can be adopted from fruit-growing.
In conjunction with the newly developed cutter, the height of the lower span wire at 25 cm is an improvement for training the vines.
It is still best to train the hops upward on a wire, whereas training nets have not proved to be as good. With the training wire the number of vines per wire can be controlled best of all.

In the production of hops the traditional **method with pruning** is preferred instead of the **non-cultivation method**, as although more work is needed, by cutting and working the ground the spread of infection with peronospora and powdery mildew as well as the amount of weeds is reduced and therefore less plant protectives are required.

Low-trellis production is only economically efficient with suitable **varieties**. Although the English varieties tested are not ready for marketing, they provide a good basis for breeding.

Testing production techniques for the ecological hop production

Sponsored by: Bayerische Landesanstalt für Bodenkultur und Pflanzenbau
(Bavarian State Research Centre for Agronomy)

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

Project Manager: B. Engelhard

Working on project: Dipl.-Biol. F. Weihrauch, M. Felsl, M. Fischer, A. Neuhauser

Duration of project: 01.04.2002 – 31.03.2005

Findings: In the first project year the following sections were researched and at the same time the following briefly described findings were obtained:

For the use and the establishment of predatory mites in hop yards a large-scale trial was set up at the location in Buch on about 1 hectare with four parts each of which was repeated four times. On altogether eight plots predatory mites (*Typhlodromus pyri*) commercially bred in plastic bags each containing about 100 mites (about 16,000 altogether) were deposited on every seventh plant punctually on 13.06. and the other spider mites (*Tetranychus urticae*) and predatory mite development in the stock was monitored every week. On 23.07. *T. pyri* was deposited punctually for the second time in the middle of the plots (about 8,000 mites); so on an average there were altogether 30 insects per plant. The desired effect of the spider mite control was unfortunately not reached as it was impossible to differentiate significantly between the predatory mite plots and the untreated plots up until the harvest. Only very few *T.* p*yri* (45 mites) were found during the monitorings. Although at the harvest none of the experimental plots showed hardly any crop-reducing damage by spider mites. Before the harvest felt bands were put on the hop poles as an overwintering retreat for predatory mites and in each case one wire was left hanging on the pole until the winter. Winter quarters to accommodate predatory mites is still being evaluated at the present time. However, at present it looks as though hardly any insects were found overwintering here as obviously the population density of *T. pyri* on the hops was too little in late summer.

The **further development of a method to control the two-spotted spider mite by grease barriers** on the hop vines was carried out as the fourth part in the same trial. All the plots likewise remained free of spider mite damage up until harvesting. The use of a tractor-drawn heated applicator for spreading the grease was also successfully used over wide areas.

The **use of lacewing larvae for combating aphids** took place at the Ursbach location. In four large-scale plots altogether 20,000 larvae of *Chrysoperla carnea* (about 31 insects per wire) were set free on 29.05. and on 14.06.. Only during an aphid monitoring on 25.06. significantly less aphids were found in these plots than in untreated plots. However, by the end of July the aphid population had completely disappeared in the whole yard and during a trial harvesting on 30.08. no difference could be seen at all between untreated plots, lacewing and quassia treated (see below) plots.

To **make overwintering quarters for lacewings in hops** 16 specially conceived "lacewing hotels" (stone blocks with openings made of thin chipboard with sides 30 cm long, which were filled with straw) were hung on the hop poles on 30.08. in the experimental yard before harvesting at the Ursbach location. Next to them in Ursbach eight further lacewing hotels were erected on 04.09. on each of two exposed places out on openland (on the ridge of a hill, vines protected from wind in the valley) on 150 cm high wooden stakes. The hotels were dismantled on 17.12. and stored in a cool, dark barn. Four hotels respectively from the three different locations were opened in January in the laboratory and the arthropods overwintering in them were classified and counted. The evaluation showed that the hotels on the hop poles with an average of 255 insects per hotel significantly accommodated the most lacewings.compared with the 45 lacewings on the ridge of the hill and 31 insects in the valley. Consequently the antagonistic potential of a hotel with about 125 overwintering lacewing females which in spring produce about 300 larvae each, of which in the course of their development about 300 aphids are eradicated is roughly eleven million aphids. The specific use of this potential should be checked in May 2003 by opening the remaining hotels in the experiment according to schedule, those which have been stored in the cool barn.

Testing plant protectives, which comply with the production regulations for eco-hop production, provided the following results: The use of a quassia extract to control hop aphids can be estimated as extremely effective. The control of powdery mildew (*Sphaerotheca humuli*) using a *Bacillus subtilis* preparation (brand-name "Serenade") was rated very badly. The checking of a low-copper preparation to control peronospora (*Pseudoperonospora humuli*) had to be broken off at two locations because of ineffectiveness. However, the effectiveness of another low-copper preparation (brand-name "Solocuivre") for combating peronospora was however judged positively in the first year with it being used up to flowering

Analysing ageing components in the hops essential oil by means of solid phase micro-extraction (SPME)

Sponsored by: Bayerische Landesanstalt für Bodenkultur und Pflanzenbau
(Bavarian State Research Centre for Agronomy)

Financed by: $NATECO_2$ GmbH & Co. KG
Hallertauer Hopfenveredelungsgesellschaft mbH

Project Manager: Dr. K. Kammhuber

Cooperation: Professor Dr. Rolf Schödel, Fachhochschule Weihenstephan

Working on project: Jürgen Plass

Duration of project: 01.10.2002 – 31.03.2003

Findings: It was possible to analyse hop oil components with the standard addition. ß-caryophyllene-oxide and 2-pentadecanone as ageing components were analysed as these substances are available commercially. The concentration of both components increases with the ageing of the hops.

1.2 Main areas of research

1.2.1 Main research area: Breeding

Leitung: Dr. E. Seigner

Powdery mildew resistance breeding

Working on project: A. Lutz, J. Kneidl,
Dr. E. Seigner

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

Breeding powdery mildew resistant quality hops in the aroma and bitter sector

Measures 2002:

- 114 specific in-crossings of powdery mildew resistances
- Improving the powdery mildew resistance testing in the greenhouse by using powdery mildew isolates with defined virulence characteristics from the Hallertau region
- Evaluating various sources of resistance:
  - Testing wild hops, varieties from abroad and seedlings in the greenhouse and out in the field
  - Testing for powdery mildew resistance in the yard without using fungicides (approx. 2000 seedlings per crop year and 500 wild hops)
  - Powdery mildew resistance test in the laboratory:
    106 breeding lines, 25 wild hops, 20 foreign varieties and 8 Huell varieties

    Reliable, fast testing for the resistance characteristics with an established powdery mildew infection and test system in the Petri dish in combination with PM isolates of defined virulence.

    At present there is a range of 13 different monosoric isolates of *Sphaerotheca humuli* available which originated from England, France, USA and from the Hallertau growing area. This spectrum of virulences is unique in its wide scope and makes it possible to test for almost all the resistance genes used and known in breeding hops.

1.2.2 Main research areas in hop production

Project Manager: G. Roßbauer

Working on project: E. Niedermeier, J. Münsterer, Dipl. Ing. (FH) H. Dorfner

Research on optimum production methods with the variety Hallertauer Mfr.

The variety Hallertauer Mfr. has gained in importance due to the increasing demand. Its production is linked with a certain risk for the hop-grower, as it is very susceptible to wilting.

Nitrogen fertilizer with nitrification blockers

Nitrogen fertilizers containing nitrate are rapidly soluble; however it is suspected that due to a high concentration of nitrate the risk of wilting is increased. With the nitrogen fertilizers used the nitrification of the ammonium nitrogen is blocked; consequently the nitrogen is slowly released to the hop plants.
As a comparison, commercially available nitrate of ammonium fertilizer is used in the experiment.
In addition to this with varying amounts of nitrogen it is examined whether the yield is affected when the N fertilizer is further reduced.

Harvest-time trials

In order to find the optimum harvest time, from a practice stand of hops 20 wires were harvested respectively at intervals of 3 days and repeated four times. Evaluation was on yield, alpha-acid content, aroma and external quality (colour and lustre, attacks of pests and diseases, disintegration).

1.2.3 Main research areas: Plant protection

Project Manager: B. Engelhard

Testing the insecticide resistance of hop aphids *(Phorodon humuli)*

Working on project: R. Huber, M. Mayer, M. Fischer, A. Baumgartner

By regularly using the same active substances the danger is that they develop resistance. Checks are carried out annually to ascertain changes in the effectiveness of insecticides.
For this, aphids are collected throughout the Hallertau at the beginning of the migration and cultivated further on hop plants in the laboratory or in climatic cabinets. These are labelled as "Hallertauer Stamm 200x". If weaknesses in effectiveness are observed during the season in certain hop yards, aphids are collected from them and labelled as "Line x".
In the laboratory the insecticides are tested in various concentrations to see whether there are shifts in effectiveness with regard to the individual aphid lines.
In 2002 various methods were compared – the "Hüller Method" and two methods from plant protective firms. It could be seen that the "Hüller Method" was the earliest to show first changes in effectiveness.

Controlling aphids with the few products available

Working on project: R. Huber, M. Mayer, O. Ehrenstraßer, M. Fischer, J. Weiher

The registered products were used on experimental plots in various spraying series to control the hop aphid. These trials are necessary to optimize the use of the products and to enable advisory information to be made for the next season.

Influence the products for controlling powdery mildew have on the alpha acid contents and the yield

Working on project: R. Huber, M. Mayer, J. Weiher, M. Fischer, A. Baumgartner

Basically it must be tested whether the plant protectives used have a positive or negative effect on the yield as well as being effective against the respective pathogen.
The "Strobilurine" group of active substances for combating fungal diseases is said to have a so-called "greening effect" in other cultures. This means that the plants remain green longer, store more nutrients and therefore obtain higher yields.
The direct comparison of all registered groups of active substances in the first year of testing showed **no** different alpha-acid contents and yields.

1.2.4 Main research areas: Quality, Chemistry and Technology of hops

Project Manager: Dr. K. Kammhuber

Development of a NIR calibration based on HPLC data

Cooperation: Dr. M. Biendl, Hallertauer Hopfenveredelungsgesellschaft mbH
J. Betzenbichler, Hallertauer Hopfenveredelungsgesellschaft mbH
R. Schmidt, NATECO_2 GmbH & Co. KG
U. Weiss, Hopfenveredelung HVG Barth, Raiser GmbH & Co. KG

Working on project: E. Neuhof-Buckl, B. Wyschkon, Dr. K. Kammhuber

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

In September 2000 the laboratories of the above-mentioned firms and the Bavarian State Research Centre for Agronomy in Hüll began to set up a NIR calibration based on HPLC data. This calibration will be extended and checked every year. Within the Work Group for Hop Analytica (AHA) it will be decided when this calibration is suitable to be put into practice.

2 Weather conditions in 2002

Bernhard Engelhard, Dipl. Ing. agr.

The first half of January was marked by normal, cold winter weather. The winter came to an early end with the thaw which set in on 19th January; the temperature rose in January up to max. 15.6°C mean daytime temperature. In February and March the temperatures were well above the average over many years which could be seen from the earlier start in vegetation.

Precipitation which was 70 or 85 % above the average over many years made it almost impossible for the ground to be worked in February and March; it was also very difficult to put up the training wires. It was April before the ground dried out and was passable as normal.
The high temperatures even before vegetation began and the lack of frosty nights were probably the reason for the early and extremely strong aphid migration and the early appearance of the common spider mite. It was surprising that with these temperatures the infestation with alfalfa weevil was relatively slight.

The labour peaks in the spring, the work of training the hops and stripping the lower parts of the vines was interrupted by frequent rainfall.
The temperatures were moderate into the first ten days of June but afterwards rose to reach peaks of 33 °C. The hop stands reached the top of the trellis at the normal time and were marked by the laterals being well formed.
It was possible to carry out the second hilling up and grubbing with a good soil structure.

The rain showers from May to August were plentiful and above all well spread out so that sufficient water was always available for the plants. Combined with moderate summer temperatures the growth was altogether good and the flower buds were assessed very positively.

The common spider mite developed into a problem – with the above-average high temperatures in June the multiplying cycle from egg to fully grown insect was very short (approx. 2 weeks) so that the population could quickly multiply. The optimum spraying time was not observed in all cases.

The hops were harvested between the familiar mixture of rain and sunshine.
Measures to work the ground and other tasks in the hop yard (trellis repairs, grubbing) were almost impossible following the harvest as one rainy period was followed directly by the next one.

Resumé:

- above average warm, wet winter
- optimum distribution of rain showers in the summer
- above average very wet autumn

Table 2.1: Weather data (monthly mean averages or month totals) from 2002 compared with the 10- und 50-year mean averages

Month		Temperature at height of 2 m Average (°C)	Min.∅ (°C)	Max.∅ (°C)	Relat.air moisture (%)	Precipi-tation (mm)	Days w. precipit. >0,2 mm	Sun-shine (hrs.)
January	2002	-1,1	-5,1	3,1	87,2	13,0	9,0	84,7
∅	10-j.	-0,6	-3,3	2,8	86,4	36,4	11,2	63,8
	50-j.	-2,4	-5,1	1,0	85,7	51,7	13,7	44,5
February	2002	4,7	0,6	9,7	79,6	63,0	15,0	82,8
∅	10-j.	1,3	-2,8	5,8	82,9	38,2	11,8	90,4
	50-j.	-1,2	-5,1	2,9	82,8	48,4	12,8	68,7
March	2002	5,1	-0,3	11,7	78,1	120,3	7,0	199,5
∅	10-j.	3,9	0,1	9,4	79,0	67,3	15,2	133,1
	50-j.	2,7	-2,3	8,2	78,8	43,5	11,3	134,4
April	2002	8,2	2,4	14,4	69,2	23,6	8,0	184,3
∅	10-j.	8,3	3,0	13,8	73,8	53,5	11,5	157,3
	50-j.	7,4	1,8	13,3	75,9	55,9	12,4	165,0
May	2002	13,8	7,9	20,3	76,1	101,5	12,0	195,7
∅	10-j.	13,9	7,7	19,9	71,3	77,8	11,9	219,4
	50-j.	11,9	5,7	17,8	75,1	86,1	14,0	207,4
June	2002	18,4	11,6	25,3	70,7	81,2	11,0	273,8
∅	10-j.	16,0	9,9	22,0	72,6	100,3	14,5	218,5
	50-j.	15,3	8,9	21,2	75,6	106,1	14,2	220,0
July	2002	17,6	11,8	24,2	78,3	103,7	17,0	212,9
∅	10-j.	17,5	11,7	23,6	74,8	112,7	15,6	211,8
	50-j.	16,9	10,6	23,1	76,3	108,4	13,9	240,3
August	2002	17,7	12,3	24,1	81,7	106,0	10,0	194,6
∅	10-j.	17,5	11,4	24,0	75,9	81,7	12,4	219,3
	50-j.	16,0	10,2	22,5	79,4	94,9	13,3	218,4
September	2002	11,7	6,3	17,9	83,0	89,2	11,0	173,4
∅	10-j.	12,8	7,8	18,5	81,4	77,3	13,8	152,6
	50-j.	12,8	7,4	19,4	81,5	65,9	11,4	174,5
October	2002	8,4	4,2	13,2	86,7	116,1	22,0	90,4
∅	10-j.	9,1	5,1	13,8	85,2	65,7	13,7	105,4
	50-j.	7,5	2,8	13,0	84,8	60,0	10,4	112,9
November	2002	5,7	2,8	9,0	93,6	129,2	18,0	35,9
∅	10-j.	3,2	0,3	6,3	89,0	56,1	11,3	59,7
	50-j.	3,2	-0,2	6,4	87,5	58,8	12,6	42,8
December	2002	1,1	-1,3	3,7	92,8	77,1	18,0	40,4
∅	10-j.	0,4	-2,5	3,2	87,7	53,6	14,5	51,9
	50-j.	-0,9	-4,4	1,6	88,1	49,1	13,3	34,3
Year 2002		9,3	4,4	14,7	81,4	1023,9	158,0	1768,4
10 – year average		8,6	4,0	13,6	80,0	820,7	157,4	1682,9
50 –year average		7,4	2,5	12,5	81,0	828,8	153,0	1663,0

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

3 Statistical Data on Hop Production

Bernhard Engelhard. Dipl. Ing. agr.

3.1 Production data

3.1.1 Structure of hop production

In the year 2002 the hop acreage in the Federal Republic of Germany decreased by 668 ha to 18,352 ha compared with 19 020 ha in the previous year (- 3.51 %).

The number of hop farms also decreased in 2002. i.e. by 183 (=8.61 %) from 2,126 to 1,943 farms. The average hop acreage per farm for the whole Federal Republic is now 9.45 ha compared with 8.95 ha in 2001.

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

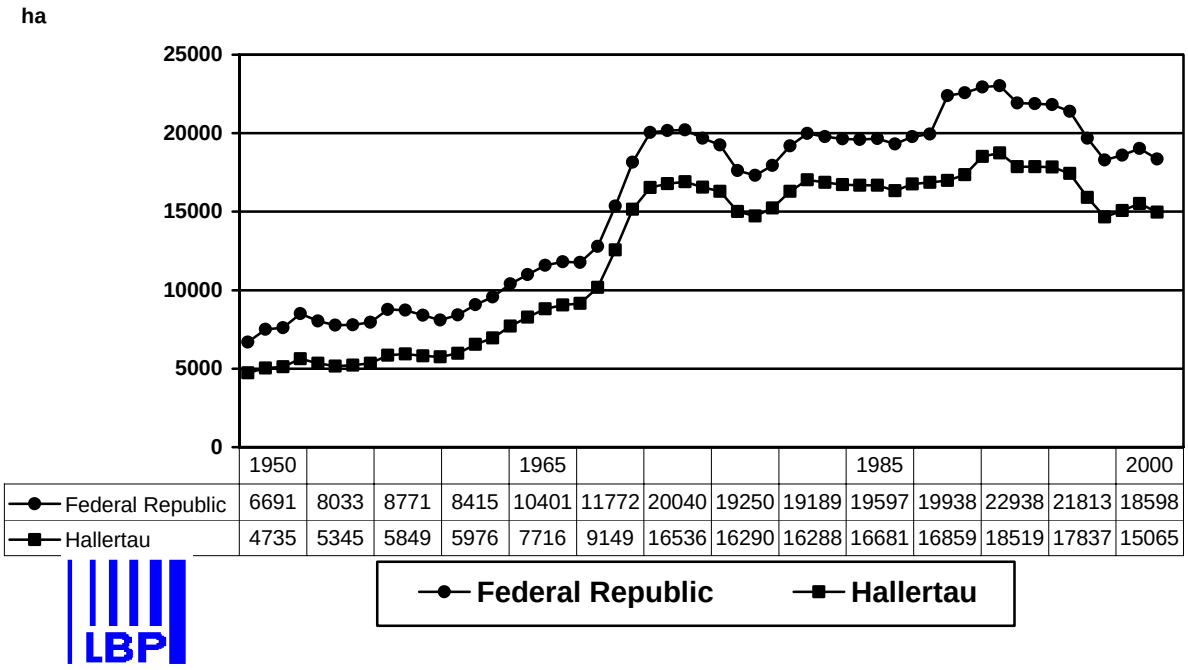
Year	No. of farms	Average hop acreage per farm in ha
1953	14 631	0,58
1963	13 259	0,68
1973	8 591	2,33
1974	8 120	2,48
1975	7 654	2,64
1976	7 063	2,79
1977	6 617	2,90
1978	5 979	2,94
1979	5 772	2,99
1980	5 716	3,14
1981	5 649	3,40
1982	5 580	3,58
1983	5 408	3,66
1984	5 206	3,77
1985	5 044	3,89
1986	4 847	4,05
1987	4 613	4,18
1988	4 488	4,41
1989	4 298	4,64
1990	4 183	5,35
1991	3 957	5,70
1992	3 796	6,05
1993	3 616	6,37
1994	3 282	6,69
1995	3 122	7,01
1996	2 950	7,39
1997	2 790	7,66
1998	2 547	7,73
1999	2 324	7,87
2000	2 197	8,47
2001	2 126	8,95
2002	1 943	9,45

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

Production area	Hop acreage				Hop farms				Hop acreage per farm in ha	
	in ha		Increase + / Decrease - 2001 to 2002		2001	2002	Increase + / Decrease - 2001 to 2002		2001	2002
	2001	2002	ha	%			Farms	%		
Hallertau	15 510	14 967	- 543	- 3.50	1 630	1 527	- 103	- 6.32	9.52	9.80
Spalt	455	427	- 28	- 6.15	130	118	- 12	- 9.23	3.50	3.62
Hersbruck	98	98	± 0	± 0	18	16	- 2	- 11.11	5.44	6.13
Tettnang	1543	1 444	- 99	- 6.42	309	243	- 66	- 21.36	4.99	5.94
Bitburg u.) Rheinpfalz)	19	20	+ 1	+ 5.26	2	2	± 0	± 0	9.50	10.00
Elbe-Saale	1 395	1 396	+ 1	+ 0.07	37	37	± 0	± 0	37.70	37.73
Fed. Republic of Germany	19 020	18 352	- 668	- 3.51	2 126	1 943	- 183	- 8.61	8.95	9.45

Diagram 3.1:

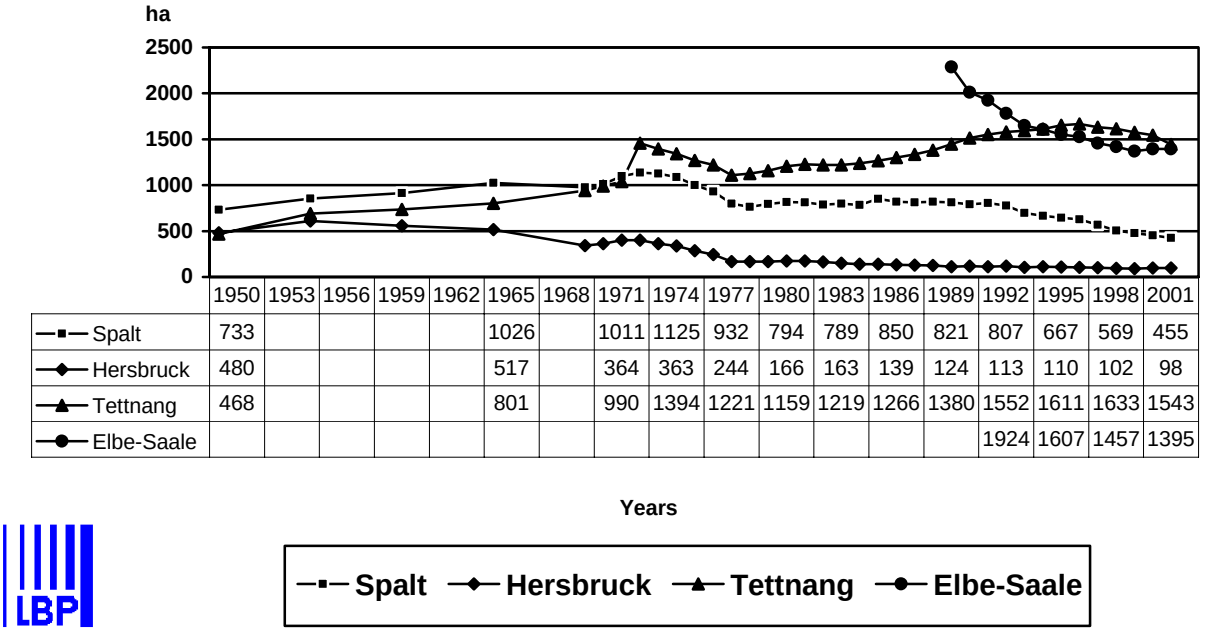
Hop acreage in the Federal Republic and in the Hallertau production area



	1950				1965					1985				2000
Federal Republic	6691	8033	8771	8415	10401	11772	20040	19250	19189	19597	19938	22938	21813	18598
Hallertau	4735	5345	5849	5976	7716	9149	16536	16290	16288	16681	16859	18519	17837	15065

Diagram 3.2

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



	1950	1953	1956	1959	1962	1965	1968	1971	1974	1977	1980	1983	1986	1989	1992	1995	1998	2001
Spalt	733					1026		1011	1125	932	794	789	850	821	807	667	569	455
Hersbruck	480					517		364	363	244	166	163	139	124	113	110	102	98
Tettnang	468					801		990	1394	1221	1159	1219	1266	1380	1552	1611	1633	1543
Elbe-Saale															1924	1607	1457	1395

Table 3.3: Hop varieties in the German production regions in ha in 2002

Part 1 - Aroma varieties

Anbaugebiet	Anbau-fläche gesamt	Haller-tauer Mfr.	Spalter	Tett-nanger	Hers-brucker spät	Hüller Bitterer	Perle	Spalter Select	Hall. Tradition	Saphir	Aromasorten	
Hallertau	14.967	838	2		1.359	10	3.193	852	1.751	59	8.064	53,88%
Spalt	427	126	138		11		18	115	11		419	98,13%
Hersbruck	98	27			8		20	21	7		83	84,69%
Tettnang	1.444	515		921			5		2		1.443	99,93%
Rheinpfalz } Bitburg }	20	2				2	6	2	3		15	75,00%
Elbe-Saale	1.396						143		9		152	10,89%
Bundesgebiet	18.352	1.508	140	921	1.378	12	3.385	990	1.783	59	10.176	55,45%
Anteil je Sorte in %		8,22%	0,76%	5,02%	7,51%	0,07%	18,44%	5,39%	9,72%	0,32%		

Variety change in the Federal Republic

2001 ha	19.020	1.409	153	992	1.644	15	3.606	1.080	1.850	19	10.768	56,61%
2002 ha	18.352	1.508	140	921	1.378	12	3.385	990	1.783	59	10.176	55,45%
Veränderung in ha	-668	99	-13	-71	-266	-3	-221	-90	-67	40	-592	-5,48%

Tabe 3.3: Hop varieties in the German production regions in ha in 2002

Teil 2 - Bitter varieties

Anbaugebiet	Northern Brewer	Brewers Gold	Nugget	Target	Hall. Magnum	Hall. Taurus	Hall. Merkur	Colum-bus	Sonstige	Bitterstoffsorten	
Hallertau	922	71	463	47	4.053	1.199	109	9	30	6.903	46,12%
Spalt					3		5			8	1,87%
Hersbruck		2			10		1		2	15	15,31%
Tettnang					1					1	0,07%
Rheinpfalz } Bitburg }					2	3				5	25,00%
Elbe-Saale	315		82	4	778	41	20	4		1.244	89,11%
Bundesgebiet	1.237	73	545	51	4.847	1.243	135	13	32	8.176	44,55%
Anteil je Sorte in %	6,74%	0,40%	2,97%	0,28%	26,41%	6,77%	0,74%	0,07%	0,17%		

Variety change in the Federal Republic

2001 ha	1.695	127	581	64	4.535	1.155	41	13	41	8.252	43,39%
2002 ha	1.237	73	545	51	4.847	1.243	135	13	32	8.176	44,55%
Veränderung in ha	-458	-54	-36	-13	312	88	94	0	-9	-76	-0,95%

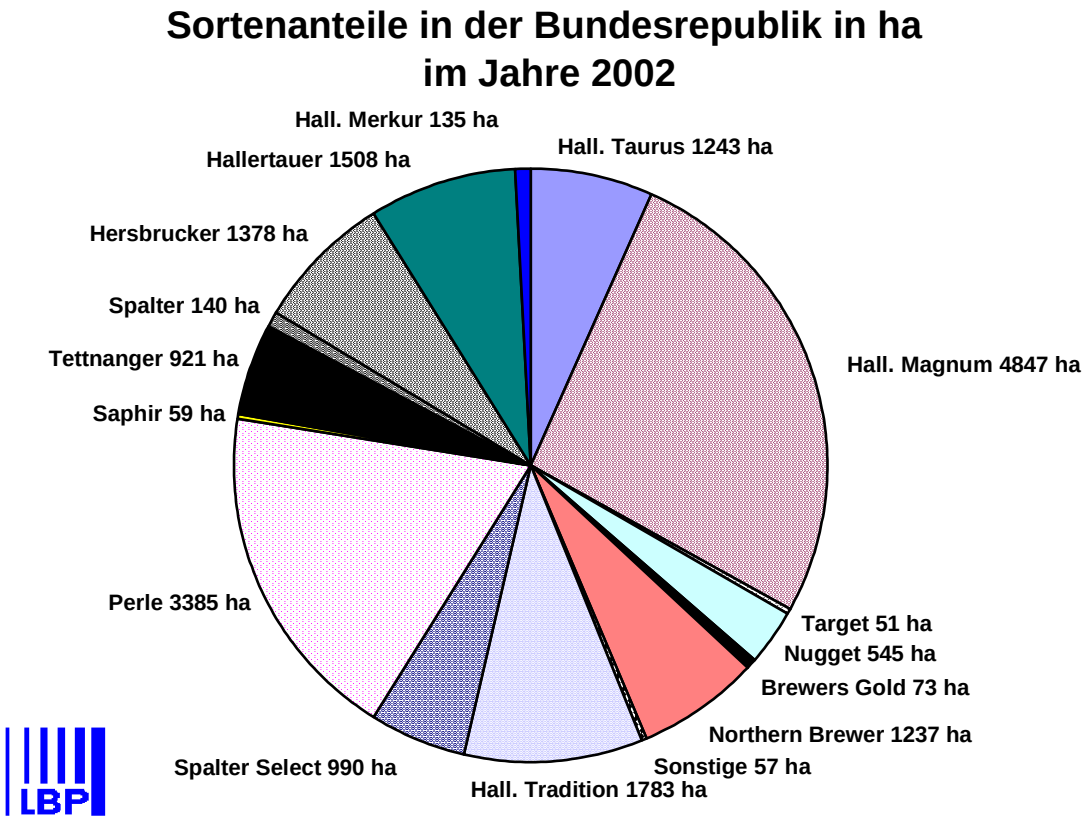
3.1.2 Hop varieties

With regard to the hop varieties, in 2002 there was a slight shift in favour of the bitter varieties. The proportion of aroma varieties in 2002 was 55.46 % compared with 56.61 % in 2001. The bitter varieties have a proportion of 44.54 % of the production area compared with 43.39 % in 2001.
The production areas of the aroma varieties, except for Hallertauer Mfr. and Saphir, were reduced without any exceptions.

The acreages of the bitter varieties Northern Brewer (- 458 ha), Brewers Gold (- 54 ha), Nugget (- 36 ha) and Target (- 13 ha) were also reduced. An increase in the production area was recorded for the varieties Hallertauer Magnum (+ 312 ha), Hallertauer Taurus (+ 88 ha) and Hallertauer Merkur (+ 94 ha)

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

Diagram 3.3:



3.2 Crop situation in 2002

The total crop in the Federal Republic of Germany yielded 32,270,635 kg (= 645,413 Ztr.) compared with 31,576,465 kg (= 631.529 Zentner) in 2001. The size of the crop is about 694,170 kg (= 13.884 Zentner) above the result of the previous year; this means an increase of around 2.19 %.

The yields per hectare and relative figures in the Federal Republic are shown in Table 3.4. The yields per hectare of the individual varieties and production areas are listed in Table 3.5 as well as the yields for the whole Federal Republic compared with the figures for 2001.

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

	1995	1996	1997	1998	1999	2000	2001	2002
Yield Ztr./ha	31.1	35.1	31.9	31.4	30.5	31.5	1660 kg (33.2 Ztr.)	1758 kg (35.2 Ztr.)
Relative to 100% (long-term. ∅ =35 Ztr.)	88.9	100.3	91.1	89.7	87.1	90.0	94.9	100.6
Acreage in ha	21.885	21.813	21.381	19.683	18.299	18.598	19.020	18.352
Total crop in Ztr.	681.081	766.070	681 035	617.181	558.247	585.841	31.576.465 kg (= 631.529 Ztr.)	32.270.635 kg (= 645.413 Ztr.)

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

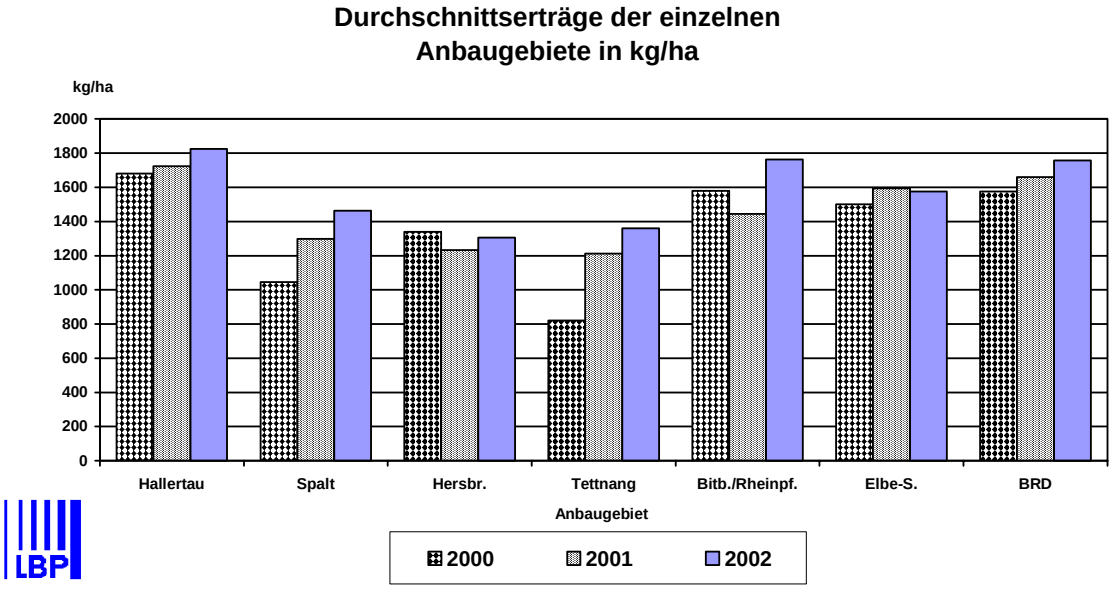


Table 3.5: Average yields of the individual hop varieties in the German production areas in 2002 in kg per ha

Aroma varieties

Production area	Haller-tauer	Spal-ter	Hers-brucker	Hüller Bitterer	Tett-nanger	Perle	Spalter Select	Hall. Trad.	Saphir
Hallertau	1138	1775	1832	1636	-	1837	1996	1992	801
Spalt	1340	1186	1326	-	-	1875	1947	1542	-
Hersbruck	1181	-	1394	-	-	1146	1723	1259	-
Tettnang	1489	-	-	-	1291	-	-		-
Bitburg } Rheinpfalz }	1412	-	-	1218	-	1958	1682	1332	-
Elbe-Saale	-	-	-	-	-	1458	-	1349	-
Bundesgebiet 2002	1276	1194	1826	1566	1291	1818	1984	1982	801
2001	1383	1091	1648	1512	1060	1567	1886	1725	110
± zu 2001 kg/ha	- 107	+ 103	+ 178	+ 54	+231	+ 251	+ 98	+ 257	+ 691
Ernte in to Bundesgebiet	1923.8	167.2	2515.7	18.8	1189.4	6143.6	1964.2	3529.7	47.3

Bitter varieties

Production area	Northern Brewer	Brewers Gold	Nugget	Target	Hall. Magnum	Hall. Taurus	Hall. Merkur	Colum-bus	Others	Total
Hallertau	1581	2473	2301	2206	1839	1933	936	2238	1891	1825
Spalt	-	-	-	-	770	-	269	-	-	1464
Hersbruck	-	1960	-	-	1064	-	1190	-	660	1306
Tettnang	-	-	-	-	-	-	-	-	981	1360
Bitburg } Rheinpfalz }	-	-	-	-	2812	1755	-	-	-	1763
Elbe-Saale	1314	-	1932	1788	1685	1677	710	1740	-	1576
Bundesgebiet 2002	1513	2459	2245	2174	1812	1925	880	2085	1648	1758
2001	1506	2132	2050	2076	1936	1536	352	1456	1485	1660
± zu 2001 kg/ha	+ 7	+ 327	+ 195	+ 98	- 124	+ 389	+ 528	+ 629	+ 163	+ 98
Ernte in to Bundesgebiet	1871.4	179.5	1223.6	110.9	8781.7	2392.2	118.8	27.1	65.9	32270.6

Source: EU report

Diagram 3.5: Crop volume in the Federal Republic

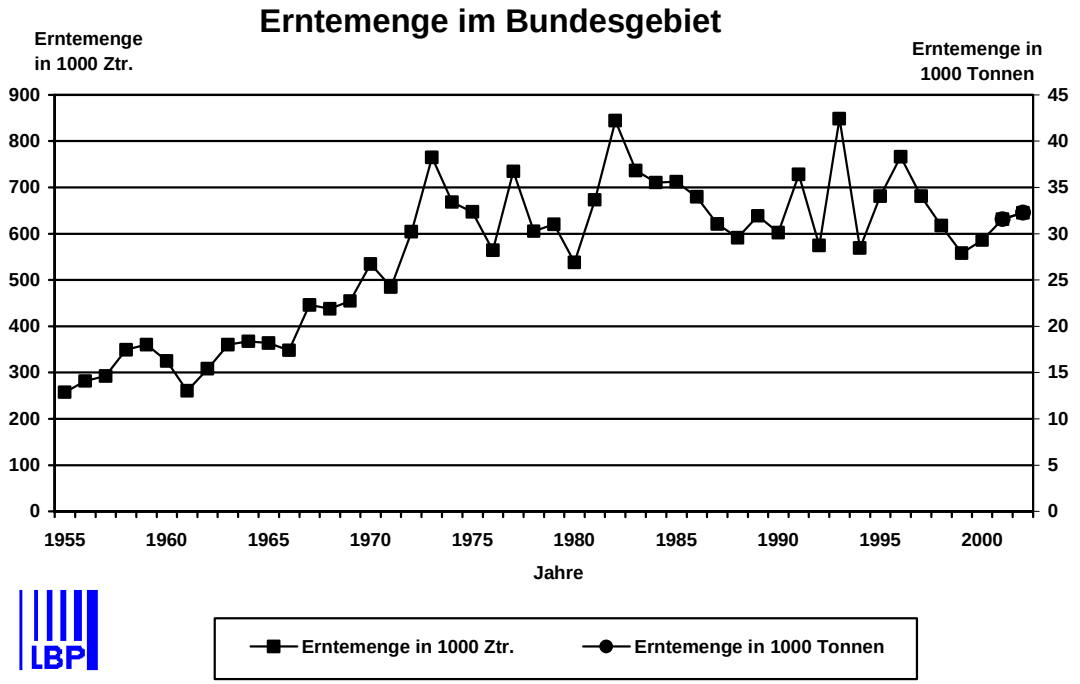


Diagram 3.6: Average crop per ha hop acreage in the Federal Republic

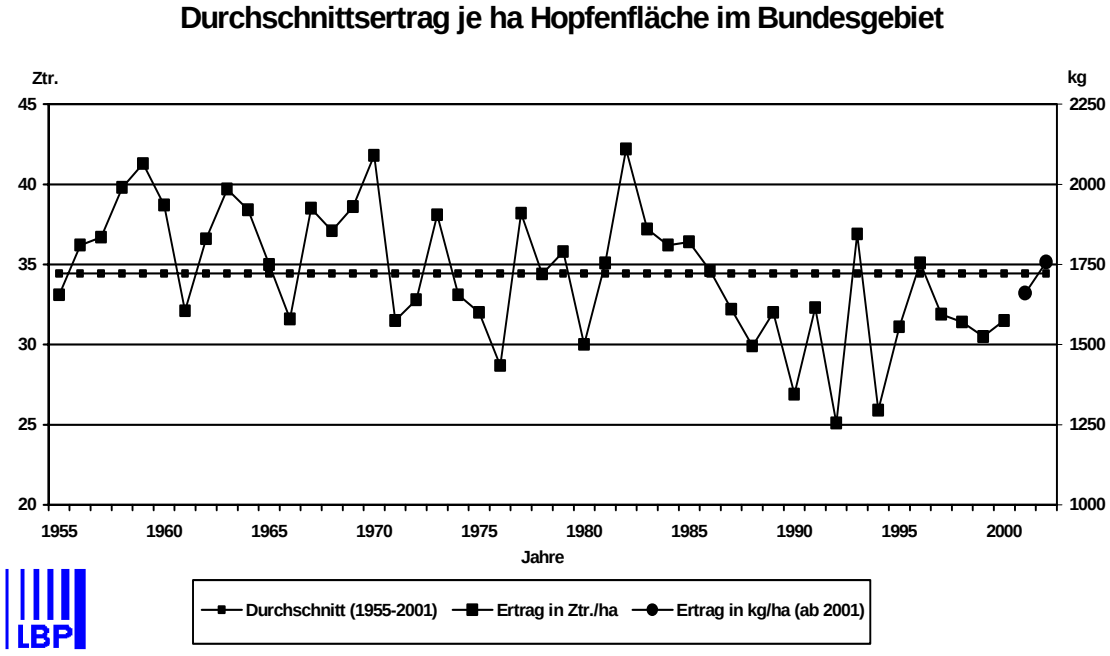


Table 3.6: Yields per hectare in the German production areas

Production area	Yields in Ztr./ha total acreage (from 2001 in kg/ha)								
	1994	1995	1996	1997	1998	1999	2000	2001	2002
Hallertau	26.7	32.3	35.1	32.8	32.5	31.2	33.6	1724 kg	1825 kg
Spalt	26.7	26.2	32.3	26.5	22.1	28.2	20.9	1298 kg	1464 kg
Hersbruck	22.4	23.9	27.9	28.3	28.8	23.5	26.8	1233 kg	1306 kg
Tettnang	27.2	24.1	28.9	31.2	26.8	28.3	16.4	1212 kg	1360 kg
Bitburg } Rheinpfalz }	25.2	31.3	39.0	34.9	30.1	31.4	31.6	1445 kg	1763 kg
Elbe-Saale	16.8	27.7	30.6	23.6	27.5	27.3	30.0	1594 kg	1576 kg
∅ Yield per ha Fed. Republic	25.9	31.1	35.1	31.9	31.4	30.5	31.5	1660 kg	1758 kg
Total crop Fed. Republic	568 686	681 081	766 070	681 035	617 181	558 247	585 841	31 576 to 631 529	32 271 to 645 413
Acreage Fed. Republic	21 930	21 885	21 813	21 381	19 683	18 299	18 598	19 020	18 352

Source: EU report

Table 3.7: Alpha-acid values of the individual hop varieties

Variety	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	10-year ∅
Hallertauer	4.9	3.2	3.8	4.8	5.1	4.4	3.9	4.5	4.3	4.3	4.32
Spalter	3.9	2.6	3.3	4.8	6.0	4.5	4.1	4.5	4.5	4.7	4.29
Tettnanger	4.3	3.0	2.6	4.5	4.9	3.7	3.5	4.7	4.1	4.1	3.94
Hersbrucker	3.4	1.3	2.2	4.0	4.6	3.4	2.0	4.6	2.7	2.9	3.11
Hüller Bitterer	5.6	4.0	4.0	5.4	7.9	6.5	5.2	6.6	5.7	6.9	5.78
Perle	7.1	3.7	5.3	7.9	8.8	6.5	6.7	8.0	6.8	8.0	6.88
Spalter Select	5.1	2.2	3.7	5.4	6.6	5.3	4.3	5.8	4.6	5.4	4.84
Hall. Tradition	5.8	3.9	4.7	6.5	6.8	5.6	5.7	6.8	6.3	6.7	5.88
Saazer	3.8	2.5	3.3	3.3	3.8	4.1	3.9	-	-	-	-
Northern Brewer	8.5	5.5	7.4	9.7	10.1	8.5	8.6	9.6	8.7	9.3	8.59
Brewers Gold	6.5	4.0	4.8	7.0	8.2	7.3	5.9	7.3	6.1	6.7	6.38
Record	6.1	3.1	4.4	7.3	8.4	6.5	6.3	8.3	6.0	-	6.30
Orion	7.5	4.3	5.9	8.4	9.3	7.4	7.0	8.6	8.2	-	7.40
Nugget	10.0	9.1	9.3	10.2	12.9	10.5	9.6	11.8	10.9	11.3	10.56
Target	11.0	8.5	9.4	11.6	12.7	10.8	11.1	12.1	11.7	11.5	11.04
Hall. Magnum	12.6	10.1	11.5	13.9	15.9	13.0	12.8	14.1	13.4	13.6	13.09
Hall. Taurus	-	-	-	15.6	13.8	13.3	15.2	14.9	15.1	15.3	-
Hall. Merkur	-	-	-	-	-	-	-	-	12.1	12.4	-
Columbus	-	-	-	-	-	-	-	-	10.6	-	-

Source: EU report

3.2.1 Hop marketing 2002

The hop marketing in the year 2002 was extremely difficult. The biggest quantities of spot hops were taken into a pool by the hop-trading firms and the producer groups. Part payments were made for certain varieties. Payments have still not been made for varieties which are difficult to market. Therefore no average price can be calculated for spot hops and neither can the total average price. The earnings per hectare hop acreage cannot be determined for this reason either.

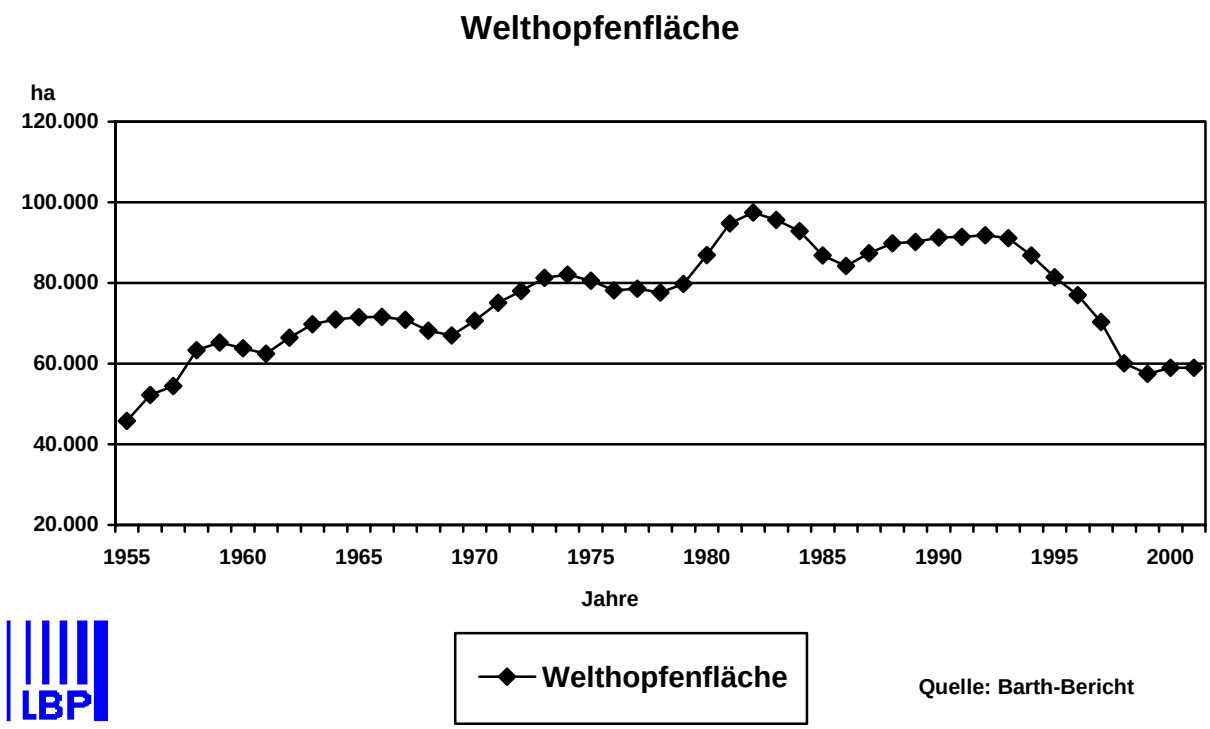
3.2.2 World hop market

Table 3.8: World hop market

	1993	1994	1995	1996	1997	1998	1999	2000	2001
World hop acreage in ha	91 121	86 786	81 466	76 967	70 290	60 111	57 427	58 991	58 946
Change in ha		-4 335	-5 320	- 4 499	- 6 677	-10 179	- 2 684	+ 1 564	- 45
World hop crop in million Zentner	2.74	2.43	2.53	2.49	2.24	1.89	1.91	1.93	1.98
Change in million Zentner		- 0.31	+ 0.10	- 0.04	- 0.25	- 0.35	+ 0.02	+ 0.02	+ 0.05
World average yield in Ztr./ha	30.07	28.00	31.06	32.35	31.92	31.48	33.24	32.79	33.64
World alphaproduction in 1000 kg	9 097	6 907	7 831	9 300	8 782	7 248	7 393	8 294	8 747
World beer production in million hl	1 188	1 214	1 248	1 269	1 300	1 301	1 365	1 392	1 421
Increase/Reduction in %		+ 2.19	+ 2.80	+ 1.68	+ 2.44	+ 0.8	+ 3.46	+ 1.98	+ 2.08
Amount of hops harvested per hl beer in grams	115	99	101	98	86	72	70	69	70
Alpha-Production per hl beer produced in gram	7.66	5.66	6.27	7.33	6.76	5.57	5.42	5.96	6.15

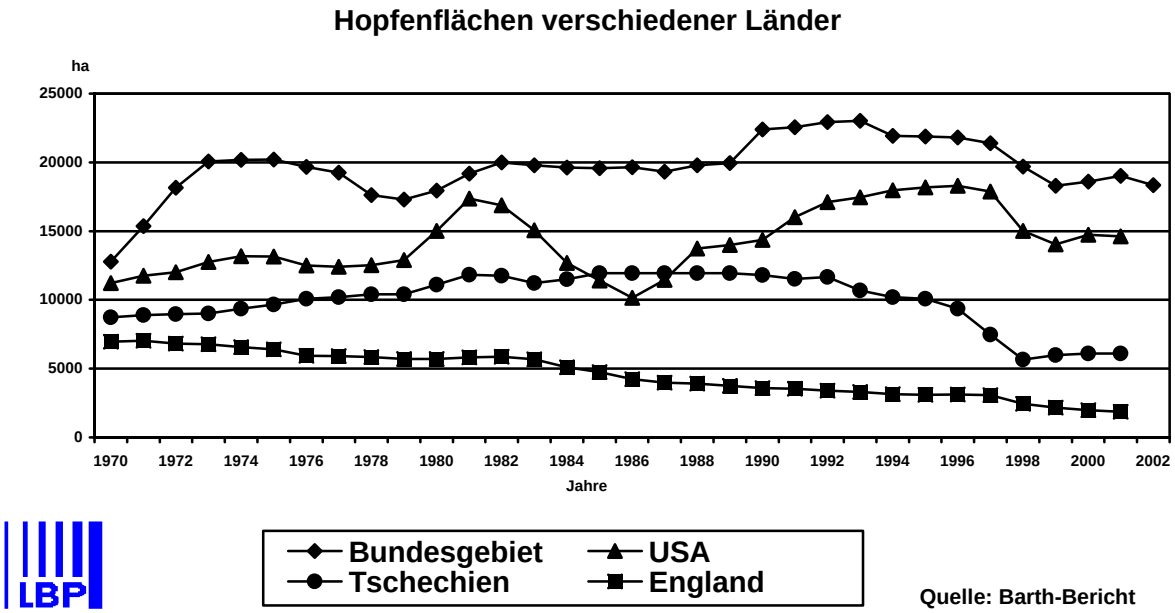
Source: Barth report

Diagram 3.7: World hop acreage



Quelle: Barth-Bericht

Diagram 3.8: Hop acreage of various countries



Quelle: Barth-Bericht

Diagram 3.9: World hop crop

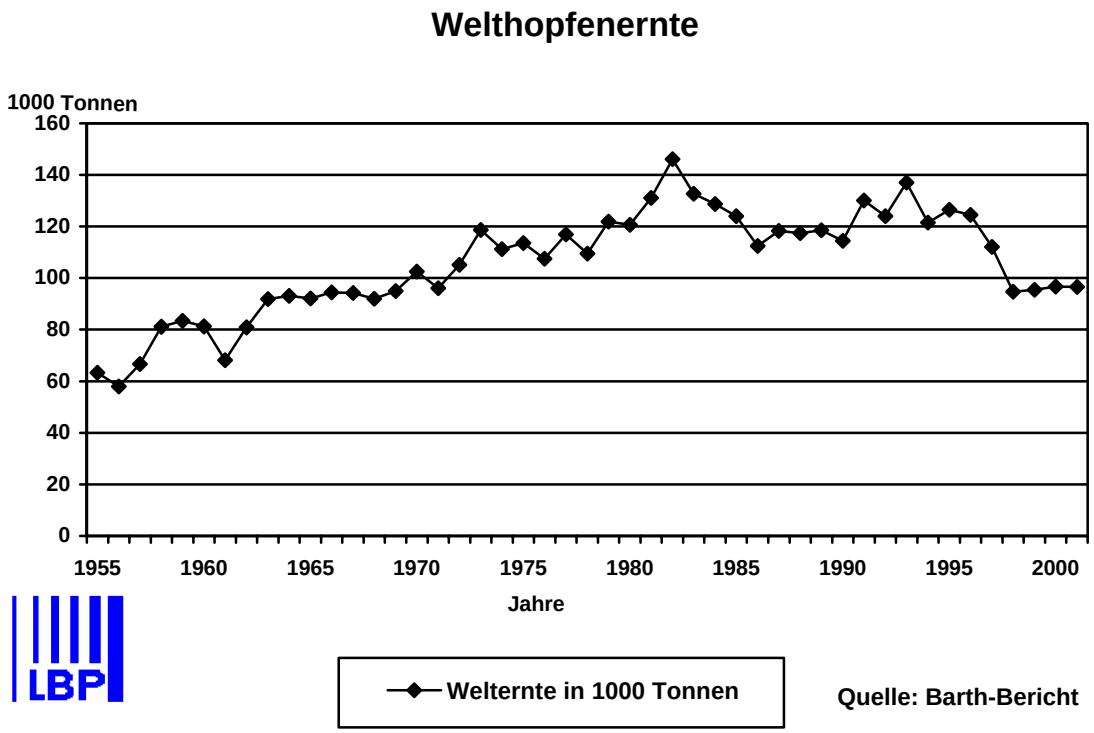
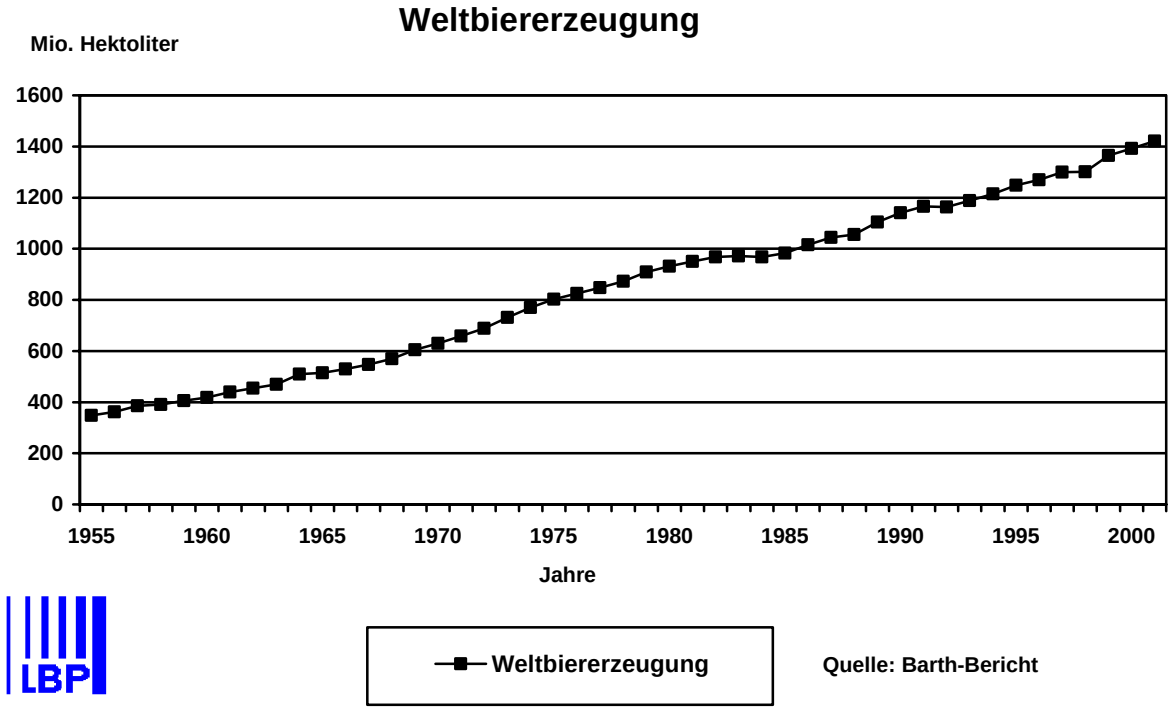


Diagram 3.10: World beer production



4 Hop Breeding

Dr. Elisabeth Seigner, Dipl. Biol.

4.1 Practical hop breeding

4.1.1 Crossings 2002

76 crossings were carried out in 2002 with the following breeding aims:

No. of crossings

	36	Aroma hops with good Peronospora tolerance and powdery mildew resistance
	11	Low trellis hops with Peronospora tolerance and powdery mildew resistance
	67	Bitter hops with good Peronospora tolerance and powdery mildew resistance
total:	114	

The number of crossings was considerably increased again in 2002 compared with the previous years, as meanwhile there is a greater number of powdery mildew resistant crossing partners available.

4.1.2 Results of the seedling tests

4.1.2.1 Seedlings 2000

Peronospora (*Pseudoperonospora humuli*) tolerance test for the seedlings 2000

Of the seedlings 2000 there are 2340 descendants from 40 aroma crossings and 82 bitter crossings now being grown in the breeding yard in Huell.
The varieties Hallertauer Mfr., Hallertauer Tradition, Spalter Select and Perle were grown as reference varieties for the seedlings in the aroma hop direction. The reference varieties for the seedlings in the bitter hop direction are Hallertauer Magnum, Hallertauer Taurus, Nugget and Wye Target.

Powdery mildew (*Sphaeotheca humuli*) resistance test for the seedlings 2000

In an isolated hop yard there are additionally approx. 1600 descendants from 66 bitter hop crossings. They are tested for powdery mildew resistance in field trials. During the whole vegetation period this stand of hops was not treated with any chemical pesticides against powdery mildew.

Table 4.1: Powdery mildew infection of reference varieties for the seedlings 2000 in the resistance test in Huell

Variety	Powdery mildew infection (0-9) dry hops monitoring	
	from – up to	∅
Hallertauer Magnum	2-5	3,5
Hallertauer Taurus	2-4	3,0
Nugget	4-6	5,0
Wye Target	0	0

Result of the seedlings 2000 from the Peronospora and powdery mildew test

The seedlings 2000 were harvested for the first time in 2002. Of the 76 seedlings selected eight seedlings with single plant yields of more than 1000 g and 13 seedlings with alpha-acid values over 15 % were chosen.
Seven promising breeding lines will therefore be propagated after the first harvesting and included in the “Stammespruefung” (trials with replications at two different locations) 2003.

4.1.2.2 Seedlings 99

Peronospora tolerance test for the seedlings 99

Of the seedlings 99, 1250 descendants from 41 aroma crossings and 1060 descendants from 57 bitter crossings are being grown in the breeding yard in Huell.
The varieties Hallertauer Mfr., Hallertauer Tradition, Spalter Select and Perle were grown as reference varieties for the seedlings in the aroma hop direction. The reference varieties for the seedlings in the direction of bitter hops are Hallertauer Magnum, Hallertauer Taurus, Nugget and Wye Target.

Powdery mildew resistance test for the seedlings 99

In an isolated hop yard there are additionally 275 descendants from nine aroma hop crossings and approx. 2060 descendants from 57 bitter hop crossings. They are tested for powdery mildew resistance in field trials. During the whole vegetation period this stand of hops has not been treated with any chemical insecticides against powdery mildew. As mainly seedlings in the direction of bitter hops were tested, Hallertauer Magnum, Hallertauer Taurus, Nugget and Wye Target are grown as reference varieties.

Table 4.2: Powdery mildew infection of the reference varieties of the seedlings 99 in the resistance test in Huell

Variety	Powdery mildew infection (0 - 9) dry hops monitoring			
	2001		2002	
	from - up to	∅	from – up to	∅
Hall. Magnum	1 – 5	2,5	3-4	3,8
Hall. Taurus	0 – 1	0,8	0-4	2,0
Nugget	3 – 6	4,0	0-2	1,0
Wye Target	0	0	0	0

Number of seedlings 99 harvested in the powdery mildew resistance test with a powdery mildew resistance comparable with Wye Target

Monitoring grade 0: 122 seedlings
Monitoring grade 1: 9 seedlings
Monitoring grade 2: 11 seedlings

In 2001 and 2002 the spread of powdery mildew was considerably less than in previous years in the breeding yard as well as in the practice. This shows the powdery mildew attacks of the four reference varieties (Table 4.2). The plants of the powdery mildew resistant variety Wye Target remained free of infestation in both years.

Results of the seedlings 99 from the Peronospora and powdery mildew test

During the two-year yield test altogether 318 seedlings were harvested.
51 seedlings could be selected with single plant yields of more than 1000 g and 39 seedlings with alpha-acid values more than 15 %.
10 lines were already included in the new „Stammespruefung“ as early as 2002. A further seven lines are designated for the „Stammespruefung” 2003.

4.1.3 Results of the „Stammespruefungen" (trials with replications at two different locations)

4.1.3.1 „Stammespruefung" 2001 in Huell and Rohrbach

Table 4.3: Results of the 2002 crop

Line / Variety	Yield Ztr./ha	Aroma 1-30	Alpha-acids	Beta-acids	Cohu-mu-lone	Yield Ztr./ha	Aroma 1-30	Alpha-acids	Beta-acids	Cohu-mu-lone
	Huell (clay soil)					Rohrbach (sandy soil)				
Hall. Tradition		27	6,2	4,1	23,6		27	5,1	3,9	25,2
Hall. Merkur		23	13,5	6,0	17,3		23	11,7	4,7	16,7
97/007/011		27	7,3	5,0	23,0		27	5,9	4,3	22,7
97/007/040		26	6,1	5,5	25,7		27	5,2	4,2	24,6
97/010/023		27	8,1	5,9	24,7		-	-	-	-
97/025/007		26	0,3	9,5	34,4		26	0,2	8,9	35,5
97/026/006		27	3,4	8,4	15,8		-	-	-	-
97/033/014		25	6,4	4,2	16,1		-	-	-	-
97/040/003		23	14,2	5,2	38,6		19	14,3	5,1	38,9
97/040/036		22	8,5	6,7	16,9		22	6,2	4,8	20,3
97/060/008		23	10,8	4,5	33,9		21	10,5	4,0	35,2
97/060/011		23	17,7	5,6	36,6		21	16,4	5,5	36,6
97/060/025		22	12,4	5,0	39,8		23	10,9	4,2	40,5
97/060/030		18	10,3	5,1	15,1		21	9,6	4,6	17,2
97/060/054		23	11,2	3,9	36,9		24	9,1	3,3	38,7
97/060/721		23	16,9	5,9	39,6		-	-	-	-
97/060/724		21	13,0	4,4	37,5		-	-	-	-
97/060/754		20	11,3	4,7	39,1		-	-	-	-
97/065/753		19	13,6	7,3	23,9		21	13,9	7,0	24,4
97/071/737		21	11,6	7,2	28,7		-	-	-	-
97/076/754		22	12,3	7,8	36,1		23	12,4	7,4	37,6
97/077/763		21	12,6	3,8	25,0		-	-	-	-
97/079/005		20	10,1	2,6	24,0		-	-	-	-
97/081/722		20	10,8	4,3	26,6		-	-	-	-

Alpha- and beta-acids in % (dry weight basis)
Cohumulone in % of the alpha-acids

As the „Stammespruefung" 2001 developed very unevenly due to damage by wild hares, in 2002 only one wire per stand was trained up. For this reason the figure for the yield has been omitted. The hop components listed should only be regarded as guidelines, as the alpha-acid values of root cuttings are generally much lower than in plants which give a full yield.
The aroma breeding line 97/025/007 is marked by an almost total lack of the alpha-acid values. Apparently here the conversion of the beta-acids into alpha-acids, which normally takes place during ripening, is blocked.
The breeding line 97/060/011 appears to be particularly promising. Therefore it was included in a production test as early as 2002.

4.1.3.2 „Stammespruefung“ 2000/2 in Huell and Rohrbach

Table 4.4: Results of the 2002 crop

Line / Variety	Yield Ztr./ha	Aroma 1-30	Alpha-acids	Beta-acids	Cohu-mu-lone	Yield Ztr./ha	Aroma 1-30	Alpha-acids	Beta-acids	Cohu-mu-lone
	Huell (clay soil)					Rohrbach (sandy soil)				
Hall. Tradition	48,2	26	6,2	4,8	24,1	55,7	26	5,8	4,7	25,9
Hall. Merkur	62,1	22	10,8	5,7	18,6	56,1	22	12,4	6,9	17,9
96/001/001	36,8	26	6,4	7,0	23,9	38,3	26	5,5	6,5	23,3
96/001/008	49,0	27	6,2	7,5	23,3	32,6	27	4,5	6,1	22,5
96/001/017	32,5	27	5,2	6,9	19,9	40,9	26	4,7	7,5	21,2
96/001/018	30,5	26	7,1	6,1	21,7	33,4	27	7,1	6,1	22,1
96/001/021	45,8	25	5,6	6,8	22,4	31,5	27	5,6	7,1	21,9
96/001/024	61,5	26	5,4	7,9	19,0	41,1	27	5,0	7,3	19,1
96/008/014	69,1	26	5,3	10,5	16,5	66,4	27	4,8	10,8	15,6
96/010/024	45,5	27	4,9	10,1	18,6	45,1	26	4,2	9,5	18,9
96/012/011	45,0	26	5,9	4,2	23,7	35,7	25	4,9	3,5	24,3
96/015/030	54,3	22	6,9	5,3	19,1	58,0	25	7,0	5,7	20,1
96/016/034	48,4	26	8,2	8,0	16,3	49,4	26	7,0	7,6	18,1
96/026/017	45,2	27	7,3	7,2	24,3	37,4	27	7,9	7,6	19,7
96/030/011	63,2	27	3,9	9,3	14,4	53,4	26	3,9	8,9	15,4
96/030/014	42,3	26	4,8	9,2	12,5	25,9	24	3,9	7,3	16,0
96/030/016	34,5	26	6,1	7,0	14,4	-	-	-	-	-
96/030/041	51,3	26	4,4	9,2	10,3	50,8	25	4,3	8,4	11,7
96/031/009	44,9	26	3,5	12,7	14,5	30,8	26	3,3	11,6	15,3
96/031/027	51,1	25	4,9	6,6	15,6	49,2	25	4,2	6,1	16,0
96/035/026	53,6	25	6,0	6,7	13,3	49,9	26	5,0	6,7	12,1
96/037/025	54,2	25	6,5	6,0	22,6	51,9	25	4,8	6,9	21,8
96/054/009	47,4	26	3,8	5,0	20,8	-	-	-	-	-
96/069/037	55,5	22	15,3	6,0	19,4	38,9	22	16,1	6,3	20,1

Alpha- and beta-acids in % (dry weight basis)
Cohumulone in % of the alpha-acids

The „Stammespruefung“ 2000/2 was set in 2000 and fully harvested for the first time. In the case of seedlings from 1996 it was possible to select 21 interesting aroma breeding lines. They are marked by a balanced alpha/beta ratio and low cohumulone values. On the other hand in the high-alpha sector only the breeding line 96/069/037 attained the required breeding aims.

4.1.3.3 „Stammespruefung“ 2000 in Huell and Rohrbach

Table 4.5: Results of the 2002 crop

Line / Variety	Yield Ztr./ha	Aroma 1-30	Alpha-acids	Beta-acids	Cohu-mu-lone	Crop Ztr./ha	Aroma 1-30	Alpha-acids	Beta-acids	Cohu-mu-lone
	Huell (clay soil)					Rohrbach (sandy soil)				
Hall. Magnum	54,8	23	13,6	7,5	28,8	54,9	21	14,8	7,2	26,7
Hall. Taurus	50,2	21	15,5	5,2	21,7	47,2	22	16,4	5,1	23,0
Nugget	49,2	20	12,1	4,6	25,6	70,5	19	11,5	4,5	28,0
Wye Target	56,1	21	12,2	6,0	33,3	62,7	19	11,7	5,0	36,3
94/075/240	54,0	21	15,1	7,1	21,8	61,5	22	13,2	7,5	20,7
94/075/248	40,0	20	11,5	8,8	19,4	53,0	21	13,3	9,4	20,0
94/075/250	57,7	22	7,9	7,8	17,7	57,2	22	8,6	8,7	17,9
94/075/761	40,8	21	13,8	6,7	13,3	57,0	19	15,5	6,7	14,5
95/080/721	53,4	22	9,3	4,2	39,6	70,8	20	11,1	5,5	41,2
95/083/769	58,3	19	13,5	4,3	25,7	73,1	19	14,4	4,4	27,5
95/090/703	42,3	18	14,0	5,9	34,2	45,5	19	14,3	5,7	31,7
95/093/702	38,7	17	16,7	5,1	26,2	29,4	17	16,0	4,6	24,0
95/093/716	47,0	20	16,0	5,4	29,9	46,6	20	16,9	5,3	29,3
95/094/751	37,7	20	9,1	4,5	47,8	40,8	18	10,5	4,8	47,8
95/094/766	59,2	22	10,6	4,3	30,5	59,5	20	10,9	4,4	32,0
95/094/775	62,4	22	10,8	6,5	21,8	59,0	18	9,6	5,4	23,9
95/094/834	50,9	21	15,7	6,0	36,5	53,2	19	16,4	5,9	34,2
95/094/841	53,7	21	12,0	4,0	31,9	60,3	19	13,1	4,1	33,5
95/094/850	45,8	20	14,1	6,3	25,3	51,3	18	14,5	5,7	23,4
95/096/726	52,5	19	14,0	4,9	24,8	55,1	20	13,6	4,4	25,0
95/099/748	40,3	19	13,4	5,3	23,7	51,0	16	14,8	5,3	23,5
95/099/790	56,3	18	13,6	5,0	27,6	54,5	19	16,4	5,0	26,0
95/100/709	54,2	16	10,4	5,5	41,0	58,5	15	12,5	5,2	37,3
95/100/713	46,6	17	9,8	5,2	38,7	45,4	18	10,4	5,2	39,6
95/100/722	28,9	17	13,0	5,6	37,4	18,1	17	10,3	4,9	33,2
95/100/760	59,5	17	8,9	3,7	22,7	51,8	19	9,4	3,9	22,8
95/100/787	56,2	21	12,2	4,7	36,0	-	-	-	-	-
95/100/804	49,6	22	8,2	4,9	34,2	45,7	20	9,2	5,2	34,0
95/103/728	59,9	17	10,9	3,7	32,2	63,4	17	11,5	4,0	32,0
95/103/758	56,4	19	8,5	6,7	26,4	50,9	20	8,3	6,4	25,5

Alpha- and beta-acids in % (dry weight basis)
Cohumulone in % of the alpha-acids

The lines of the „Stammespruefung“ 2000 are marked by a good powdery mildew resistance. However only a few lines attained yields and alpha-acid values above those of the reference varieties.

4.1.3.4 „Stammespruefung“ 99 in Huell and Rohrbach

Table 4.6: Results of the 2002 crop

Line / Variety	Yield Ztr./ha	Aroma 1-30	Alpha-acids	Beta-acids	Cohu-mu-lone	Crop Ztr./ha	Aroma 1-30	Alpha-acids	Beta-acids	Cohu-mu-lone
	Huell (clay soil)					Rohrbach (sandy soil)				
Hall. Trad.	43,5	27	7,0	5,7	24,7	34,9	26	6,7	5,5	24,1
Hall. Magnum	37,9	22	15,4	7,7	27,7	50,5	22	14,3	7,0	25,8
Hall. Taurus	44,1	22	17,2	5,5	22,3	46,8	21	17,5	5,4	23,3
Phoenix	19,3	22	13,0	5,8	26,4	22,3	19	12,8	5,8	25,5
Wye Target	60,9	19	11,9	5,0	36,6	55,9	19	12,5	5,6	36,6
94/022/045	37,3	26	5,4	4,2	23,8	41,6	24	5,7	4,9	24,3
94/041/019	55,8	27	6,5	4,5	14,6	54,8	27	5,6	4,1	16,2
94/045/001	47,1	26	8,2	5,5	18,2	41,2	27	7,7	5,8	17,5
94/057/779	71,1	23	12,5	5,5	23,0	59,8	22	11,2	5,6	21,6
94/075/733	63,2	21	14,8	7,4	23,4	56,4	21	15,3	7,1	23,9
94/075/806	41,7	21	12,8	8,5	24,9	41,8	19	14,1	7,8	24,5
95/089/735	24,2	16	6,4	8,0	17,6	35,7	17	6,1	8,8	19,4
95/090/718	45,3	22	9,8	4,7	26,7	41,9	21	9,3	4,7	25,9
95/094/721	63,0	20	14,1	6,3	33,7	62,4	23	13,7	6,0	34,1
95/094/730	63,9	20	13,9	5,6	27,4	56,9	21	14,8	5,5	27,7
95/094/741	63,0	22	13,6	4,8	35,1	48,0	20	13,3	4,8	36,4
95/094/744	43,2	19	8,5	4,2	24,4	45,3	21	8,3	4,4	24,1
95/094/769	42,0	20	14,4	5,2	29,8	38,4	21	15,1	5,0	30,1
95/094/793	48,9	19	14,2	5,1	30,0	48,4	21	15,1	5,1	30,4
95/094/816	72,2	21	17,3	6,0	36,6	68,1	22	18,5	5,8	36,3
95/103/735	58,4	23	15,3	6,2	25,9	55,5	22	15,1	6,0	22,5
95/103/743	59,2	23	15,7	4,7	24,7	57,4	22	13,6	4,3	25,8
95/110/743	42,3	22	13,0	4,7	28,5	41,7	21	13,2	4,7	27,9
95/110/747	20,3	20	9,6	4,6	23,4	27,9	21	9,8	4,1	23,2

Alpha- and beta-acids in % (dry weight basis)
Cohumulone in % of the alpha-acids

Only the breeding line 94/041/019 is interesting in the aroma sector. It is marked by a high yield potential, fine aroma and low cohumulone values. Among the bitter lines many breeding lines show a very high yield potential.

4.1.3.5 „Stammespruefung“ 98 in Huell and Rohrbach

Table 4.7: Results of the 2002 crop

Line / Variety	Yield Ztr./ha	Aroma 1-30	Alpha-acids	Beta-acids	Cohu-mu-lone	Yield Ztr./ha	Aroma 1-30	Alpha-acids	Beta-acids	Cohu-mu-lone
	Huell (clay soil)					Rohrbach (sandy soil)				
Hall. Magnum	41,8	22	14,9	7,4	27,9	50,9	22	13,9	6,6	26,4
Hall. Taurus	35,0	21	17,6	5,7	22,4	55,0	22	13,8	4,0	24,2
Nugget	47,4	21	12,4	5,0	26,7	65,5	21	11,8	4,5	27,3
Wye Target	58,2	19	11,0	4,8	36,4	48,9	20	10,7	4,8	36,6
93/015/751	63,6	20	13,3	8,6	50,5	-	-	-	-	-
93/015/766	38,5	19	9,3	8,1	34,6	-	-	-	-	-
93/018/772	31,1	17	12,7	7,0	38,5	-	-	-	-	-
93/019/740	49,3	21	13,2	5,3	27,3	-	-	-	-	-
93/023/744	38,0	20	13,9	6,6	29,9	57,1	20	11,5	5,9	32,9
93/023/763	53,6	21	13,3	6,3	22,9	-	-	-	-	-
93/025/701	35,3	19	10,1	7,3	22,8	-	-	-	-	-
93/026/706	50,1	18	10,7	5,7	22,1	41,1	21	10,5	4,6	24,9
93/026/706	54,3	18	11,6	5,8	21,8	-	-	-	-	-
93/034/765	46,5	21	12,1	4,4	22,5	41,7	22	13,0	3,8	24,4
93/034/766	47,7	21	12,2	4,2	23,4	31,1	17	10,0	4,3	24,4
93/034/783	37,6	21	8,7	4,2	25,8	-	-	-	-	-
93/104/702	23,3	18	13,7	6,0	37,0	-	-	-	-	-
94/057/720	61,8	21	11,7	6,4	25,3	74,6	22	10,8	5,7	25,4
94/057/735	57,0	22	11,8	5,1	37,3	62,5	23	11,3	4,6	37,9
94/057/832	51,7	22	13,6	5,6	25,6	47,3	22	13,7	5,7	25,9
94/074/025	43,1	20	12,7	6,8	22,8	40,1	21	11,5	6,1	22,5
94/075/031	30,8	22	9,0	5,7	18,0	27,7	22	8,2	5,7	17,5
94/075/064	15,3	21	15,5	8,5	23,8	41,3	21	14,9	8,4	22,2
94/075/720	44,6	20	8,8	8,9	17,0	44,0	20	7,8	9,4	15,8
94/075/734	44,6	22	11,4	7,9	16,9	49,3	22	10,0	7,9	16,1
94/075/754	32,5	21	14,3	7,8	19,2	43,2	22	14,0	8,5	18,6
94/075/758	41,9	20	15,2	8,3	19,5	54,8	20	15,7	7,9	20,8
94/075/762	28,8	20	9,1	6,9	25,0	37,2	21	9,7	7,6	24,4
94/075/766	52,1	20	16,7	7,4	26,8	57,8	21	16,3	6,8	26,3
94/075/767	44,1	21	12,4	5,5	19,3	56,0	21	13,9	5,6	20,5

Alpha- and beta-acids in % (dry weight basis)
Cohumulone in % of the alpha-acids

The „Stammespruefung“ 98 was harvested for the fourth time in 2002 and is therefore finished. The best results were produced by two breeding lines from the crossing 94/075 which will be further tested in the “Hauptpruefung” and in the production tests. They are shown in Table 4.8 compared with the standard varieties Hallertauer Magnum and Hallertauer Taurus.

Table 4.8: Average of the results of promising lines of the 1999 – 2002 crops compared with Hall. Magnum und Hall. Taurus

Line / Variety	Yield Ztr./ha	Aroma 1-30	Alpha-acids	Beta-acidse	Cohu-mu-lone	Yield Ztr./ha	Aroma 1-30	Alpha-acids	Beta-acids	Cohu-mu-lone
	Huell (clay soil)					Rohrbach (sandy soil)				
Hall. Magnum	32,0	22,5	13,5	6,9	25,8	38,8	22,0	14,0	7,2	26,5
Hall. Taurus	33,2	21,0	16,2	5,3	21,7	44,4	21,3	15,7	5,0	23,0
94/075/758	38,5	20,0	15,9	7,7	20,1	52,0	20,0	16,8	8,0	20,5
94/075/766	43,1	20,0	16,6	6,7	25,9	46,8	20,8	16,9	6,6	26,9

Alpha- and beta-acids in % (dry weight basis)
Cohumulone in % of the alpha-acids

4.1.4 Results of the "Hauptpruefungen" (trials with advanced selections in various replications)

4.1.4.1 „Hauptpruefung" 2000 in Rohrbach

Table 4.9: Results of the 2002 crop

Line / Variety	Yield Ztr./ha	Aroma 1-30	Alpha-acids	Beta-acids	Cohumulone
Aroma lines					
Hall. Tradition	50,6	27	6,3	5,3	24,0
91/013/025	50,3	27	7,5	7,4	15,8
91/024/015	32,9	27	5,1	5,3	14,9
91/033/015	35,7	27	5,9	3,4	14,0
Bitter lines					
Hall. Taurus	55,6	22	17,0	5,3	22,3
Hall. Merkur	42,1	23	13,6	7,0	17,9
93/010/034	49,0	23	13,4	4,5	21,6
93/010/036	69,6	23	15,8	5,8	26,3
93/010/063	68,7	22	14,2	6,6	29,4
93/024/733	42,4	23	12,7	5,5	26,7
94/075/758	50,9	21	15,8	7,7	21,3
94/075/761	50,7	22	15,5	6,4	14,0
94/075/766	57,4	22	15,8	6,6	25,3
95/094/721	63,7	21	12,3	5,1	33,6
95/094/730	60,8	22	14,9	5,4	26,7
95/094/850	54,1	22	13,8	5,2	23,7

Alpha-and beta-acids in % (dry weight basis)
Cohumulone in % of the alpha-acids

4.1.4.2 „Hauptpruefung“ 2001 in Rohrbach

Table 4.10: Results of the 2002 crop

Line / Variety	Yield Ztr./ha	Aroma 1-30	Alpha-acids	Beta-acidss	Cohumulone
Bitter lines					
Hall. Merkur	45,2	23	12,7	6,4	17,8
94/075/248	55,0	21	12,3	9,1	19,9
94/075/806	51,8	20	12,9	8,6	24,7
95/094/741	61,6	23	13,4	4,8	35,6
95/094/769	47,6	22	14,7	5,0	27,9
95/094/816	76,4	22	15,9	5,2	35,2
95/094/834	54,1	22	14,9	5,6	34,7
95/099/790	60,9	22	14,4	5,0	26,7

The most interesting breeding lines of the “Hauptpruefungen” 1997 – 2000 were included in both the “Stammespruefungen” 2000 and 2001. As both trials were fully harvested for the first time, the results can be compared. Of the three aroma breeding lines tested, the line 91/013/025 appears to be the most interesting one. Besides a high yield potential and good analysis data it is also marked by favourable agronomical characteristics.
The bitter lines 93/010/036 and 95/094/816 seem to be particularly promising. Both breeding lines produced constant high yields and alpha-acid values in the past few years.

4.1.5 Results of the practical hop-growing tests

4.1.5.1 Aroma and bitter lines on the Schwarzmeier farm in Rohrbach

Table 4.11: Results of the 2002 crop

Line	Year of planting	Yield Ztr./ha	Aroma 1-30	Alpha-acids	Beta-acids	Cohumulone	Powdery mildew-resistant
Aroma lines							
Hall. Tradition	1989	29,7	27	5,9	4,7	27,7	-
Perle	1989	29,5	26	7,2	4,2	31,9	-
Saphir	2001	24,5	27	2,9	5,6	12,8	-
83/069/008	2001	25,4	28	5,8	5,1	22,3	-
87/024/055	1997	34,9	26	6,2	5,2	13,4	-
87/024/056	2000	30,8	26	8,1	5,4	15,6	-
89/002/025	2001	27,2	27	8,4	6,4	22,0	
90/024/032	2000	33,5	27	5,5	8,7	18,4	-
91/013/025	2000	40,8	26	6,7	6,8	20,0	-
91/033/015	2000	25,1	27	6,2	3,4	16,6	-
91/059/025	2001	54,1	23	9,8	3,5	18,0	-
Bitter lines							
Hall. Taurus	1994	49,6	23	15,2	4,9	24,9	-
Hall. Magnum	1989	39,6	23	12,7	6,4	27,1	-
Hall. Merkur	1995	35,8	22	13,4	6,1	20,1	+
93/010/036	2000	58,3	23	13,7	5,2	27,5	+
93/010/063	2000	55,3	23	13,3	6,2	32,0	+
94/075/758	2000	51,0	21	15,7	7,7	22,5	+
94/075/761	2000	33,5	22	14,3	6,6	16,5	+
94/075/766	2000	50,8	21	14,8	6,8	28,3	+
95/094/721	2000	55,2	23	13,0	5,2	32,2	+
95/094/730	2000	54,7	23	12,6	5,0	26,3	+
95/094/766	1999	55,4	22	10,6	4,0	31,5	+
95/094/816	2001	56,6	22	12,6	4,4	38,7	+

Alpha- and beta-acids in % (dry weight basis)
Cohumulone in % of the alpha-acids

The production test on the farm of Schwarzmeier has been renewed to a large extent over the past few years. The findings obtained from this year's results has unfortunately been affected by copper. In addition the extensive precipitation reduced the already low pH-value in the upper layer of the soil. Through this copper was released and caused considerable damage to the plants in parts of the trial. Not only the yields but also the alpha-acid values were affected. In particular the aroma varieties and breeding lines were affected. In the bitter sector the variety Hall. Merkur showed the most harmful symptoms.

4.1.5.2 Testing the Huell breeding lines with low cohumulone values on the Busch farm in Huell

Table 4.12: Results of the 2002 crop

Line / Variety	Year of planting	Yield Ztr./ha	Aroma 1-30	Alpha-acids	Beta-acids	Cohumulone
Saphir	1994	39,8	27	4,4	7,7	11,8
83/069/008	1994	42,4	28	6,4	6,3	18,0
87/024/003	1994	43,1	26	8,6	6,3	13,9
87/024/055	1994	42,1	26	7,7	5,3	12,2
87/024/056	1994	51,7	25	9,6	6,1	13,0
89/002/025	1994	39,2	27	9,2	7,0	18,9
91/013/025	2001	48,0	25	9,5	7,9	15,0
91/033/015	2001	28,1	27	8,3	3,9	14,4
93/053/033	1999	45,0	25	8,6	7,8	20,4
93/059/005	1999	50,3	25	5,9	8,2	20,8
93/081/013	1999	51,3	26	6,3	6,9	20,7
93/088/003	1999	42,6	25	4,4	6,8	20,7
93/100/059	1999	31,1	23	13,1	9,3	18,0
94/075/240	1999	52,5	18	15,2	7,4	19,6
94/075/734	1999	48,4	23	10,8	7,4	17,7
94/075/758	2001	52,0	21	16,7	8,4	21,0
94/075/761	1999	40,5	22	15,1	6,5	13,7
96/001/024	2001	38,5	25	5,1	7,6	19,5
96/008/014	2001	49,1	25	6,2	9,7	17,1
96/030/011	2001	53,9	25	4,5	9,7	14,7
Glacier	2001	-	26	6,7	8,9	10,9
Horizon	2001	-	21	11,2	5,7	20,8

Alpha- and beta-acids in % (dry weight basis)
Cohumulone in % of the alpha-acids

In this test breeding lines, which do not fulfil the brewing requirements are constantly replaced by new ones.

4.1.5.3 Aroma and bitter lines on the Pichelmeyer farm in Grafendorf

Table 4.13: Results of the 2002 crop

Line / Variety	Yield Ztr./ha	Aroma 1-30	Alpha-acids	Beta-acids	Cohumu-lone	Powdery mildew-resistant
Aroma lines						
Saphir	42,6	27	3,4	6,7	11,8	-
87/024/055	53,1	25	7,6	6,1	13,3	-
87/024/056	40,7	25	9,4	6,4	13,9	-
90/024/032	30,7	26	4,8	7,7	17,5	-
91/019/001	35,4	26	3,0	4,8	34,1	-
91/020/045	31,3	28	5,8	6,2	21,1	-
92/011/068	35,2	26	4,0	7,0	26,1	-
Bitter lines						
Hall. Magnum	44,0	22	14,3	6,4	26,3	-
Hall. Taurus	44,6	22	17,8	5,9	22,4	-
Hall. Merkur	43,2	22	14,1	7,5	18,7	+
Nugget	57,2	21	12,7	5,4	28,0	-
Wye Target	59,2	19	12,2	6,2	36,3	+
90/061/009	51,0	22	10,2	7,2	27,4	-
91/045/021	61,3	21	16,1	5,3	21,3	-
91/059/025	39,3	24	11,1	4,9	17,2	-
92/085/766	32,4	17	15,0	9,8	19,8	-
93/010/004	66,0	22	14,6	6,0	29,1	+
93/010/017	65,9	21	13,3	7,0	22,0	+
93/010/034	65,6	21	15,6	5,6	24,5	+
93/010/036	59,8	23	16,4	6,3	27,7	+
93/010/063	59,1	22	14,3	6,7	31,2	+
93/010/063	58,5	23	14,1	7,2	32,7	+
93/024/733	61,7	20	12,8	5,5	31,0	+
94/075/758	40,6	21	16,8	8,9	21,4	+
94/075/758	57,9	21	16,1	9,3	22,0	+
94/075/761	68,7	22	14,8	6,6	15,6	+
94/075/766	56,7	22	15,0	6,3	26,9	+
94/075/766	43,6	22	15,3	7,2	27,2	+
95/094/721	68,5	21	12,6	5,5	32,3	+
95/094/730	70,4	22	14,4	5,7	27,8	+
95/094/730	52,8	22	14,3	5,9	27,8	+
95/094/816*	57,7	22	15,5	5,6	37,5	+
95/094/834	30,2	21	14,7	5,5	35,9	+
95/094/850	50,4	21	15,0	5,7	25,9	+

Alpha and beta-acids in % (dry weight basis)
Cohumulone in % of the alpha-acids
* planted in 2001, 1 wired trained per plant

4.1.5.4 Testing Huell breeding lines and varieties at the Thuringian State Institute for Agriculture

Table 4.14: Results of the 1998 – 2002 crops at the Apolda location

Line / Variety	Year of planting	Yield (Ztr./ha)				Alpha-acids			
		1999	2000	2001	2002	1999	2000	2001	2002
Aroma lines									
Perle	1988	50,2	34,0	26,6	31,3	8,4	7,1	7,4	8,2
87/024/055	1997	44,8	32,6	29,1	30,7	5,3	6,1	4,8	5,9
87/024/056	1996	48,6	32,6	25,9	32,2	7,6	8,0	8,3	7,7
91/059/025	1996	43,6	38,4	30,1	39,5	9,1	8,9	8,3	7,3
Bitter lines									
Northern Brewer	1988	43,0	29,0	30,4	37,5	9,3	8,6	7,7	8,1
Nugget	1988	53,0	49,6	29,2	46,8	9,8	12,7	8,9	10,8
Hall. Magnum	1992	55,2	40,8	36,0	35,5	13,7	17,1	12,9	14,0
Hall. Merkur	1996	47,2	41,8	35,2	34,4	13,0	15,5	12,8	12,0
Hall. Taurus	1996	28,4	-*	-*	-*	14,5	15,7	13,8	14,3
90/061/009	1994	37,6	26,2	27,1	29,0	8,6	11,1	13,6	12,7
93/010/004	1996	52,4	46,0	42,5	33,0	13,9	14,7	11,6	10,9
93/010/017	1996	53,8	45,4	37,6	40,6	11,9	12,2	12,7	11,7

Alpha-acids in % (dry weight basis)
*no crop recorded due to bad crown rot

10 promising Huell breeding lines were planted anew at the Apolda site in spring 2002.

4.1.6 Collecting and testing wild hops

4.1.6.1 The collection of wild hops

The collection of wild hops was continued in autumn 2001 with 15 new sources. Besides samples from all over Germany wild hops originating from Finland, Turkey and Japan were grown. Powdery mildew resistant plants could be selected in eight of the 15 new origins.

4.1.6.2 Testing the wild hops 2002

In March 2002 about 500 seedlings were planted out in an isolated hop yard, in order to test them over several years for their agronomical characteristics as well as resistance to disease, yields and components. The rest of the powdery mildew-resistant seedlings were given to other hop research facilities.

4.1.7 Breeding for powdery mildew resistance

4.1.7.1 Improved testing for powdery mildew resistance of seedlings in the greenhouse

In the spring of 2002 for the first time powdery mildew races with defined virulences were used for resistance testing in the greenhouse. At the beginning of February four powdery mildew isolates, representing the typical virulence spectrum for the Hallertau, were propagated by EpiLogic and prepared for inoculation in the greenhouse. Nearly 100000 seedlings from various crossings were tested from February to April in the greenhouse for their resistance to powdery mildew. By using powdery mildew strains with characteristic virulence properties, for the first time it could be guaranteed that testing was actually carried out with those races which are predominant in the Hallertau hop growing region. In addition to this, using powdery mildew isolates propagated in the laboratory the infection pressure in the greenhouse could be kept quite high. Therefore the selection of seedlings in the greenhouse was much more reliable and informative than in previous years. Also in February 2003 these powdery mildew isolates were again provided by EpiLogic and used for resistance screening of the seedlings in the greenhouse.

4.1.7.2 Extensive testing for powdery mildew resistance in the Huell breeding material – Tests in the greenhouse and in the laboratory

134 seedlings, breeding lines and varieties from abroad were tested in 2002 in the greenhouse. Parallel to this they were tested in the laboratory for their resistance to powdery mildew in the Petri dish using a specific powdery mildew infection and testing system that has been worked out by EpiLogic and the LBP. By being tested simultaneously in the greenhouse and in the laboratory, findings on resistance could be verified and - due to the EpiLogic testing system - also defined more precisely with regard to the effective resistance genes.

The four above-mentioned powdery mildew isolates were used as infection material for the greenhouse screening, in which testing was carried out for resistance to all the powdery mildew pathotypes occurring in the Hallertau. In the laboratory the Hallertau isolates as well as one from England were used for the resistance testing. With the English isolate the hops were tested for their resistance to the virulences v1 and v2.

In general, seedlings which are screened in the greenhouse are only a few weeks old and are test only for susceptibility or resistance. A very much more exact monitoring was carried out in the case of those 134 seedlings, breeding lines and varieties. The plants were tested twice for powdery mildew infection over a period of about one month. The criteria for the monitoring grades 0-9 are summarized in Table 4.15.

Considerable differences were ascertained in the reaction of the respective hop varieties or breeding lines to powdery mildew infection. Delayed development of symptoms, weakened intensity of infection, strong or slight sporulation on the hop leaves of the respective varieties / breeding lines are important observations which must also be taken into consideration when recommendations are given for specific use of fungicides for controlling powdery mildew in the field.

In the laboratory one pair of leaves respectively at the most sensitive stage (1st or 2nd nodes) were used for the powdery mildew resistance test. The evaluation criteria for hops susceptible or resistant to powdery mildew are shown in Table 4.16. The results of the resistance tests run parallel in the greenhouse and in the laboratory with the Petri dish

infection system in the case of the Hallertau powdery mildew isolates showed a very good concurrence (with only few exceptions).

It was very advantageous that tests could be made in the laboratory with powdery mildew pathotypes (e.g. isolates with v1 and v2 virulences) which have not yet occurred in Germany and have therefore never been used for testing in the greenhouse. Consequently compared with the greenhouse test, important new findings could be gathered on the effectiveness of the resistance when grown outside of Germany. Some breeding lines as well as varieties neither showed infection with the Hallertau races nor with the English powdery mildew strains and are therefore considered to be very promising in carrying new effective resistance genes.

Table 4.15: Assessment of the powdery mildew resistance in the greenhouse

Monitoring grade	Powdery mildew development on hop foliage
0*	no infection
1*	very little infection spots which only look slightly lighter
2	very few clearly visible infection spots without mycelium
3	more frequent infection spots, none or hardly any mycelium
4	few infections, white mycelium with little sporulation
5	many infections with clear mycelium formation and sporulation
6	many pustules with strong mycelium formation and sporulation
7	very many pustules and strong sporulation
8	very many pustules and strong sporulation, stems infected
9	extremely infected, growth affected

* classified as powdery mildew resistant

Table 4.16: Assessment of the powdery mildew resistance in the laboratory

Monitoring grade	Powdery mildew development on hop leaf in the Petri dish
0*	no infection
0.1*- 0.2*	10 - 20% of sporulation of susceptible reference variety(NB or HM)
0.3 - 0.6	30 - 60% of sporulation of susceptible reference variety(NB or HM)
0.7 - 0.9	70 - 90% of sporulation of susceptible reference variety(NB or HM)
1	strong sporulation, like susceptible reference variety

* classified as powdery mildew resistant

In every Petri dish test the leaf with the strongest symptoms of infection was given the monitoring grade 1 (= 100% infection), according to the reference variety („Northern Brewer“ or „Hallertauer Magnum“). The leaves of the genotypes being tested showed no visible powdery mildew infection or more or less strong attacks and then relating to the reference variety were assessed with the infection grade 0 %, 10 %, ..90 % and the monitoring grade 0 - 0.1 .. and 0.9. With an infection of ≥ 30 % of the maximum infection intensity of the reference variety the genotype is classified as susceptible to powdery mildew.

4.1.7.3 Wild hops as a very promising resource for new powdery mildew resistance

In recent years a very extensive wild hop pool has been built up in Huell. Due to its wide geographic origins (Europe, USA, Japan) this collection of wild hops is regarded as an important new genetic resource. After these wild hops were first tested for resistance to powdery mildew (*Sphaerotheca humuli*) and to the Peronospora (*Pseudoperonospora humuli*) in the greenhouse and in the vegetation hall, more than 1000 individuals showed resistance to these diseases.
A better characterisation and evaluation of these powdery mildew resistances found in the pool of wild hops should be made in a project sponsored by the Scientific Station for Brewing in Munich. Those wild hops which are so far classified as resistant will be tested in the Petri dish with various powdery mildew races of clearly defined virulences. Thus new kinds of so far unknown resistance genes should be identified which finally are available for crossing in and broadening the genetic basis for powdery mildew resistance in the Huell breeding material.

4.1.7.4 Use of the powdery mildew testing system in the Petri dish combined with powdery mildew isolates of defined virulence

The powdery mildew infection system established by EpiLogic and the LBP in the Petri dish in combination with the powdery mildew isolates is used in the most diverse tests linked with powdery mildew (Fig. 4.1).

The development of the powdery mildew infection and testing system and the production of the powdery mildew isolates has received financial support from the Scientific Fund of the German Brewing Industry within the scope of the project Wifoe-B52 b.

With all the tests shown in Fig. 4.1 an important contribution will be made to the resistance breeding as well as to the integrated plant protection. At present, a set of 13 different monosporic isolates of *Sphaerotheca humuli* from England, France, the USA and from the Hallertau growing area is kept as inoculation material. It is worldwide unique in its range. This set of pathotypes makes it possible to do tests on almost all the resistance genes so far used and known in hop breeding.

Figure 4.1:

The two components for many powdery mildew tests:

- **Powdery mildew infection and test system in the Petri dish**
- **Powdery mildew isolates with defined virulence properties**

Use

- 13 powdery mildew (PM) isolates with defined virulence properties as infection material for resistance tests in the greenhouse and laboratory

  Powdery mildew infection and testing system in the Petri dish + PM isolates

- for reliable and rapid resistance screening in mapping populations, breeding lines and wild hops
- to prove the effect of specific resistance genes
  - identification of still effective resistance genes for breeding
  - identification of new resistance sources in wild hops
  - identifying DNA-markers
- for infection and sensitivity studies of various development stages of hop foliage, flowers and cones to powdery mildew

4.1.8 Infection behaviour of the powdery mildew (*Sphaerotheca humuli*) to hops in various stages of development

The effectiveness in controlling powdery mildew must be improved. At the same time, the resistance breeding which for many years has been carried out very intensively at the Hop Research Institute, must be supported by a purposeful use of fungicides at the right time. In compliance with integrated plant protection it is therefore absolutely essential to collect detailed information on the infection potential of *Sphaerotheca humuli* on hops in various developmental stages. Only through extensive studies which are aimed at identifying the most sensitive leaf and cone stages, pesticides can be applied at the proper time. In order to identify highly sensitive phases during the vegetation period, leaves, flowers and cones in various stages of development were tested in the laboratory for their susceptibility to powdery mildew. These powdery mildew studies were based on the miniaturised infection and testing system in the Petri dish established by EpiLogic and the LBP.

The Scientific Fund of the German Brewing Industry provided financial support for working out the powdery mildew testing system and also made the necessary funds available for these tests for powdery mildew sensitivity (Wifö Project No. B 52 b).

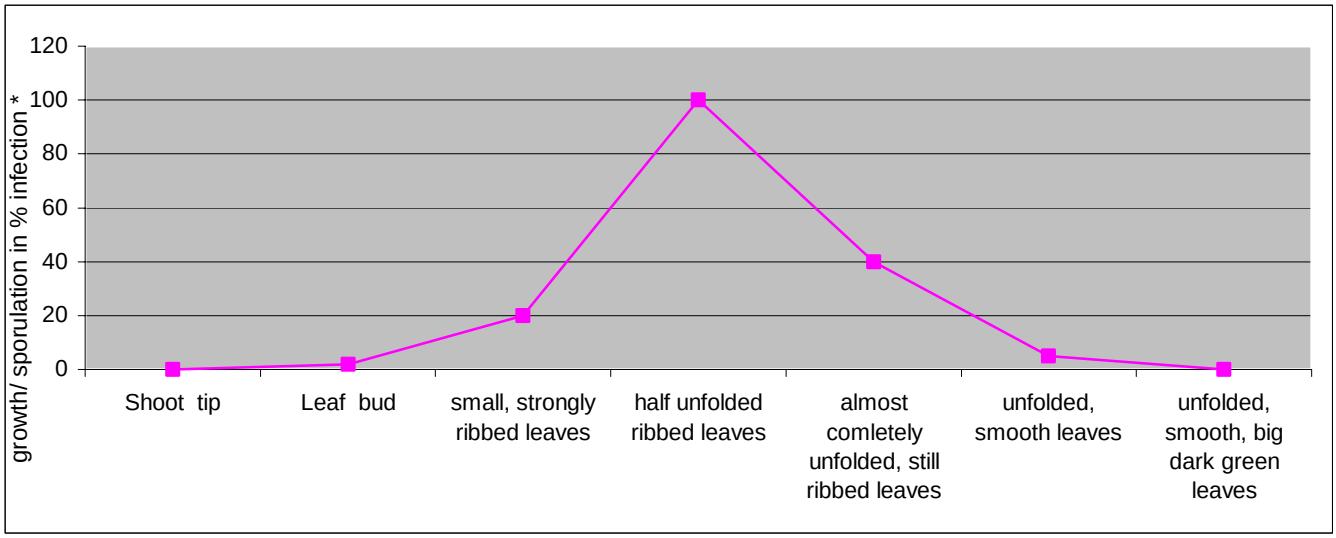
Each week from April onwards leaves and later on flowers and cones of the highly susceptible varieties "Northern Brewer“ and "Hallertauer Magnum“ were harvested from out in the field and artificially inoculated in the laboratory in the Petri dish with a powdery mildew isolate from the Hallertau growing region with defined virulence properties. After an incubation time of 8 days under standardised conditions the leaves, flowers or cones were scrutinised under the binoculars for growth of mycelium.

After two vegetation periods these tests showed quite clearly that particularly young leaves which had just unfolded are extremely susceptible to powdery mildew (Fig. 4.2). Probably the metabolically and physiologically highly active young leaves provide optimum nourishment and consequently good growth conditions for the parasitic powdery mildew fungus. In addition to this the thin cuticles and wax coating of the young leaves encourage the fungus to force its way in with its germinating tube. This would also explain why leaf infections are considerably reduced with increasing age and with stagnating growth and why older leaves can no longer be re-infected with powdery mildew.

Until the beginning of August flowers as well as cones could be infected with powdery mildew during each stage. On the other hand attendant infections in flowers and cones made it more difficult to gain accurate evidence on the first infection with powdery mildew. Here the practice observations were confirmed that flowers in every developmental stage due to the multitude of feathery stigma provide a huge surface area for the powdery mildew to attack and therefore represent the most susceptible stage. Also the insides of the cone bracts reacted particularly sensitively. From mid-August onwards a considerably reduced susceptibility to powdery mildew could be observed.

According to the findings in these susceptibility studies on leaves, flowers and cones preventive measures must be retained to control the powdery mildew. Fungicides must be used to control it at the latest when the first infections are visible on the foliage. The consistent use of plant protectives is appropriate particularly during the flowering stage right up to the formation of the cones. The findings on susceptibility in the bracts of the cones are of particular interest. As the outsides of the bracts more rapidly show a certain "age related resistance", it is possible to save on fungicides at the end of the vegetation period as far as varieties with good cone closure are concerned, such as "Hallertauer Taurus“.

Figure 4.2: **Powdery mildew susceptibility of the various leaf stages (May – June)**



*Infection in % relatively too highly susceptible leaf material

Young leaves which have just unfolded are extremely susceptible:

- Physiol. very active + thin cuticles / wax-coating → optimal for parasitic powder mildew.

From beginning of July even young leaves react less sensitively.

Literature:

Seigner, E., Seefelder, S., Haugg, B., Engelhard, B., Hasyn, S. and Felsenstein, F.G. (2003): Infektionspotenzial des Echten Mehltaus (*Sphaerotheca humuli*) in Abhängigkeit vom Entwicklungsstadium des Hopfens (*Humulus lupulus*) . Gesunde Pflanzen, 55 (2), 29-33.

4.2 Biotechnology and genome analysis

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

This research project started on 01.11.2001 is aimed at establishing an effective transformation method for gene transfer in hops. When such a method has been established, ultimately genes that confer resistance to fungi should be transferred into the hops. This work is being financed by the Bavarian State Ministry for Agriculture & Forestry.

Pieces of stem (= internodia) from four important hop varieties were successfully transformed with the help of suitable strains of agrobacteria and vectors with selectable markers and the GUS reporter gene system. Meanwhile from some transformation experiments plants could be selected and regenerated. However, so far only in the case of one hop variety several of the selected plants were tested as positive, i.e. as transgenic by means of GUS-colouring. Moreover, these GUS positive plants have been tested as been transgenic by PCR. All these hops have taken up the corresponding gene in their genome.

To improve the regeneration ability, the most diverse induction and regeneration media, i.a. mixed with antibiotics, were tested. Regeneration was solely via indirect organogenesis, i.e. callus was formed from which green shoots first appeared, which afterwards formed roots. Depending on each individual genotype and the media components between 7 and 30 little plants could be regenerated per explantat (average results from 6 experiments). The best regeneration rates were obtained with internodia from the "Saazer“ variety.

Regenerated hop plant with the GUS marker gene

Furthermore first experiments for the induction of embryoids were carried out for the production of genetically uniform plants. At the same time diverse phyto-hormone compounds were used, but so far no embryoids could be inducted and regenerated.

Outlook:

By means of Southern Blot and hybridisation, it must be checked to see whether the whole plants are transgenic and carry the specific gene (chimeric?). In addition, it has to be examined whether this gene continues to be inherited in a stable way.

For the other varieties the transformation-regeneration system must be optimised first of all. The regeneration of hop plants from tissue culture is however a difficult and extremely lengthy process.

Information on genes, which can convey resistances against fungal diseases is at present being gathered and evaluated. However, first of all basic research must be carried out here on the use and effectiveness of such genes in hops. So it cannot at all be expected that transgenic plants will be used in the field of hop breeding over the next years.

4.2.2 Genome analysis

4.2.2.1 Identifying powdery mildew resistance markers

This year in the gene diagnostic research in hops the focus was also on working out DNA markers closely linked to resistance genes that allow to identify powdery mildew (PM) resistant seedlings. Using molecular markers for various powdery mildew resistance genes seedlings can be selected straightaway very quickly and accurately. In addition DNA-markers enable to screen very effectively for stacked PM resistance genes. Within the scope of the project (Wifö-No. B80) "Development of molecular selection markers for powdery mildew resistance to support effectively the breeding of quality hops“ first of all mapping populations were constructed. Interim financing has been provided by the Hopfenveredlungsgesellschaft e.V., Wolnzach, now the project is sponsored by the Scientific Fund of the German Brewing Industry.
The crossings listed in Table 4.17 were carried out during summer 2001 and were available for the powdery mildew resistance test and for molecular analyses in 2002. In the mapping populations the segregation of two, at present in the Hallertau fully effective resistance genes was tested: the R2 gene of the English variety "Wye Target“ and its descendants and the RBu gene of the Slovenian variety "Buket“. In summer 2002 two crossings were also carried out with a powdery mildew resistant wild hop from the Eifel region. Next year using the progeny of this crossing DNA-markers for this wild hop resistance will be worked out.

Table 4.17: Segregation of the powdery mildew resistant genes into the mapping populations

Progeny from the crosses	No. of seedlings (F1-Pop.)	Phenotype resistant:suscep-tible		expe cted	χ^{2-}	PM isolate
Buket (RBu) x 96/09/01	**120**	**57**	**63**	**1:1**	**0.30**	**HU2**
Buket (RBu) x 97/36/05	**160**	**84**	**76**	**1:1**	**0.40**	**HU2**
Buket (RBu) x 98/27/731 (R2)	**131**	**103**	**28**	**3:1**	**0.92**	**HU2+E9**
Wye Target (R2) x 93/36/02	**120**	**67**	**53**	**1:1**	**1.63**	**HU2**
Wye Target (R2) x 96/09/01	**120**	**58**	**62**	**1:1**	**0.13**	**HU2**
84/008/24 (R2) x 98/044/049	**120**	**67**	**53**	**1:1**	**1.63**	**HU2**

In identifying markers for the resistance genes R2 and RBu it was the first time that the resistance assessment was based on the powdery mildew infection and testing system in the Petri dish established by EpiLogic and the LBP. This resistance test system provides much more reliable and informative resistance data for mapping populations and consequently better preconditions for working out markers closely linked to the resistance genes. In order to provide the most accurate information on the quality of potential resistance markers, various crossings with one and the same resistant individual were carried out. In order to verify identified R2 markers in a different genetic background an additional crossing was carried out using the female breeding strain 84/008/24, a powdery mildew resistant descendant of "Wye Target“.

From the approx. 6-8 week old hops grown from seeds in the greenhouse (mapping populations) in each case the youngest, completely unfolded pair of leaves was inoculated artificially with powdery mildew in Petri dishes. After eight days incubation time (22°C; 12-hour light/dark rhythm) the leaves of the seedlings were monitored and compared with the reference variety (highly susceptible leaf of the variety "Northern Brewer“, 100 % infected with powdery mildew) and classified as resistant (0-20 % infected) or susceptible (30-100 % infected). The test was repeated again three weeks later.

The powdery mildew isolate HU2 with defined virulence properties served as an inoculum for all seedling populations. Thus powdery mildew susceptible and resistant seedlings could be distinguished very easily. Besides HU2 the English isolate E9 has been used to differentiate clearly between the effect of the two different resistances in the crossing Buket (RBu) x 98/27/731 (R2).

Based on the resistance data provided by this petri dish testing out of the various mapping populations DNA pools with ten resistant or susceptible individuals were formed (bulked-segregant method). These DNA pools were screened with altogether 240 AFLP primer combinations for differences in the DNA banding pattern. So far three very promising markers for the Rbu gene were detected which could be found in almost all resistant seedlings from all three “Buket” crossings. According to the number of “false positive” individuals (DNA fragment lacking or present, which did not concur with the resistance monitoring) in the various crossings, the hit rate varied for the individual resistance marker. The concurrence between phenotypical and genotypical (DNA-marker fragment) powdery mildew resistance with the Buket marker RBu-279 is between 92 and 97 %, with RBu-284 between 91,7 and 92,5 % and with RBu-319 between 92,5 and 94,5 %.

It was also possible to work out a resistance marker for the R2 gene from "Wye Target“. On testing this marker in several mapping populations with the marker R2-181, in 92,5 or 96,9 % of the seedlings powdery mildew susceptibility or resistance could be proven successfully.

Among the descendants of the crossing "Buket“ (RBu) x 98/27/731(R2) individuals could be identified in the molecular analysis which carry no markers, which only show the R2-Marker or a combination of RBu- and R2 markers. If this result should be confirmed next year, this would be a decisive milestone in establishing marker-assisted selection in resistance breeding in hops.

In order to check the reliability of the powdery mildew resistance data monitored in the Petri dish, the seedlings were re-tested in the greenhouse in Huell. Due to the fact that the inoculum HU2 was obtained from a Huell powdery mildew infection and that these powdery mildew virulences from Huell also occur in the greenhouse, those resistance data in the laboratory concurred with those in the Huell greenhouse to 100 %.

4.2.2.2 Use of sex-specific DNA-markers

236 hop seedlings from various crossings of the year 2001 did not show any flowers until late autumn and so it was not possible to distinguish male and female hops. However this information was necessary to be able to separate the plants in the autumn and to transplant them according to their sex either to Huell or to Freising (hop yard with only males). Using two male-specific DNA-markers (an STS- and a RAPD-marker) for the identification of male hops it was possible to reach a decision in the laboratory within only few days. 81 male and 155 female plants were identified.

In addition to this, the molecular sex identification was carried out with 400 hop seedlings from various mapping populations. In this way, there was a time saving of one year.

A male hop had "crept in“ in a hop propagating facility. Among 100 plants which are used for the propagation, it was possible to identify the male hop very quickly with the help of the

typical male DNA fragment in the DNA fingerprint. This example from the practice shows the tremendous advantage of molecular markers. Without this quick marker diagnosis there would have been a considerable expense for the propagating facility. Either all the 100 hops of the variety to be propagated would have had to have been destroyed or otherwise after waiting a year the male hop would have been discovered and removed.

4.2.2.3. Verification of hop genotypes (trueness-to-type analyses)

For the hop industry DNA fingerprints were made from altogether 157 hop samples. Using the AFLP method it was possible to quickly ascertain the assignment to a specific variety or the sex. Besides ten AFLP primer combinations six hop micro-satellites were used in these analyses. The micro-satellites were worked out in one of the projects financed by the Scientific Fund of the German Brewing Industry.

5 Hop Production and Hop Advisory service

Georg Roßbauer, Dipl. Ing. agr.

5.1 Fertilization

5.1.1 Nmin tests 2002

Nitrogen fertilization in accordance with DSN (Nmin) has been introduced into the practice; it has become an integral part of the fertilizer planning. 3993 hop yards were tested in Bavaria in 2002 for their Nmin content and a fertilizer was recommended.
The development of a number of the samples for the Nmin test has been drawn up in Table 5.1.

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

Year	Number of samples	Nmin kg N/ha	Fertilizer recommended kg N/ha
1983	66	131	
1984	86	151	
1985	281	275	
1986	602	152	
1987	620	93	
1988	1031	95	
1989	2523	119	
1990	3000	102	
1991	2633	121	
1992	3166	141	130,0
1993	3149	124	146,0
1994	4532	88	171,3
1995	4403	148	126,6
1996	4682	139	123,3
1997	4624	104	146,7
1998	4728	148	118,5
1999	4056	62	166,6
2000	3954	73	157,7
2001	4082	59	162,6
2002	3993	70	169,0

With the aid of a computer a detailed recommendation for nitrogen fertilizer based on the Nmin content was compiled for the hop-growers for every hop yard tested. The soil samples for the Nmin test were taken between the end of February up to the end of March at a depth of 0-90 cm. As well as the content of nitrate (NO_3) and ammonium (NH_4) the crop yield, the type of soil as well as the green fertilizer and organic fertilizer, which the hop-grower has stated in the questionnaire are taken into account in order to calculate the fertilizer to be recommended. The nitrogen fertilizer is distributed according to the needs of the variety.
In Table 5.2 the number of hop yards tested, the average Nmin value as well as the average nitrogen fertilizer calculated from this has been compiled for the Bavarian production areas based on the administrative districts.

Table 5.2: Number, average Nmin contents and fertilizer recommended in the hop yards of the admin. districts and production areas in Bavaria 2002

Production area	Admin. district	Number of samples	Nmin kg N/ha	Fertilizer re-comended kg N/ha
Hallertau	Pfaffenhofen	1276	65,3	164
	Freising	400	78,0	169
	Eichstätt	282	82,5	150
	Kelheim	1617	69,7	173
	Landshut	276	59,9	174
Average	**Hallertau**	**3859**	**67,8**	**168**
Spalt	Roth	106	85,1	155
	Weißenburg-Gunzenhausen	0	0	
Average	**Spalt**	**106**	**85,1**	**155**
Hersbruck	Hersbruck	28	69,7	169
Bavaria		**3993**	**69,7**	**169**

In Table 5.3 the values are listed according to varieties.
Altogether Nmin contents were considerably lower in 1999, 2000, 2001 and 2002 than in the preceding years.

Table 5.3: Number, average Nmin contents and fertilizer recommended for various hop varieties in Bavaria 2002

Variety	Number of samples	Nmin kg N/ha	Fertilizer recommended kg N/ha
Columbus	2	47,1	187
Target	21	82,2	176
Nugget	119	51,9	176
Brewers Gold	10	59,8	174
Hallertauer Merkur	11	65,5	172
Hallertauer Taurus	332	64,4	172
Hallertauer Magnum	1024	62,6	172
Hallertauer Tradition	462	72,1	170
Record	1	69,6	170
Spalter Select	278	74,5	169
Sonstige	8	55,0	168
Hersbrucker Spät	333	71,2	166
Perle	815	77,8	165
Saphir	8	38,3	165
Hüller	3	83,6	165
Hallertauer Mfr.	278	62,9	161
Northern Brewer	236	83,1	159
Spalter	52	77,3	150

5.1.2 Trial with green compost

Green compost with a quality mark has been available for more than a decade for the organic fertilization of agricultural areas.
With the bio-waste regulation (BioAbfV) dated 21st Sept. 1998 a legal basis has been made to regulate the use of bio-waste on areas used for agriculture, forestry and horticulture.
In the spring of 1993 a trial was started in a hop yard in Engelbrechtsmünster in order to test the effects of fertilizing with green compost on yield, formation of components and soil parameters.

Important data on trials and location:

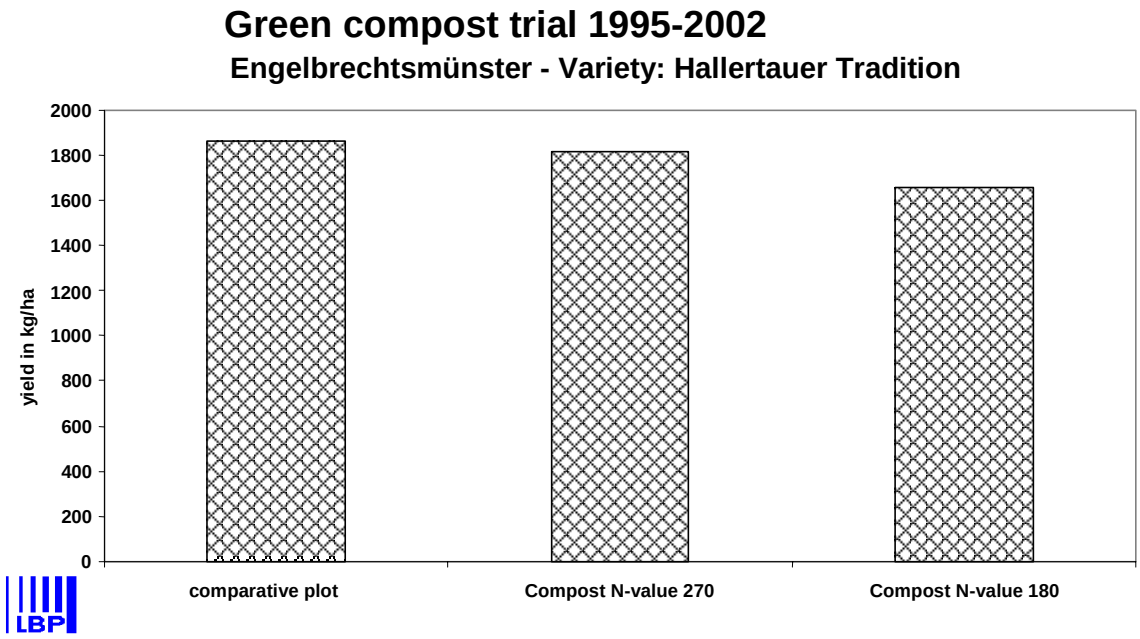
- 3 stages: N set value 270 without compost
  N set value 270 with compost
  N set value 180 with compost
- Fertilizing with green compost amounting to 20 m^3/ha annually. In P_20_5 content this corresponds to the annual amount extracted by the hops. For spreading reasons every second year 40 m^3/ha was distributed, that means altogether 200 m^3/ha between 1993 and 2001.
- Green fertilizer was regularly sown-in.
- Soil type: sand

Table 5.4: Results of soil tests 1993-2002

Soil test	Nmin kg/ha stage			PH value stage			P_20_5 mg stage			K_2O mg stage			MgO mg stage		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1993	-	-	-	5,5	5,5	5,5	23	23	23	24	24	24	11	11	11
1994	67	65	64	-	-	-	-	-	-	-	-	-	-	-	-
1995	74	62	69	-	-	-	-	-	-	-	-	-	-	-	-
1996	96	101	96	-	-	-	-	-	-	-	-	-	-	-	-
1997	91	82	90	5,2	5,5	5,8	22	23	28	24	26	33	6	10	11
1998	132	189	114	-	-	-	-	-	-	-	-	-	-	-	-
1999	76	55	80	5,6	5,8	6,0	21	22	20	23	18	19	9	7	10
2000	91	91	57	-	-	-	-	-	-	-	-	-	-	-	-
2001	47	53	47	5,7	6,1	6,3	20	17	24	15	15	17	10	10	14
2002	42	45	51	-	-	-	-	-	-	-	-	-	-	-	-

The nutrient loading of the green compost was gathered from the respective declaration which was attached to the delivery note.
With 20 m^3/ha and per year, on an average 40 kg/ha P_20_5, 48 kg/ha K_2O and 40 kg/ha MgO were distributed.
With mineral P, K, Mg fertilizers the required doses were balanced out by hand plot by plot after the soil test.
The nitrogen mineralisation was ascertained annually via DSN (Nmin). The Nmin value in kg N/ha was deducted from the N set value, the difference was fertilized with mineralised N in the form of lime nitrate of ammonium in three doses (beginning of April, end of May and end of June).

Diagram 5.1:



In Diagram 5.1 the average yield can be seen in the respective stages. Stage 3 clearly shows that as far as the N set value 180 is concerned, the N supply was not adequate for an optimum crop development. The crop development in the present trial is similar to the comparable field trials. Here too the addition of organic substance via green compost did not quickly result in a higher N mineralisation. The positive soil improving effect (developing humus, aggregate stability, soil microbiological activity etc.) and the N supply must be seen in the long-term.
The alpha content was not affected by the testing stages.
The trial is finished. The soil physical tests will be made in spring 2003. These results will be published in the Annual Report 2003.

5.1.2 Nutrient potential trial in Eschelbach: Effects of various P-, K-, Mg-, S-fertilization on soils with an optimum supply

In 1999 a nutrient potential trial was set up at the Eschelbach location to investigate which fertilization effects various phosphate, potash, magnesium and sulphur fertilizers have on the hop yield in a soil which has an optimum supply of these nutrients.

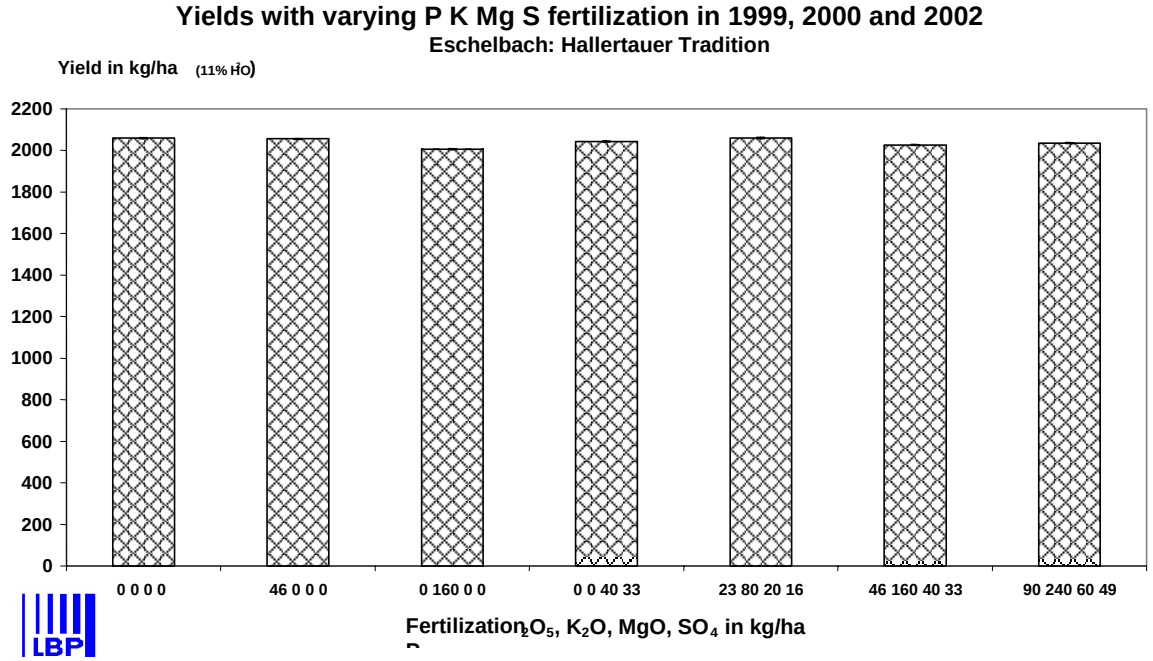
Location and trial data:
Type of soil: sandy clay
Hop variety: Hallertauer Tradition
Mineral fertilizer used: - super phosphate
- 60ies potash
- kieserite (MgO + S)

Table 5.5: Description of trial and soil test linked with it

Trial plot					Results of soil testing (CAL mg)											
Stage	Fertilizer kg/ha				1999				2000				2001			
	P_2O_5	K_2O	MgO	S	pH	P_2O_5	K_2O	Mg	pH	P_2O_5	K_2O	Mg	pH	P_2O_5	K_2O	Mg
1	0	0	0	0	5,8	7	21	10	4,9	11	21	6	4,9	9	17	6
2	46	0	0	0	5,8	7	20	10	5,1	9	22	6	5,2	11	21	7
3	0	160	0	0	5,7	9	23	10	5,4	10	31	7	4,9	9	23	6
4	0	0	40	33	5,3	8	19	9	5,2	5	16	8	5,0	8	24	11
5	23	80	20	16	5,6	10	23	10	5,7	7	21	7	5,1	10	21	8
6	46	160	40	33	5,4	8	22	10	5,9	6	27	8	5,2	9	27	9
7	90	240	60	49	5,5	9	24	10	5,1	7	34	8	5,1	10	31	9

The trial plots are planned with four repeats respectively and each plot is fertilized manually in the spring. The addition of organic fertilizers is not possible for the whole duration of the trial. Rape-seed is sown in all the trial plots annually and therefore organic mass is added which is nutrient neutral.
The farm uses nitrogen fertilizer according to the Nmin fertilizer recommendation with lime-nitrate of ammonium 27/0. With this it is guaranteed that no magnesium or sulphur additives affect the trial.
It was not possible to harvest this trial in 2001 due to a hailstorm.
As the variety Hallertauer Tradition was grubbed in autumn 2002 the crop results for 1999, 2000 and 2002 are shown in Diagram 5.2 as an interim report.

Diagram 5.2: Yields with varying P K Mg S fertilization in 1999, 2000 and 2002



The average yields show no significant deviations throughout all the fertilization stages. The same applies for the alpha acid values.
The interim results clearly show that with soil values of nearly 10 mg up to a good 20 mg according to the CAL method there is a high nutrient supply potential for optimum crops.

5.2 Corn borer in hops

In the seal district of Altmannstein, north of the Danube frequent attacks of the corn borer were found in hops of the 2002 crop. More reports came from Mühlhausen (seal district of Siegenburg), Engelbrechtsmünster (seal district of Geisenfeld), Oberlauterbach (seal district of Wolnzach) and Niederthann (seal district of Pfaffenhofen a.d. Ilm).
The corn borer statistics for Bavaria show that the Hallertau is meanwhile right at the centre of the area affected.

Plant damage
The corn borer, a butterfly with a wingspan of 25-30 mm, deposits its eggs at the end of June on the underside of the leaves on maize or hops. Two weeks later the larvae hatch out and bore into the upper part of the maize or hop plants. Due to the feeding damage in the hollow canal of the hop vines, the flow of juice is interrupted and the upper parts of the vines die off; this can be seen up to a length of four metres. Hop varieties with thin vines e.g. Perle or Hallertauer Tradition are more badly affected than hop varieties with strong vines such as Hallertauer Magnum or Hersbrucker Spät.

Ascertaining the race
The Federal Biological Institute, the Institute for Biological Plant Protection, Darmstadt has investigated corn borer larvae by means of PCR and compared them with larvae of other origins. The larvae sent in from hops or maize from the Altmannstein area can be classified according to the Z-race (monophag, *ostrinia nubilalis*); this is the race which almost exclusively causes the damage in maize. This race has recently started attacking hops as well.

Monitoring and gathering statistics
The monitoring carried out at the beginning of September showed that the corn borer larvae had bored into the remaining vine stalks just above the ground, in order to survive the winter. It was also clear in hops that the larvae avoid any contact with the ground as rivals in the form of fungi or bacteria are present in the soil.
The statistics gathered in 12 farms within the main area affected around the town of Laimerstadt showed that of 96 ha of hops 56 ha were damaged (5-25 % crop losses). The 40 ha which were assessed inconspicuous were mainly treated with the insecticide Baythroid 50 (active substance cyfluthrin) to control the aphid.
The warning issued by the Agricultural Office in Ingolstadt to control the corn borer in maize with insecticides was on 7th July, 2002 for the Altmannstein area. This date was very convenient as it fell in the period for the second aphid control in hops. Farm statistics and own monitorings showed that the active substances in the insecticide: imidacloprid (Confidor), pymetrozine (Plenum) und amitraz (Mitac) had no crucial influence on the development of the larvae, except for the pyrethroid Baythroid 50.

Phytosanitation measures
As a precautionary measure to reduce the attacks the following were recommended:
- transport chopped vines to farmland and plough them in
- cut vine stems off deep down and burn them.
- put pressure on maize growers to harvest maize stems and straw and plough them in deeply
- observe 2003 warning for maize and hops and control pest with chemical sprayings.

Target: To grow hops and maize without any special use of plant protectives to control the corn borer.

The last time there were reports about corn borer attacks was 50 years ago. Essential phytosanitation measures quickly solved the corn borer problem at that time too.

5.3 Low trellis yards

In the three-year research project sponsored by the Federal Ministry for Consumer Protection, Food and Agriculture (BMVEL) via the Federal Institute for Agriculture & Food (BLE) important research for growing hops in low trellis yards was carried out in cooperation with the Bavarian State Institute for Land Use Management (Now the Bavarian State Institute for Agriculture, Institute for Land Use Management, Construction & Environmental Technology). The experimental work was carried out at the Pfaffenhofen, Rohrbach and Gressau locations.
The most important results are summarized as follows:

Setting up the low-trellis yard

- The height of 3 m has proved its worth.
- The distance of 2.70 m between rows in the experimental plot at Pfaffenhofen is convenient for work. A further reduction making the distance between the rows of 2.50 m, as at the Gressau location, comes up against limiting factors for workability.
- Three kinds of masts were tested.
  Wooden masts are suitable, if the top ends of the trunk are not more than 8-9 cm in diameter, because the work of the picking machine is hindered by the the stronger masts.
  Metal masts, 6 cm thick, are suitable for the picking machine but they are very expensive and to some extent unstable.
  Concrete masts, 7.5 cm thick have proved to be very good; the cost is very reasonable.
- A height of 25 cm for the **lower span wire** has proved its worth. Compared with a height of 45 cm the growth of the shoots is considerably better, this facilitates training the hops.
- The best **distance between plants** for the traditional varieties is 0.8-0.9 m. It could not be ultimately fixed for the dwarf varieties. According to experience collected so far it could possibly be raised from 0.50 m to 0.60-0.70 m with 1-2 training wires per plant.
- Galvanized wire has been tried and tested as training wire. Here the number of shoots can be controlled best of all. By using a net considerably more shoots grow upwards; this results in too dense a stand with a reduction in yield.

Cutter

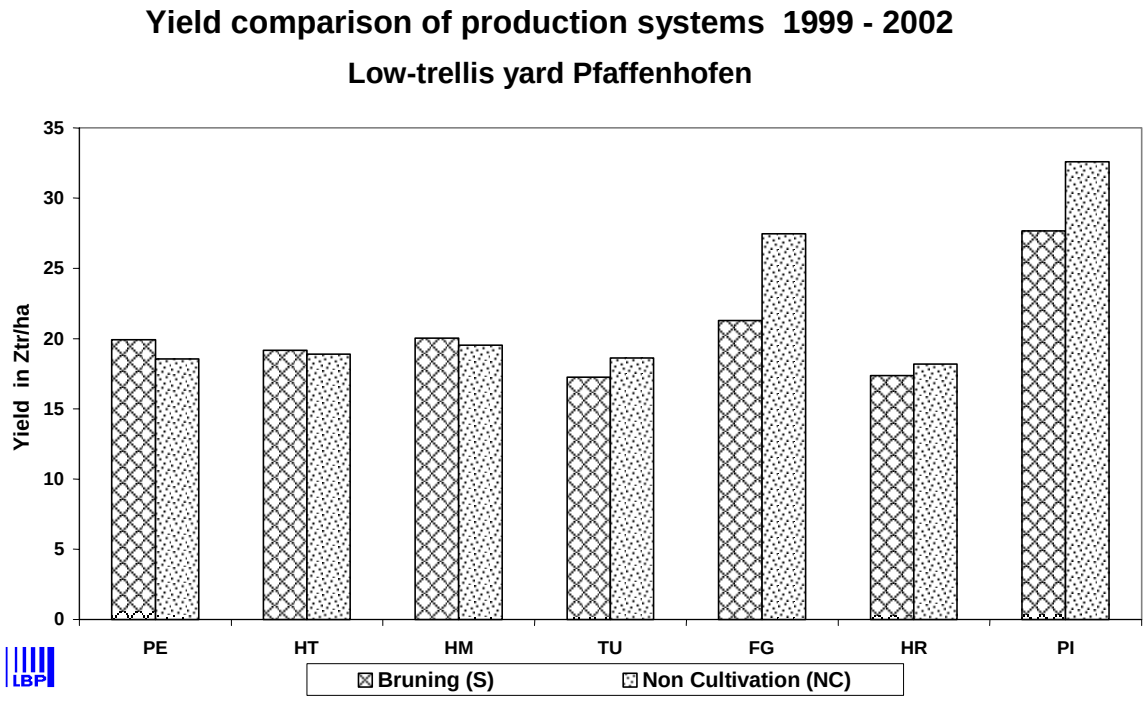
Special focus of the research project was on the development and testing of a cutter for low-trellis yards which works under a span wire of 25 cm. This was solved by the Landtechnik Weihenstephan. The newly developed cutter with only one disc-blade can carry out the pruning work with no problem underneath the 25 cm span wire. An extra developed sharpener speeds up the work and helps to avoid sharpening the blade too frequently. This provides the basis for pruning the vines under the lower span wire at a height of 25 cm and reduces the work in training them up the wires.

Diagram 5.3: **Cutter with one disc-blade for pruning low-trellis hops under the span wire**

Varieties

The research project has again shown that the traditional varieties bred for high-trellis yards are not suitable to be grown on low-trellises, because the lower yields do not allow an economic production. However, the content of alpha acids is higher than in high-trellis yards.
On the other hand the English dwarf varieties show that with special varieties a crop can be grown in which the profitability can be attained; the variety Pioneer e.g. in the course of the project could reach an average yield of 30.2 Ztr./ha.
The dwarf varieties used are not actually satisfactory as far as quality goes and therefore do not sell well, but they are a valuable basis for the breeding of suitable varieties.
Short growing, high-yield dwarf varieties which fulfil the quality requirements of the market are the prerequisite for the economic production of hops in low-trellis yards.

Diagram 5.4:



Production methods

- The non-cultivation method, when the pruning and soil work is omitted, has the advantage that it saves work; however a considerable disadvantage is that the spread of infection with peronospora and powdery mildew is considerably higher and in addition to this there is more weed growth and it is difficult to control it.
  Altogether the amount of plant protection in the non-cultivation method with about 206-233 €/ha is considerably higher than using the traditional method with pruning.
- Using the traditional method with pruning and soil work the spread of infection with peronospora and powdery mildew is reduced by pruning. At the same time, by sowing ground cover the weed growth is considerably reduced due to the various phases of soil work (ploughing, uncovering and pruning, hilling) and with sowing a catch crop between the rows (repeated grubbing). These measures result in savings in plant protectives.
  A disadvantage is the increase in work as well as a delay in sprouting due to the pruning, which with slow-growing dwarf varieties led to noticeable crop reductions. However, it has shown here that by pruning as soon as possible almost the same high yields were produced as in the non-cultivation plots without pruning. Therefore the advantages of this method can also benefit the dwarf varieties.
  Altogether the advantages are prevalent in the traditional method with pruning.

Tending

In trials within the scope of this research project it was seen that the work for training and thinning out cannot be reduced infinitely.
In various trials for training hops, even without help with training several shoots reached the training wire (up to 12 shoots), but with more than 3 shoots per training wire the stand was too dense and this resulted in crop reductions. This could be seen particularly clearly in the case of the training net.

To create the prerequisites for the highest possible yield no less than 2 and no more than 3 shoots should grow up each training wire. This must be controlled by training the hops up and retraining them. In addition to this the surplus lower shoots must be cut off and the lower shoots which grow later on must be removed by etching.
Due to the lower span wire at a height of 25 cm, the work of training the shoots up is made considerably easier.
However, at least 35-40 AKh/ha must be planned for tending the hops.

Fertilization
Compared with production in high-trellis yards the amount of fertilizer is considerably less in low-trellis yards. On an average during the trial year 40 kg N/ha fertilizer was adequate for an optimum yield, with phosphate, potash, magnesium and lime the requirements are about 40 % less than in high-trellis yards.

Plant protection and attacks of pests and diseases
The research project produced important findings on the attacks of pests and diseases. It clearly showed that the spread of common spider mite in low-trellis yards is considerably higher, caused by overwintering in the remaining vines and due to better chances of it spreading in the hop stands.
There was no difference in the spread of aphid attacks.
The infection with peronospora and powdery mildew differ more through the susceptibility or resistance of the respective varieties than through the difference between high- and low-trellis yards,

Plant protection methods
The methods of plant protection still need to be improved. A collector and a tunnel device were used. Both gadgets have advantages and disadvantages. The problems are in the technical handling and even distribution of the spray.
The reduced drift and the saving in plant protectives with the recycling devices are a considerable advantage in the low-trellis hop production.

Harvesting methods
The tractor-towed picking machine provided good picking results and picking quality. For use over a wide area there would need to be another dosing device to fill the cleaning machine.

Business aspects
A comparison of the costs shows that the variable costs for the production of hops in low-trellis yards in the traditional way with pruning are about 1164 €/ha and in the non-cultivation method without pruning about 1158 €/ha lower than in high-trellis production. This is particularly due to the lower labour and fertilizer costs as well as by omitting the annual hop-training wire.
The traditional varieties bred for high-trellis yards only attain a gross margin of 1000-1400 €/ha in low-trellis yards. This is insufficient to cover the fixed costs.
If on the other hand, with the variety Pioneer the price of a marketable variety is applied to the yield obtained in the trial, then there would be a gross margin which comes very close to economic production. Therefore the profitability of the low-trellis hop production depends on the availability of suitable varieties.

5.4 Tests with different harvesting times with Hallertauer Mfr.

Time and time again the optimum harvesting time has been a subject of discussion. At the same time the requirements can differ completely.

The following factors can be affected by the harvesting time:

- Yield
- Bitter contents (% alpha-acids)
- Aroma
- External quality (colour and lustre, defects, attacks of pests and diseases)

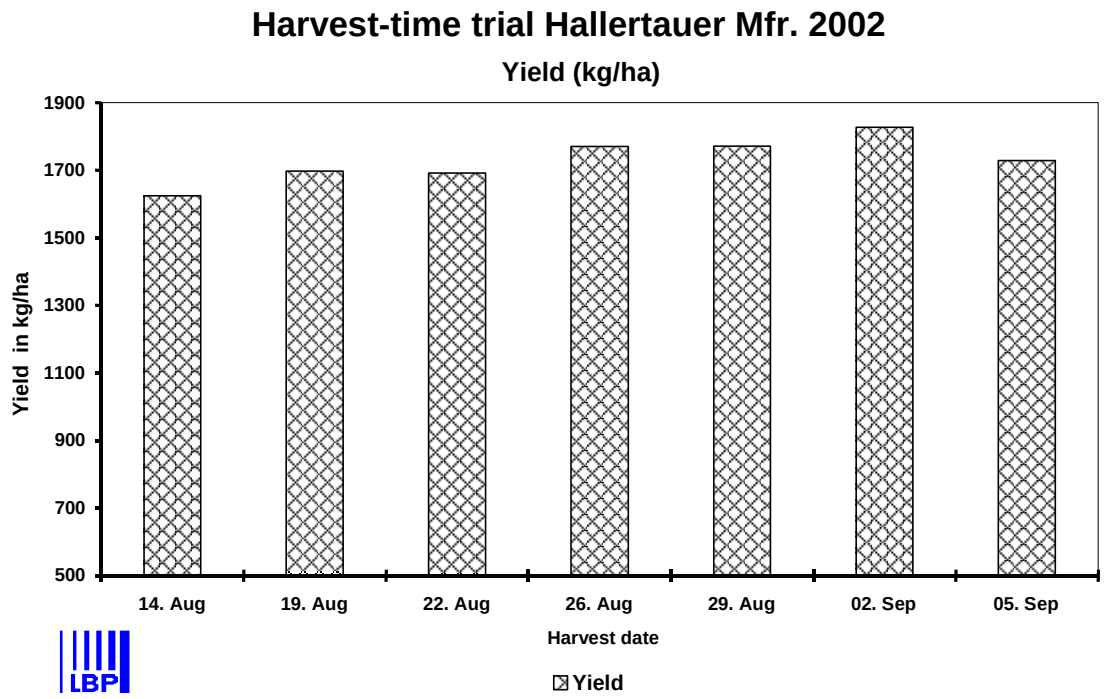
Since 2002 tests have been carried out to ascertain the optimum harvesting period in the case of the variety Hallertauer Mfr. At intervals of 3 days 20 training wires are harvested and evaluated at 9 times and repeated four times.

Table 5.6: Tests and methods carried out

Yield:	Green hops weighed in the plot, with the aid of a dried sample converted into dry weight into kg/ha with 11 % moisture content
Alpha-acid content:	Measuring the alpha-acid content with HPLC 2 weeks after the respective harvesting date, conversion into % alpha-acids with 11 % water content of the hops
Aroma:	Monitoring in compliance with the standard method of the Scientific Commission of the International Hop-Growers Convention (IHB) by 3 experts
Colour and lustre	as aroma
Defects:	as aroma
Infection with pathogen:	as aroma

The results of the first trial year with the variety Hallertauer Mfr. are shown in the following charts (Diag. 5.5 - 5.7).

Diagram 5.5:



The aroma was monitored by staff of the LBP Hüll and simultaneously by staff of the Anheuser-Busch Brewery. In doing so, the samples of the first harvest times were better assessed and the late harvesting times assessed a little lower by the staff of the Anheuser-Busch Brewery than by the staff from Hüll.

Diagram 5.6:

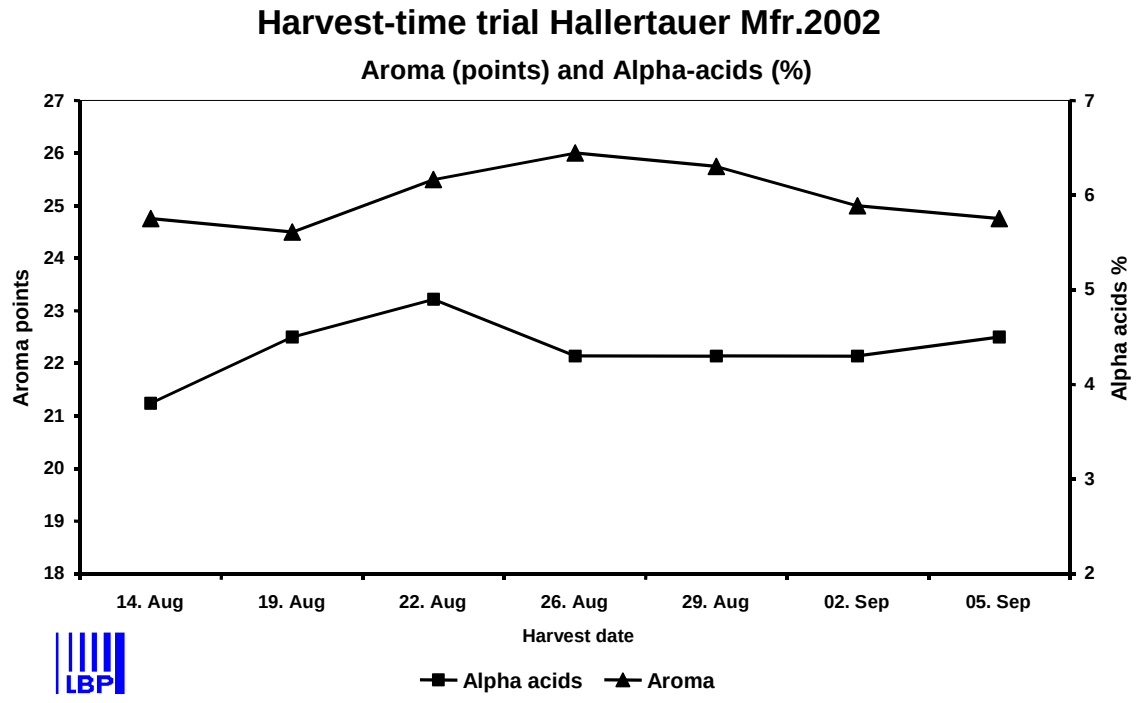
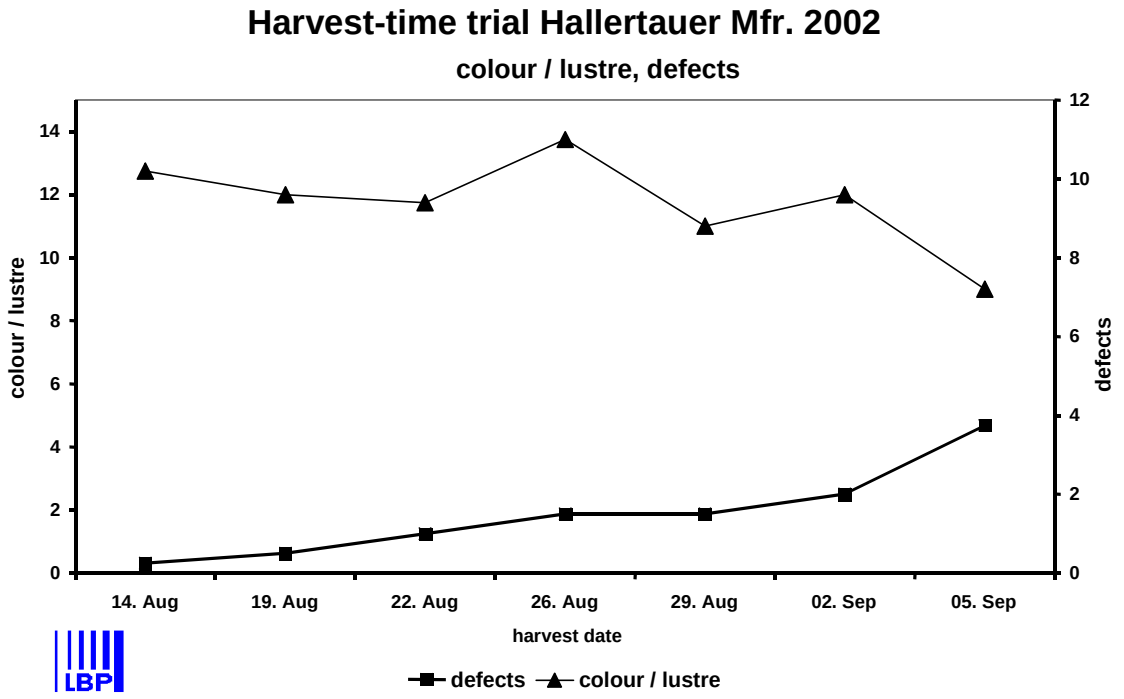


Diagram 5.7:



5.5 Optimum hop conditioning

Aims of the conditioning

- maintaining and ensuring hop quality
- gentle airing
- even homogenisation
- optimum hop moisture
- optimum airing time

In order to attain these aims, numerous trials and intensive measurements have been carried out in recent years by the H2 Hop Dept. to optimize the drying and conditioning of the hops.

Balancing the moisture by circulating air

The optimum moisture-content of the hops fresh from the kiln is between 9–10 %. By aerating the hops with circulating air, the various moisture contents of the inhomogeneous hops are balanced out and at the same time a moisture balance is obtained between spindle and bracteoles.

The duration of aeration depends on:

moisture content of the dry hops
evenness of the drying
height of tipping floor in the chamber

The aim should be to dry the hops in such a way that the required moisture content is reached immediately after they have been aerated with circulating air.

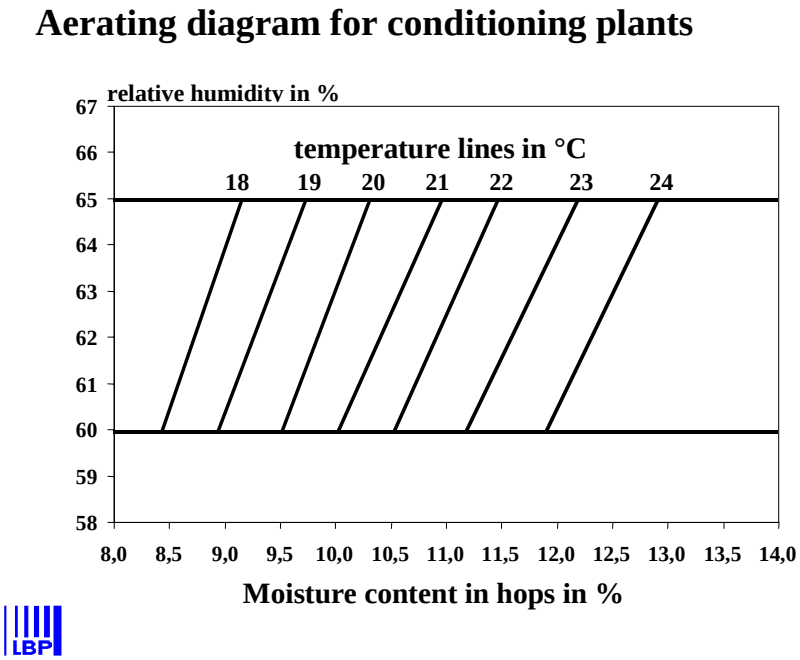
It is crucial to measure the aerating air in the incoming air channel
There is a connection between the relative humidity of the aerating air with the moisture content of the hops.
A relative humidity of 60-65 % in the aerating air corresponds to a moisture content of 9-10% in hops in the chamber. Due to this the moisture content of the hops in the chamber can be assessed when the hops are aerated with circulating air.

More gentle and more even after-treatment due to mixed air
If the hops in the chamber are too dry or too moist, the aerating air consisting of circulating air can be mixed if necessary with air with higher or lower humidity until the mixed air has reached the required humidity.

Temperature and relative humidity of the aerating air determine the hop moisture
So far the relative humidity of the aerating air was measured in the incoming air channel.
However with the same aeration times and the same relative humidity of the aerating air time and time again differing moisture contents of the hops were attained after aeration. The reason for this is in the different temperatures of the aerating air.

Optimum aerating air is between 18-24 °C and 60-65 % rel. hum.
With the aid of numerous measurements in the various conditioning facilities during the 2002 crop it was possible to compile an aeration diagram. This shows a connection between the moisture content of the hops and the temperature and the relative humidity of the aerating air.

Diagram 5.8:

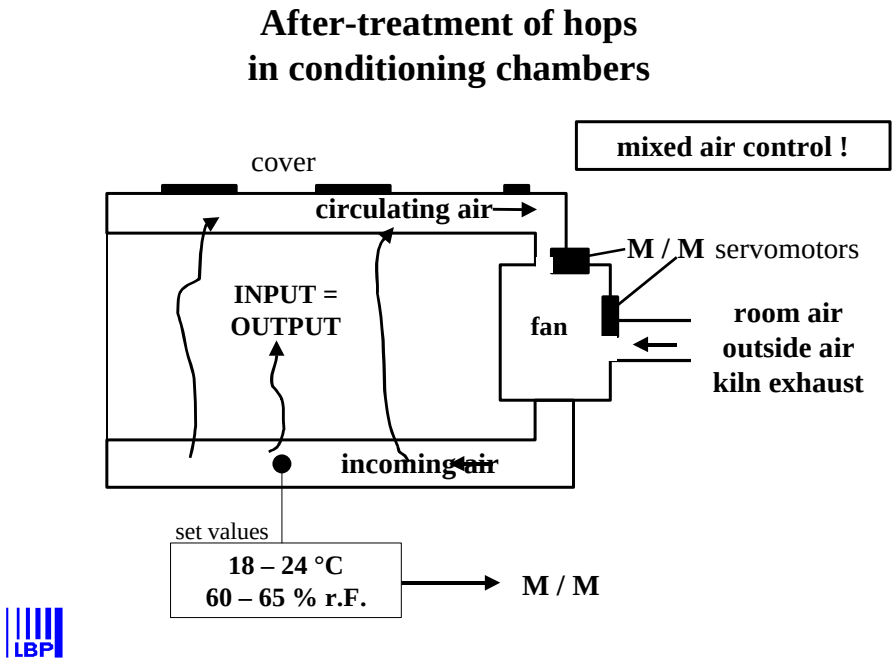


Regulating the mixed air
The temperature and the relative humidity of the aerating air is measured in the incoming air channel.
As required the air in the room, outside air or kiln exhaust is mixed in until the required temperature and relative humidity of the aerating air is reached.
This is controlled by means of air valves, automation is possible.
The hops undergo after-treatment through mixed air which is gentler, more even and is easier to control.

Notes on controlling aeration facilities

- Aim is optimum drying to 9-10 % moisture content
- Assessing the moisture content during aeration with circulating air
- Circulating air balances humidity, correct it with mixed air
- Optimum temperature range: 18-24 °C
- Optimum relative humidity: 60-65 %
- Do not considerably change temperature and relative humidity of the circulating air but only correct it! Chamber air is the main proportion of the circulating air!
- Temperature of the circulating air should correspond to the temperature in the chamber
- Documentation of the measurements of the aerating process in a conditioning protocol is very helpful
- When the hops are too dry, increase relative humidity of the aerating air step by step
- Once the aeration is finished the hops should be left in storage until they are put into sacks. It is very important to leave the aerated hops alone a while before pressing them!
- If the hops are aerated with an optimum temperature (18–24 °C), the stability of the cones with regard to disintegrating is considerably better than with cooler temperatures!
- Desired hop moisture is reached when INPUT = OUTPUT

Diagram 5.9:



5.6 Advisory service and training facilities

Besides the research work in the field of hop production, it is the task of the H2 Hops Dept. to put the results of hop research into practice through special advisory services, training facilities and talks at meetings. This also includes hop experts who provide support for the producer cooperatives.

A summary of the advisory activities are summarized as follows, in recent years increasingly new media have been used here.
The following up-to-date information is published in printed form:

- The "Green Pamphlet": Hops - production, fertilizers, plant protection, varieties - is updated annually together with the H1 Dept. as well as the Agricultural Offices (LwA) in Bavaria and the respective offices in the Federal States of Baden-Wurttemberg, Thuringia, Sachsen und Saxony-Anhalt, distributed by the LBP to the Agricultural Offices and also sent to all hop-growers in Bavaria by the producer cooperatives.
- Throughout the vegetation period, advice is sent as required (about once a week) via the cooperative-fax to the hop-growers participating.
- For the weather notes by fax, up-to-date information is also issued at weekly intervals.
- In the nitrogen fertilizer programme according to DSN (Nmin) the programme data is compiled and kept up-to-date and the results are monitored and despatched.
- Specialist information, notes on hop-growing and test results are available via the internet (Address: LBP.Bayern.de, New: LfL.Bayern.de).

The following information can be obtained by telephone:

- The peronospora warning service is compiled every workday by the H 2 Dept. in collaboration with H 1b and the agricultural offices and can be heard on the answer-phone (Tel. No. 08442/4041).
- The notes on hop-growing with up-to-date information on attacks by pests and diseases as well as on fertilization and working the ground can also be heard on the answer-phone (Tel. No. 08442/91 50 84).
-

In addition to this the hop growers can phone the hop-consultant directly regarding special problems and can obtain information by phone or can request advice on location; individual enquiries are already dealt with per e-mail.

Training courses and meetings round off the supply of information:

- Two meetings and a trial inspection for the consultants at the agricultural offices.
- Four training courses for the hop experts who provide support for the hop cooperatives
- 9 hop-growing meetings in conjunction with the agricultural offices in which approx. 50% of the hop farms in Bavaria take part, as well as other meetings for the "cooperative groups" and other groups
- Guided tours of the experimental yards in conjunction with the agricultural offices or the association of former agricultural students for the hop-growers and the hop industry.

Table 5.7: Advisory service and training facilities 2002

	No.	Tel.calls / participants
Consultations	4.809	
Cooperative fax	40	873
Notes on hop-growing for weather fax	12	
Notes on hop-growing - answer-phone	21	951
Peronospora warning - answer-phone	75	10.788
DSN (Nmin)	3.993	-
Hop-growing meetings / talks	34	1.802
Tours and training days	22	800

6 Plant protection in Hops 2002

Bernhard Engelhard, Dipl.Ing.agr.

6.1 Pests and diseases in hops

6.1.1 Alfalfa weevil (*Otiorrhynchus ligustici* L.)

Attacks by alfalfa weevil in the vegetation year 2002 can be called relatively slight up to average according to the location.
Basically it should be noted that the areas of infestation are increasing and the pest is appearing more and more frequently on sites with clay and clayey soils.
Ultracid 40 (no US tolerance) and Karate with Zeon Technologie (licensed in accordance with §18a) are available to control it.
Ultracid 40 and Karate with Zeon Technologie can be assessed in their effects with medium to good. When the infestation is considerable and the weather conditions unfavourable then they are not always satisfactory in controlling the pest and a follow-up treatment may be necessary.
The production of Ultracid 40 will be stopped and there will be a ban on its use from July 2003 onwards. Therefore endeavours must be made to obtain registration for other products.

6.1.2 Hop aphid [*Phorodon humuli* (SCHRANK)]

The migration of aphids in the Hallertau started very early on 13th May. Due to the early and unusually strong migration in many hop yards, the control threshold was often reached as early as the beginning of June. Through specifically targeted use of insecticides it was possible to keep these first attacks well under control. The weather conditions were optimum for a very good effect. The product Plenum 25 WP was used almost exclusively for the first treatment.
Altogether it was possible to control the aphid infestation effectively in the 2002 season. There are three reasons for this:

- the first spraying was a complete success
- the migration of winged aphids was finished as early as the end of June;
  it is normal to still find winged aphids during the whole month of July, which bring more infestation and
- due to the weather conditions and the extreme aphid development there were very many fungal and parasitic strains of aphids.

The control threshold of on an average 100 aphids per leaf or a maximum of 400 aphids on single leaves up to flowering was verified.
Unfortunately the product Confidor WG 70 was also in 2002 found to lack effectiveness as in the previous year. Therefore when using Confidor WG 70 it was generally recommended that it be mixed with another insecticide or acaricide.
Very good results were obtained particularly with mixtures containing Baythroid 50, although in recent years the resistance to pyrethroids was relatively high in the case of hop aphids.

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

Isolated spider mites were ascertained as early as the beginning of May, but which were kept under control by defoliating and removing the lower shoots of the hops. Again the infestation varied considerably from hop yard to hop yard.
The newly introduced control threshold also proved its worth in this season - provided that a meticulous inspection is made in each individual hop yard and the inspection complies with the strength of the attacks. The above-average temperatures in June and the occasional high temperatures in July resulted in an enormous rate of multiplication. If the attacks at the time of spraying were already too great, then the attacks could not be controlled with one spraying - second and third sprayings were necessary. Towards the end of the season the acaricides were no longer fully available.
The most important findings (not new but only verified again): Only the control of slight attacks leads to good success rates and consequently contributes to saving acaricides.

6.1.4 Minor pests

In previous years in tests it was found that the beneficial organisms in the hop yards is increasing. The plant protectives used are considerably kinder to such organisms and more selective than previous active substances. In hop yards it has been observed that also various other kinds of insects increase which can harm hop plants when they rarely occur in droves; this includes cicadas, thrips and various caterpillars. Particularly the hop leaves are damaged, more rarely the hop cones.
Flea beetles also appeared in 2002 depending on the location and have caused insect damage. The warm weather at the beginning of vegetation had a positive effect on the population development of the flea beetle.
The product Karate with Zeon Technologie (licensed in accordance with § 18a) is available in 2003 to combat the flea beetle, the wire worm and grey caterpillar up to a spraying height of 50 cm.

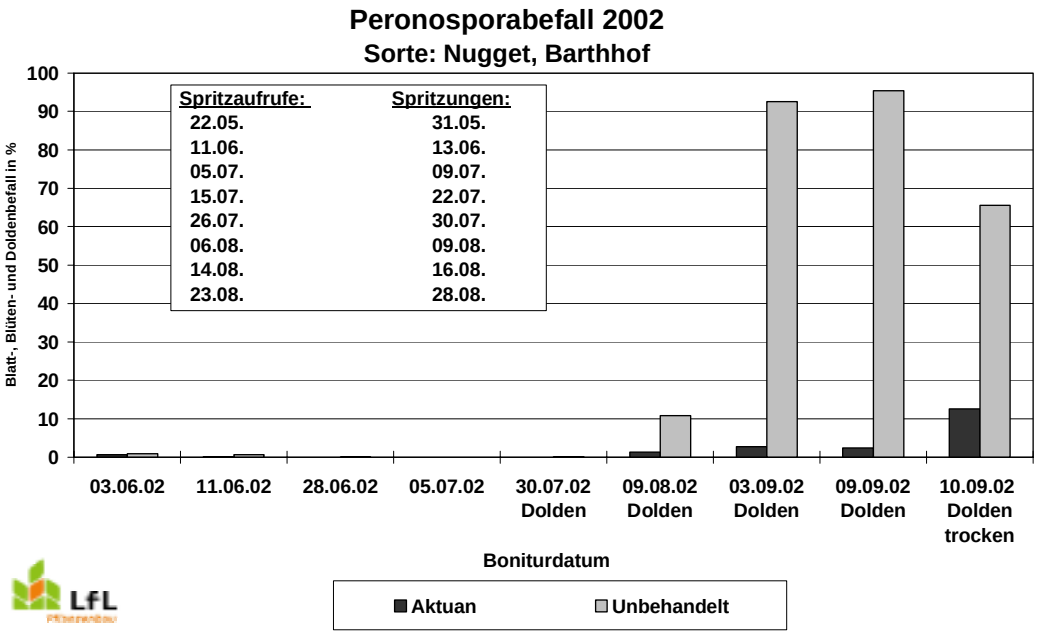
6.1.5 Peronospora [*Pseudoperonospora humuli* (MIY. et TAK.) WILSON]

Infestation development

On 22nd May the zoosporangia for the first time exceeded the threshold and a spray warning was given for susceptible varieties.
In the 2002 season there were altogether eight spray warnings, there were only four warnings for the tolerant varieties and one warning for the late ripening varieties. The total number of sprayings required were well over the mean average for many years.
Observations in untreated plots showed that perhaps one spraying could have been saved in the first half of the season. However, the spray warnings from 26th July onwards were fully justified and essential in their number and at short intervals. There was considerable damage to the hops in those hop yards, where the sprayings were not carried out,.
A problem is the sources of infection which could be eliminated with little effort:

- wild hops in hedges, banks and edges of woods
- peronospora infected breeding beds close to hop yards
- badly grubbed hop yards

Diagram 6.1: Peronospora attacks 2002 - Variety Nugget, Barthhof



6.1.6 Powdery mildew (*Sphaerotheca humuli* BURR.)

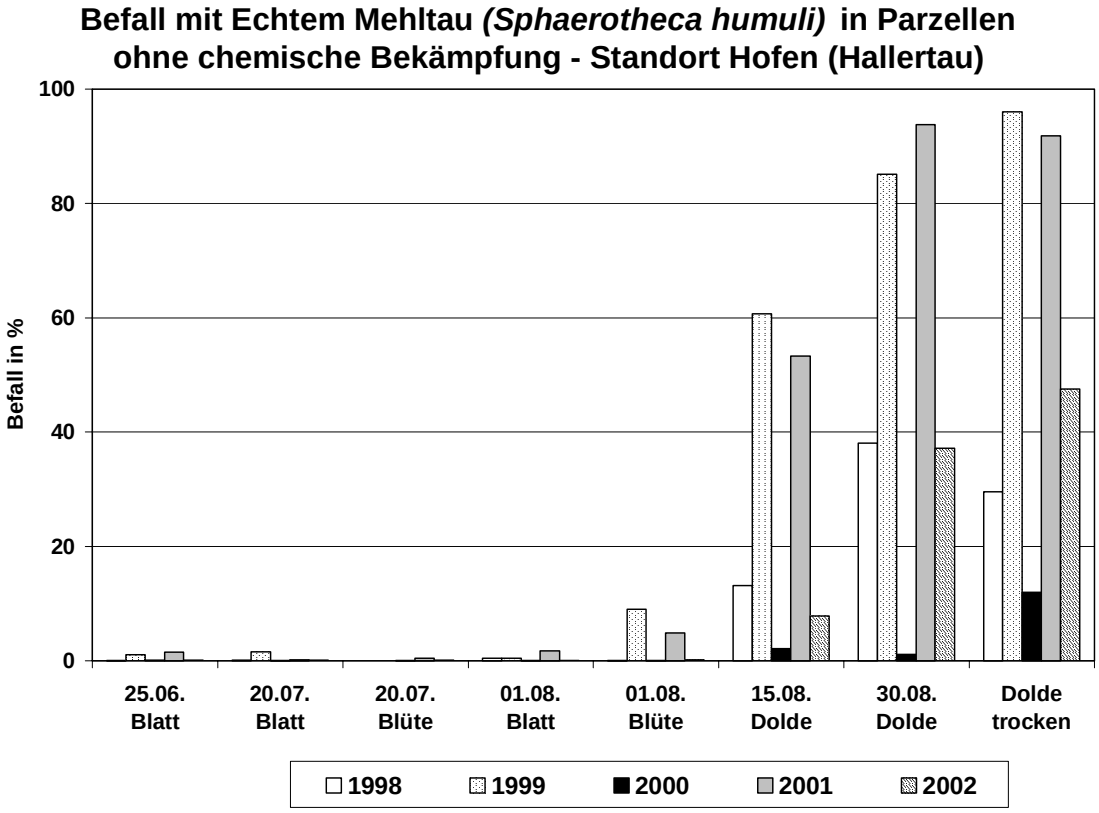
The powdery mildew appeared early at the beginning of May in different areas. As no fungicides are licensed which can control the already present attacks, this disease must be sprayed as a precautionary measure.
If sprayings are carried out too late or at too long intervals, the powdery mildew spreads out so much that it can no longer be brought under control and this results in considerable quality and crop losses.
There was a medium mildew infection at the testing location in Hofen.
(see Diagram 6.2).
It is essential to test and license more insecticides to control mildew in order to exchange the active substances in compliance with the resistance strategy. Whereas in cultivars like winter wheat the infection period is 4-6 weeks, in hops the mildew has to be kept under control for 3-4 months.

At present research is concentrated on ascertaining the time of the first infection. In addition to this:

- the cleistothecia (winter form) are being observed in climatic cabinets with various temperature conditions and

- under outdoor conditions young hop plants (April – June) are put under hop cones and hop leaves from the previous year which are badly infected with mildew. By regularly exchanging the young plants it should be possible to ascertain the time when the winter spores are released.

Diagram 6.2: **Attacks of powdery mildew (*sphaerotheca humuli*) in plots without chemical control - location: Hofen (Hallertau)**



6.1.7 Botrytis (Botrytis cinerea PERS.)

In recent years the spread of infection in the case of Botrytis has generally increased.
The Hallertauer Merkur confirms the high susceptibility for this disease ascertained during breeding. Indeed Hallertauer Magnum was badly infected again this year.
The infection occurred unusually late in 2002. So far symptoms had already become visible shortly after the cone development; in this season the extent of damage could only be seen shortly before harvesting.
No fungicide is licensed to control this disease in hops. Certain products (Ortiva, Folpan 80 WDG) have a side effect, but are not adequate for a full effect when there is widespread infection.

6.2 Mycological analyses

At the time of reporting 46 vine samples were analysed. One vine sample comprises 2-3 vines. These are dipped in ethanol 98 %, flamed off and cut in half lengthwise with a razor which has also been flamed off.
These halved vines are placed in dishes which are lined with damp filter paper and the lid is put on them.
After 3-5 days incubation at room temperature a mycellium develops which is analysed. When infected with verticillium some of them are inoculated on a culture medium and a single spore culture is started from this.

Table 6.1: Vine analyses 2002

Variety	No. of samples	Infected with			
		verticillium	fusarium	verticillium + fusarium	not infected
Magnum	2	-	-	-	2
Hallertauer Mfr.	16	5	-	-	11
Perle	8	6	-	-	2
Tradition	13	6	-	-	7
Hersbrucker	1	-	-	-	1
Northern Brewer	1	-	-	-	1
Taurus	3	3	-	-	-
Select	3	-	-	-	3
Merkur	6	1	-	-	5

6.3 Virusfree plant stocks

4368 plants were tested for virus in 2002.

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

- **Propagation nursery: Eickelmann**
  616 mother plants tested for ApMV and HMV
  of which: 16 Hersbrucker
  97 Hallertauer Magnum
  19 Hallertauer Mittelfrüher
  99 Hallertauer Merkur
  92 Perle
  4 Spalter Select
  30 Hallertauer Tradition
  40 Hallertauer Taurus
  164 Saphir

  56 young plants tested for ApMV and HMV for check

- **Hallertau cooperative**
  534 ApMV for B-certificates and verifications

- **Hallertau cooperative for Busch farm**
  336 ApMV and HMV

- **Own tests**
  67 ApMV
  153 HMV

7 Quality, Chemistry and Technology of Hops

Dr. Klaus Kammhuber, Dipl. Chemist

7.1 Introduction

Years ago the hops were only assessed by hand and sensory evaluation. With the arrival of modern analytica the analytic data gained more and more importance. Of all the components in hops primarily the alpha-acids are of greatest interest for the brewer. The use of beta-acids as a preservative in the food industry is being researched at the present time. In the sugar industry it has been investigated whether hop products can fundamentally be substitutes for formalin. The essential oils are responsible for the flowery herbal flavour in beer, in particular linalool is regarded as an indicator for a good hop aroma (Dissertation D. Kaltner).
The polyphenols have a high positive potential for health as they represent natural anti-oxidants and can catch free radicals. Xanthohumol has particularly aroused considerable public interest in recent years. Even the Cancer Research Centre in Heidelberg has carried out preliminary tests with xanthohumol.
All the analytic tests needed to support the research problems put by the Hops Dept. will be carried out in Section H1.

7.2 Breeding programmes

As in previous years the breeding in Hüll in 2002 also complied with the criteria which were laid down on 17.01.1997 during a discussion on "Strategies in the variety policy in hops and hop breeding aims“.

Breeding aims

- **Aroma varieties**

As for the aroma varieties, those varieties with the characteristics of the Saaz group are required such as Spalter Select, which guarantee crops of 40 Ztr./ha as well as definite alpha-acid contents of 4 % with a low cohumulone content.

- **Bitter varieties**

As for the bitter varieties, the aim is to breed noble and high-alpha varieties such as Hallertauer Magnum and Hallertauer Taurus with improved mildew resistance. At the same time high-yield varieties with alpha-acid contents of 12 – 13 % and good resistance characteristics should be bred.

7.2.1 Breeding programme for aroma varieties

Test results of some of the aroma lines of the 2001 with criteria of the Saaz group crop are summarized in Table 7.1 in comparison with the varieties Spalter Select, Spalter and Tettnanger . Some of the breeding lines have an alpha-acid content of almost 10 % with cohumulone proportions of less than 20 %.

Table 7.1: Breeding lines with criteria of the Saaz group, alpha-acid contents over 4 % and low cohumulone contents, 2001 crop

Breeding line	Myr-cene	2-M.-iso-butyrate	Sub. 14b	Sub. 15b	Lina-lool	Aroma-dendren	Unde-canone	Humu-lene	Farne-sene	□-Muu-rolene	ß-Se-linene	α-Se-linene	Cadi-nene	Selina diene	Gera-niol	Alpha-acids	Beta-acids	beta: alpha	Cohu-mulone	Colupu-lone
Spalter Select	2650	77	38	9	101	27	25	245	28	16	48	45	23	62	0	4,57	4,43	0,97	20,7	41,6
Spalter	3178	3	3	5	24	0	13	282	57	9	3	2	18	0	0	5,31	5,67	1,07	24,9	42,3
Tettnanger	2831	6	4	5	35	0	14	297	45	10	4	3	19	0	0	4,87	5,10	1,05	24,5	41,7
87/024/003	5197	51	14	22	36	3	6	235	21	6	3	3	16	20	0	7,46	6,44	0,86	14,7	34,6
87/024/067	1908	102	16	11	47	2	9	222	23	12	4	2	19	0	0	7,39	5,97	0,81	15,3	39,3
89/002/025	4955	93	3	8	36	0	7	200	62	7	2	2	15	0	0	9,04	7,29	0,81	18,0	50,4
93/053/033	895	122	7	5	24	0	20	304	30	12	4	2	21	0	0	6,12	6,24	1,02	19,5	39,7
93/059/005	3971	74	12	7	45	4	13	304	54	8	3	2	15	0	0	4,44	6,64	1,50	21,2	40,8
93/081/016	2719	70	13	5	40	4	10	282	45	8	1	1	16	0	0	4,25	6,67	1,57	19,5	39,3
93/092/006	1435	3	7	3	38	7	24	330	20	11	4	3	20	0	0	4,56	4,32	0,95	19,2	40,1
94/022/067	1066	5	10	3	10	0	4	293	25	8	3	2	16	0	0	4,30	2,81	0,65	17,4	36,9
94/075/720	5814	171	5	12	16	4	10	119	22	7	52	59	14	0	0	9,26	8,45	0,91	14,8	34,9
97/014/009	1941	199	4	3	44	0	19	288	30	9	4	5	19	2	0	8,12	7,13	0,88	17,5	39,3
98/004/007	2994	143	6	10	62	3	14	308	41	10	4	2	21	0	0	4,81	4,66	0,97	23,1	45,2
98/028/719	2370	16	6	10	30	1	7	239	23	9	3	2	16	0	0	4,08	3,73	0,91	25,7	46,8
99/012/001	736	19	2	5	15	14	13	187	26	11	21	21	17	34	0	6,15	2,26	0,37	22,7	46,8
99/015/026	2261	19	28	11	11	5	36	301	47	9	3	2	19	0	0	8,49	8,25	0,97	17,5	38,4
99/025/021	1317	21	4	2	26	21	16	229	29	11	27	28	18	50	0	7,38	4,33	0,59	22,8	43,9
99/036/003	1935	127	27	3	34	0	17	40	36	6	188	196	14	0	0	6,73	3,38	0,50	25,7	46,2
99/038/704	3252	98	228	13	42	10	31	329	26	12	14	8	26	6	11	6,29	5,06	0,80	23,0	41,6
99/038/716	3759	36	72	31	16	5	23	308	33	9	6	4	19	0	0	7,23	4,00	0,55	24,1	46,5

Essential oils = relative values, beta-caryophyllene = 100; alpha- and beta-acids in % as is ; Analoga in % of the alpha and beta-acids

7.2.2 Breeding programme for bitter varieties

Table 7.2 shows breeding lines with high alpha-acid contents above 12 % and cohumulone proportions of less than 25 % compared with Hallertauer Magnum, Hallertauer Merkur and Hallertauer Taurus at various locations (2001 crop). Of all the commercially grown varieties the variety Hallertauer Taurus has the highest alpha-acid content on an average followed by Hallertauer Magnum and Hallertauer Merkur. The alpha-acid content of the variety Hallertauer Merkur is somewhat less than in the variety Hallertauer Magnum. However, the variety Hallertauer Merkur is marked by a very low cohumulone content for a high-alpha variety and good resistance to mildew. In the breeding material there are also other very promising lines, which show high alpha-acid contents with low cohumulone proportions.

7.3 World hop range

This test programme is carried out annually. The aim is to determine the quality- and variety-specific components of the available domestic and foreign hop varieties when grown under the site conditions in Hüll. Table 7.3 shows the results of the crop year 2001. It can be used to assign unknown hop varieties to a specific variety type.

Table 7.2: Breeding programme "Bitter varieties", 2001 crop

Variety/breeding line	alpha-acids	beta-acids	beta:alpha	cohumulone	colupulone
Hallertauer Magnum	16,47	8,07	0,49	24,5	44,5
Hallertauer Magnum	16,05	5,01	0,31	20,5	44,2
Hallertauer Merkur	16,16	5,48	0,34	18,4	42,7
Hallertauer Merkur	14,15	6,84	0,48	16,4	40,7
Hallertauer Taurus	17,04	5,11	0,30	21,9	45,6
Hallertauer Taurus	16,39	5,46	0,34	20,7	41,8
84/012/019	12,40	6,55	0,53	24,7	47,6
91/045/021	12,03	4,16	0,35	21,1	41,8
92/085/766	15,69	9,17	0,58	17,8	40,0
93/005/020	12,12	5,94	0,49	19,1	41,0
93/010/034	12,75	3,81	0,30	22,0	41,4
93/025/701	13,10	7,56	0,58	22,1	44,2
93/026/706	12,30	4,83	0,39	21,7	42,9
93/034/765	13,28	4,05	0,31	23,4	43,5
93/100/059	15,54	9,82	0,63	16,6	39,6
94/057/779	13,83	4,69	0,34	21,6	42,3
94/074/025	15,05	5,15	0,34	22,8	45,5
94/075/758	16,04	7,84	0,49	19,3	39,1
94/075/761	16,20	6,45	0,40	15,1	31,5

Table 7.2 continued

Variety/breeding line	alpha-acids	beta-acids	beta:alpha	cohumulone	colupulone
95/066/003	13,35	6,78	0,51	23,8	44,1
95/083/769	14,36	4,01	0,28	23,2	48,6
95/093/702	19,36	4,85	0,25	23,4	44,0
95/094/850	14,31	4,72	0,33	24,6	45,0
95/096/008	15,24	5,40	0,35	15,0	36,7
95/099/748	12,36	5,26	0,43	24,6	45,0
95/103/735	16,72	5,84	0,35	22,5	44,6
95/110/747	15,17	4,96	0,33	20,2	42,9
96/069/037	13,36	5,10	0,38	20,3	39,3
98/057/011	12,29	4,16	0,34	17,1	36,7
98/064/715	12,58	4,75	0,38	22,9	44,0
98/087/015	14,30	6,17	0,43	24,7	49,2
98/094/002	13,96	6,21	0,44	23,1	45,6
98/097/704	13,79	5,41	0,39	22,1	46,1
98/101/710	12,46	3,69	0,30	23,2	47,8
98/103/021	13,61	4,99	0,37	17,6	35,6
98/105/727	16,04	5,33	0,33	22,4	48,9
98/106/733	13,91	6,95	0,50	19,3	41,5
99/038/012	12,80	4,51	0,35	17,7	36,2
99/041/001	14,46	3,65	0,25	21,5	41,4
99/055/013	13,58	3,99	0,29	24,4	48,5
99/056/021	15,35	4,77	0,31	24,1	44,1
99/060/011	17,74	5,40	0,30	24,2	45,5
99/060/016	12,94	3,51	0,27	19,9	44,9
99/061/009	19,25	4,43	0,23	18,3	36,0
99/062/735	17,20	4,39	0,26	23,1	43,6
99/065/004	16,56	4,01	0,24	19,1	37,1
99/066/705	14,44	4,21	0,29	22,8	43,6
99/067/715	12,10	4,86	0,40	24,1	48,7
99/070/019	13,46	4,04	0,30	21,2	41,9
99/075/729	12,99	4,77	0,37	17,3	41,3
99/082/726	13,92	6,22	0,45	22,9	48,0
99/084/705	12,59	3,68	0,29	21,0	46,0
99/086/021	13,06	3,77	0,29	22,9	45,1
99/090/003	13,73	5,61	0,41	24,5	50,7
99/093/718	17,84	5,77	0,32	23,6	48,6

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

Table 7.3: World hop range, 2001 crop

Variety/ Name	Myrcene	2-M-iso-butyrat	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendren	Unde-canon	Humu-lene	Farne-sene	□ -Muu-rolene	ß-Seli-nene	α-Seli-nene	Cadi-nene	Selina diene	Gera-niol	alpha-acids	beta-acids	beta: alpha	Cohu-mulone	Colu-pulone
Ahil	4432	361	36	4	18	3	7	189	55	8	8	6	16	2	0	9,38	4,02	0,4	32,5	55,5
Alliance	1097	80	1	1	20	0	5	293	6	9	4	3	18	0	0	4,56	2,62	0,5	31,6	53,0
Alpharoma	1747	192	26	15	14	5	16	321	13	12	20	19	20	0	0	7,16	2,92	0,4	25,6	50,9
Apolon	2750	61	39	5	23	0	3	199	35	8	8	5	15	0	2	6,25	3,43	0,5	26,7	48,1
Aquila	3386	70	4	105	24	45	19	14	0	13	75	73	14	106	4	5,66	3,85	0,6	50,2	72,7
Aromat	1997	28	5	7	42	0	18	315	19	11	12	8	23	0	0	3,62	4,41	1,2	23,3	40,6
Atlas	2922	606	27	8	20	0	3	178	33	8	10	7	14	0	4	6,40	3,46	0,5	40,4	63,0
Aurora	8012	178	5	38	51	0	21	217	40	6	2	2	11	0	0	9,47	4,15	0,4	21,8	50,1
Backa	1697	451	4	13	26	0	8	291	14	11	4	3	21	0	2	7,93	5,93	0,7	42,2	64,2
Belgischer Spalter	2050	112	2	8	27	9	9	172	0	10	35	37	16	54	0	4,47	3,26	0,7	25,4	49,1
Blisk	4589	221	31	6	24	0	9	195	92	8	6	5	15	2	0	9,82	4,00	0,4	32,8	57,3
Bobek	7734	91	17	62	58	0	23	269	35	8	3	2	14	0	0	6,25	5,43	0,8	23,0	44,4
Braustern	3273	93	2	34	11	0	5	260	0	8	2	2	16	0	0	8,30	5,10	0,6	25,4	47,7
Brewers Gold	1415	313	11	8	15	0	1	180	0	8	9	8	15	0	0	5,84	3,88	0,6	41,7	68,3
Brewers Stand	19871	985	45	54	77	33	20	44	0	71	95	87	123	116	8	7,64	4,53	0,5	28,9	51,1
Buket	3795	235	4	57	35	0	18	252	18	10	4	3	18	0	0	7,96	4,10	0,5	21,8	52,9
Bullion	1259	213	19	11	16	0	2	170	0	9	10	9	16	0	0	5,41	4,32	0,8	38,6	63,6
Cascade	4369	430	39	12	27	0	8	264	17	13	17	12	25	0	0	5,21	4,96	0,9	34,6	52,5
Chang bei no 2	2147	24	7	3	36	0	18	267	12	10	19	18	18	23	0	4,21	4,38	1,0	21,1	42,5
Chang bei no 1	2006	23	7	4	39	0	15	263	11	10	18	19	18	25	0	4,15	4,39	1,0	20,6	41,8
College Cluster	1039	223	22	9	9	0	5	170	0	7	8	7	13	0	0	5,37	1,86	0,3	28,3	49,1
Columbia	621	30	24	3	19	0	8	327	0	14	24	23	25	0	0	4,54	6,14	1,3	18,4	32,4

Table 7.3 continued

Variety/ Name	Myrcene	2-M-iso-butyrat	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendren	Unde-canone	Humu-lene	Farne-sene	□ -Muu-rolene	ß-Seli-nene	α-Seli-nen	Cadi-nene	Selina diene	Gera-niol	alpha-acids	beta-acids	beta: alpha	Cohu-mulone	Colu-pulone
Columbus	4294	164	26	10	14	0	6	166	0	19	16	15	35	19	3	11,90	4,67	0,39	35,9	59,6
Comet	1391	48	8	20	11	0	2	7	0	2	43	44	4	14	1	8,71	4,26	0,49	39,5	60,3
Crystal	4391	461	38	108	7	11	5	165	0	7	11	11	12	0	0	10,28	8,20	0,80	39,8	64,0
Density	1455	86	6	5	36	0	12	291	0	9	9	7	16	0	0	4,07	3,54	0,87	35,9	60,0
Dunav	1200	91	3	32	9	0	7	211	7	9	3	2	18	0	0	5,97	6,13	1,03	24,7	55,0
Early Choice	2740	117	2	12	13	0	6	273	0	8	43	46	16	0	0	3,12	1,63	0,52	33,7	52,6
Eastern Gold	1861	1	1	4	11	0	4	212	9	20	10	8	39	10	0	10,64	5,39	0,51	28,8	45,6
Eastwell Golding	1852	79	2	9	17	0	6	310	0	9	3	2	17	0	0	6,75	3,72	0,55	26,1	48,9
Emerald	1696	31	4	10	7	0	5	305	0	7	3	2	15	0	0	6,69	5,90	0,88	25,8	45,6
Estera	4004	256	2	7	40	0	8	289	19	10	5	3	17	0	0	4,64	2,80	0,60	29,4	50,7
First Gold	5779	467	2	19	28	4	12	266	14	8	94	111	23	0	0	8,05	3,58	0,44	31,1	57,6
Fuggle	3671	124	0	9	22	0	7	275	26	8	4	3	17	0	0	6,28	3,38	0,54	28,5	49,4
Ging dao do hua 791	5639	967	2	7	21	0	11	273	0	19	48	48	36	0	4	4,59	5,60	1,22	48,2	69,9
Golden Star	4626	897	3	6	25	0	13	281	11	18	42	42	32	0	5	3,71	4,51	1,22	47,9	69,2
Granit	1961	150	9	10	10	3	17	216	0	7	9	8	15	0	0	6,85	4,61	0,67	23,9	46,8
Green Bullet	4677	331	19	13	31	0	18	300	0	9	10	8	16	0	0	3,78	3,72	0,98	42,4	69,0
Hallertauer Gold	2261	82	22	5	31	0	8	311	0	9	4	2	16	0	0	5,88	6,10	1,04	19,8	40,0
Hallertauer Magnum	4663	114	35	16	9	0	4	283	0	6	4	3	12	0	0	14,08	6,73	0,48	25,9	46,2
Hallertauer Merkur	4353	142	8	8	19	2	5	299	0	9	4	3	17	0	0	14,03	6,81	0,49	17,9	41,2
Hallertauer Mfr.	349	24	2	0	19	0	8	346	0	11	5	4	21	0	0	3,39	3,92	1,15	18,0	38,3
Hallertauer Taurus	11292	130	22	19	49	0	9	278	0	8	74	77	18	0	0	17,25	5,34	0,31	21,8	44,9
Hallertauer Tradition	1443	66	12	2	35	0	8	321	0	9	5	3	19	0	0	5,65	4,89	0,87	24,1	45,4

Table 7.3 continued

Variety/ Name	Myrcene	2-M-iso-butyrat	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendren	Unde-canone	Humu-lene	Farne-sene	□ -Muu-rolene	ß-Seli-nene	α-Seli-nene	Cadi-nen	Selina diene	Gera-niol	alpha-acids	beta-acids	beta: alpha	Cohu-mulone	Colu-pulon
Herald	5861	415	6	69	12	5	20	198	0	7	24	29	15	0	0	11,04	4,08	0,37	33,4	58,0
Hersbrucker Pure	3038	186	5	9	49	16	16	211	0	13	39	38	19	57	3	4,30	2,69	0,62	25,1	47,7
Hersbrucker Spät	2071	93	6	8	57	55	13	181	0	16	57	55	18	73	3	1,97	5,29	2,69	17,9	34,8
Hüller	1675	225	36	5	35	14	8	163	0	46	60	57	78	85	3	4,94	4,56	0,92	26,7	46,0
Hüller Anfang	765	110	10	1	24	0	7	323	0	14	6	4	24	0	0	3,53	3,76	1,07	23,1	40,3
Hüller Aroma	730	53	4	3	26	0	8	336	0	12	5	4	22	0	0	3,67	3,59	0,98	26,5	49,6
Hüller Fortschritt	1566	63	10	2	34	0	9	323	0	11	6	4	20	0	0	4,09	4,99	1,22	25,0	43,8
Hüller Start	431	23	2	2	9	0	11	343	0	14	5	4	23	0	0	2,40	3,00	1,25	23,3	43,7
Japan C-730	560	8	15	26	10	0	9	198	14	9	9	8	15	3	4	3,58	2,31	0,65	36,6	58,4
Japan C-827	723	157	9	12	7	0	6	310	8	8	9	8	19	24	4	5,15	2,31	0,45	28,0	52,2
Japan C-845	1141	7	6	13	4	0	3	298	20	9	3	2	17	0	1	10,29	3,97	0,39	21,2	40,1
Japan C-966	2752	36	28	13	17	6	6	273	60	7	43	41	19	0	0	1,52	1,77	1,17	26,1	50,7
Kirin 1	5570	820	3	9	25	0	10	252	9	17	36	36	34	0	3	4,52	4,91	1,09	45,7	68,8
Kirin 2	4970	957	3	7	24	0	10	264	0	20	52	53	37	0	4	5,06	5,54	1,09	46,9	69,8
Kitomidori	749	6	6	9	4	0	2	311	13	9	4	3	18	0	1	9,73	4,31	0,44	20,9	39,2
Kumir	4649	94	4	0	27	0	8	292	10	8	3	3	14	0	0	10,59	5,08	0,48	20,3	44,2
Late Cluster	25565	811	34	80	65	27	20	43	15	56	55	73	105	73	0	7,84	5,28	0,67	27,7	48,9
Liberty	867	37	3	2	23	0	8	322	3	12	5	4	21	0	0	3,94	3,37	0,86	21,3	38,2
Lubelski	3958	14	8	6	53	0	22	314	30	11	4	3	21	0	0	5,06	4,88	0,97	24,1	42,6
Malling	3435	222	3	9	39	0	8	291	16	10	4	2	17	0	0	3,55	2,51	0,71	32,1	53,6
Marynka	8103	309	4	71	14	6	7	153	148	6	7	6	12	0	1	10,26	4,67	0,46	20,9	48,9
Mount Hood	415	41	14	2	16	0	4	263	2	13	5	3	22	0	0	3,67	5,53	1,51	21,7	41,6

Table 7.3 continued

Variety/ Name	Myrcene	2-M-iso-butyrat	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendren	Unde-canone	Humu-lene	Farne-sene	□ -Muu-rolene	ß-Seli-nene	α-Seli-nene	Cadi-nene	Selina-diene	Gera-niol	alpha-acids	beta-acids	beta: alpha	Cohu-mulone	Colu-pulone
Neoplanta	1838	142	2	17	6	0	3	205	18	8	3	2	15	0	0	7,70	3,58	0,46	39,3	65,3
Northern Brewer	4552	125	2	42	11	0	4	252	0	8	4	3	15	0	0	10,32	5,21	0,50	26,1	48,9
Nugget	2109	57	3	9	15	0	4	188	0	5	7	6	10	0	0	11,35	4,18	0,37	27,1	52,0
Olympic	2519	71	3	14	14	2	4	186	0	5	8	8	10	0	0	12,55	4,65	0,37	26,0	51,3
Omega	2232	174	15	7	17	0	5	294	0	8	47	51	17	0	0	6,95	4,23	0,61	27,4	45,9
Orion	1474	101	5	5	20	0	5	215	0	9	3	3	16	0	0	8,60	6,01	0,70	25,8	50,6
OT 48	1667	94	6	4	40	0	11	287	0	9	7	4	18	0	0	4,50	4,31	0,96	34,2	58,7
Pacific Gem	10402	847	21	37	28	0	16	281	0	8	6	4	14	0	0	11,49	6,80	0,59	40,5	66,9
PCU 280	2654	60	1	10	7	0	4	274	0	7	4	3	14	0	0	9,91	3,75	0,38	27,6	50,5
Perle	1946	68	2	12	7	0	3	287	0	7	4	3	16	0	0	6,55	4,59	0,70	30,8	54,5
Phoenix	4577	226	2	11	9	0	6	273	18	8	58	70	19	0	0	12,76	4,86	0,38	24,9	49,4
Pioneer	4826	434	3	148	9	4	19	215	0	8	29	34	16	0	0	9,72	3,72	0,38	35,2	60,4
Pride of Kent	2185	74	3	3	34	2	9	300	0	8	5	3	16	0	0	4,68	2,53	0,54	29,3	50,9
Progress	14089	909	44	49	72	29	20	34	0	79	106	98	133	128	9	6,94	4,86	0,70	28,5	50,9
Saazer	1552	8	3	4	30	0	16	321	24	11	2	2	17	0	0	2,69	4,22	1,57	24,7	40,9
Serebrianca	551	45	2	4	24	0	4	179	0	11	36	36	21	0	0	2,01	4,52	2,25	19,2	37,2
Sirem	1005	8	5	5	35	0	15	335	10	11	4	2	22	0	0	3,97	5,39	1,36	23,8	40,7
Spalter	1202	8	4	4	38	0	15	335	16	13	5	3	24	0	0	2,81	3,88	1,38	24,7	42,0
Spalter Select	5067	122	19	12	101	20	21	219	37	12	37	35	18	55	3	4,26	4,59	1,08	23,0	42,5
Sticklebract	12658	604	15	22	19	0	13	169	36	6	39	41	12	0	5	8,96	6,14	0,68	42,1	68,3
Strisselspalter	1516	36	4	5	24	32	11	184	0	11	34	37	17	42	0	2,88	4,70	1,63	18,7	36,8
Talisman	3840	100	2	35	11	0	5	249	0	8	4	3	14	0	0	8,47	4,99	0,59	25,8	47,4

Table 7.3 continued

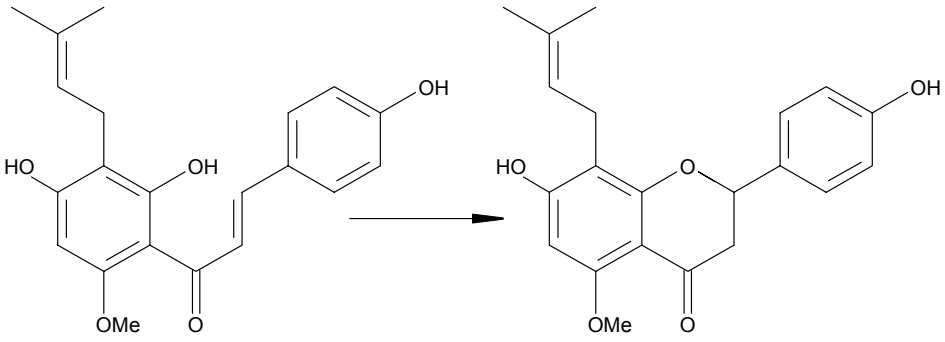
Variety/ Name	Myrcene	2-M-iso-butyrat	Sub. 14b	Sub. 15	Lina-lool	Aroma-dendren	Unde-canone	Humu-lene	Farne-sene	□ -Muu-rolene	ß-Seli-nene	α-Seli-nene	Cadi-nene	Selina diene	Gera-niol	alpha-acids	beta-acids	beta: alpha	Cohu-mulone	Colu-pulone
Tettnanger	2297	6	6	5	48	0	23	321	24	13	4	2	22	0	0	4,24	4,19	0,99	25,7	44,2
Toyomidori	2234	262	17	73	12	0	10	207	0	22	12	9	40	11	0	10,11	4,50	0,44	42,8	62,2
Ultra	365	20	2	1	16	0	3	335	0	11	5	3	19	0	0	2,50	4,12	1,65	27,1	42,4
Urozani	2613	8	3	5	81	0	13	244	24	8	27	25	19	33	0	2,72	5,20	1,91	21,7	40,3
USDA 21055	6410	507	3	229	9	0	2	128	64	6	14	15	14	0	0	10,81	4,17	0,39	45,7	69,2
Vojvodina	3098	104	2	22	14	0	10	268	7	8	3	2	15	0	0	4,62	2,73	0,59	29,1	56,9
WFG	2582	21	7	9	44	0	19	315	22	11	4	3	19	0	0	4,10	4,22	1,03	25,0	43,6
Willamette	2002	95	1	4	17	0	4	249	22	8	4	4	16	0	0	3,55	3,09	0,87	31,6	52,7
Wye Challenger	5501	380	6	30	32	0	10	258	0	8	49	56	18	0	0	5,21	4,66	0,89	24,9	46,2
Wye Northdown	2538	73	3	6	22	0	3	249	0	7	4	3	16	0	0	7,08	6,43	0,91	23,6	47,3
Wye Saxon	6367	96	6	130	19	0	14	225	50	9	50	51	16	0	2	7,50	4,65	0,62	23,0	44,5
Wye Target	3033	409	7	14	40	0	13	178	0	18	11	10	35	9	0	10,85	4,85	0,45	36,8	59,7
Wye Viking	6252	146	7	42	19	0	17	219	93	8	31	32	16	0	0	9,33	4,91	0,53	23,1	41,6
Yeoman	5776	307	15	24	13	0	6	238	0	6	43	46	16	0	0	13,76	5,83	0,42	25,6	49,3
Zatecki	4475	176	3	14	33	0	6	267	19	8	13	11	15	0	0	5,07	2,91	0,57	27,4	49,3
Zenith	3859	116	4	22	32	0	8	285	0	8	91	100	21	0	0	8,44	3,63	0,43	25,1	48,1
Zitic	5730	11	2	19	13	3	9	300	0	8	4	2	16	0	0	6,19	5,63	0,91	20,0	41,9
Zlatan	1351	10	6	5	48	0	22	336	16	13	5	3	24	0	0	3,50	4,17	1,19	24,9	41,8

Essential oils = relative values, beta-caryophyllene = 100; alpha- and beta-acids in % as is ; Analoga in % of the alpha and beta-acids

7.4 Xanthohumol

Xanthohumol has increasingly aroused public interest in recent years, as it has anti-carcinogenic potential. Xanthohumol is not very soluble in water, but it isomerises during the wort boiling into the considerably more soluble iso-xanthohumol (Diag. 7.1). This compound also shows an anti-carcinogenic potential, although a little weaker than xanthohumol. At the Chair for Brewing Technology I under Professor Back at the Technical University of Munich in Weihenstephan a beer enriched with xanthohumol has already been brewed with the name Xan in which the iso-xanthohumol content was more than 4 mg/litre.
At the Cancer Research Centre in Heidelberg xanthohumol passed preliminary screening tests with bravura, so that further tests are to be carried out in animals and afterwards in human-beings.
In Hüll all the interesting breeding lines are being tested for xanthohumol. Table 7.4 shows a list of breeding lines with more than 0.90 % xanthohumol and the four commercially grown varieties with the highest xanthohumol contents. Of the varieties already being grown the variety Hallertauer Taurus has the highest xanthohumol content with more than 1 %, followed by Wye Target, Northern Brewer and Nugget. There is even one breeding line available with 1.68 % xanthohumol. The crop year has less influence on the xanthohumol content than on the alpha-acid content. Varieties with high alpha-acid contents tend to have higher xanthohumol contents as well. The correlation however is not particularly good (Diag. 7.2). The xanthohumol content correlates only to 41.9 % with the alpha-acid content. However, the ratio xanthohumol to the alpha-acids is very stable.

Diagram 7.1: Isomerisation of xanthohumol to iso-xanthohumol



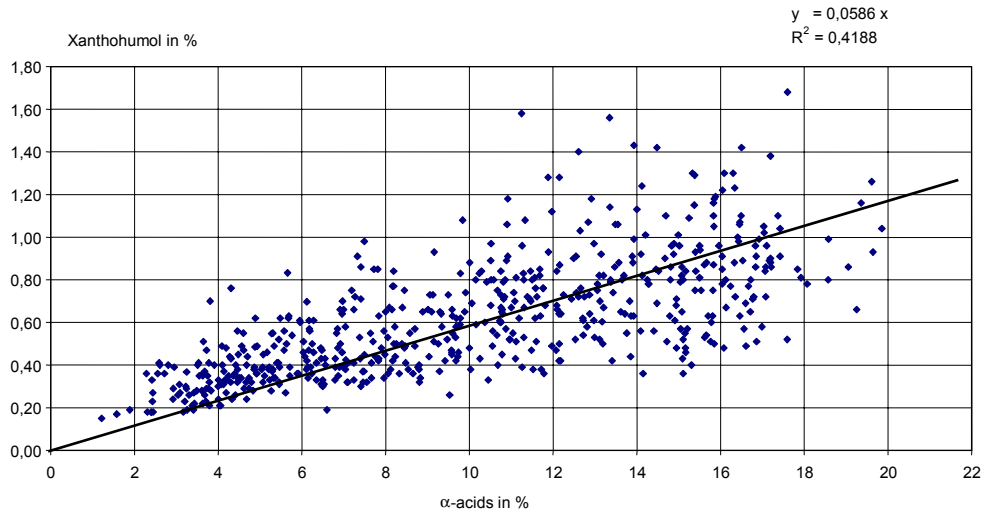
xanthohumol iso-xanthohumol

Table 7.4: Xanthohumol content of breeding lines with more than 0.90 % xanthohumol compared with four commercially grown varieties, 2001 crop

Variety/ Breeding line	xantho-humol	alpha-acids	beta-acids	beta: alpha	Cohu-mulonee	Colu-pulone	Xanthohumol/ alpha-acids %
Hallertauer Taurus	1,13	14,00	4,71	0,34	21,3	44,9	8,07
Wye Target	0,93	9,16	4,47	0,49	34,1	57,3	10,15
Northern Brewer	0,84	8,19	3,50	0,43	26,1	49,5	10,26
Nugget	0,82	13,10	4,71	0,36	26,7	52,2	6,26
99/047/722	1,68	17,60	5,32	0,30	27,1	46,1	9,55
94/075/766	1,42	16,50	6,30	0,38	25,6	49,3	8,61
94/075/766	1,30	16,30	6,09	0,37	26,7	49,4	7,98
99/061/712	1,30	16,09	5,69	0,35	27,4	49,0	8,08
93/010/036	1,29	15,38	5,21	0,34	26,3	48,6	8,39
98/097/738	1,23	16,34	6,61	0,40	25,8	53,5	7,53
99/062/727	1,22	16,05	5,66	0,35	25,6	44,9	7,60
95/099/748	1,18	10,92	4,60	0,42	24,6	45,5	10,81
95/093/702	1,16	19,36	4,85	0,25	23,4	44,0	5,99
95/099/790	1,15	15,37	6,14	0,40	26,5	47,9	7,48
95/094/730	1,10	16,49	5,32	0,32	26,4	47,6	6,67
93/010/036	1,09	15,25	5,28	0,35	26,3	49,4	7,15
99/072/732	1,06	16,45	5,13	0,31	28,1	49,7	6,44
95/094/730	0,99	13,93	4,72	0,34	24,8	47,0	7,11
99/057/001	0,99	16,92	5,35	0,32	30,0	54,6	5,85
93/024/733	0,97	12,98	4,67	0,36	25,8	49,0	7,47
95/094/816	0,91	17,42	5,76	0,33	33,6	53,5	5,22
98/105/727	0,91	16,04	5,33	0,33	22,4	48,9	5,67
99/065/722	0,91	16,85	4,18	0,25	25,4	46,8	5,40
95/093/716	0,89	17,17	5,23	0,30	25,2	53,9	5,18
94/075/761	0,88	10,01	3,45	0,34	22,5	44,4	8,79
99/062/735	0,88	17,20	4,39	0,26	23,1	43,6	5,12
93/010/034	0,86	15,08	4,34	0,29	20,7	42,0	5,70
98/067/715	0,86	16,84	5,86	0,35	42,2	64,5	5,11
93/010/063	0,85	14,46	5,74	0,40	31,0	54,2	5,88
95/094/769	0,85	16,04	4,65	0,29	31,6	52,1	5,30
99/093/718	0,85	17,84	5,77	0,32	23,6	48,6	4,76
93/010/034	0,84	15,41	4,55	0,29	20,1	41,3	5,45
94/075/758	0,84	17,06	7,49	0,44	19,9	40,4	4,92
94/075/761	0,80	16,12	6,12	0,38	13,5	29,5	4,96
95/094/741	0,80	15,11	5,09	0,34	35,3	54,5	5,29
95/103/735	0,80	16,72	5,84	0,35	22,5	44,6	4,78

xanthohumol, alpha- and beta-acids in % as is: analoga in % of the alpha- and beta-acids

Diagram 7.2: Correlation between xanthohumol content and alpha-acid content



7.5 Ring analyses for the 2002 crop

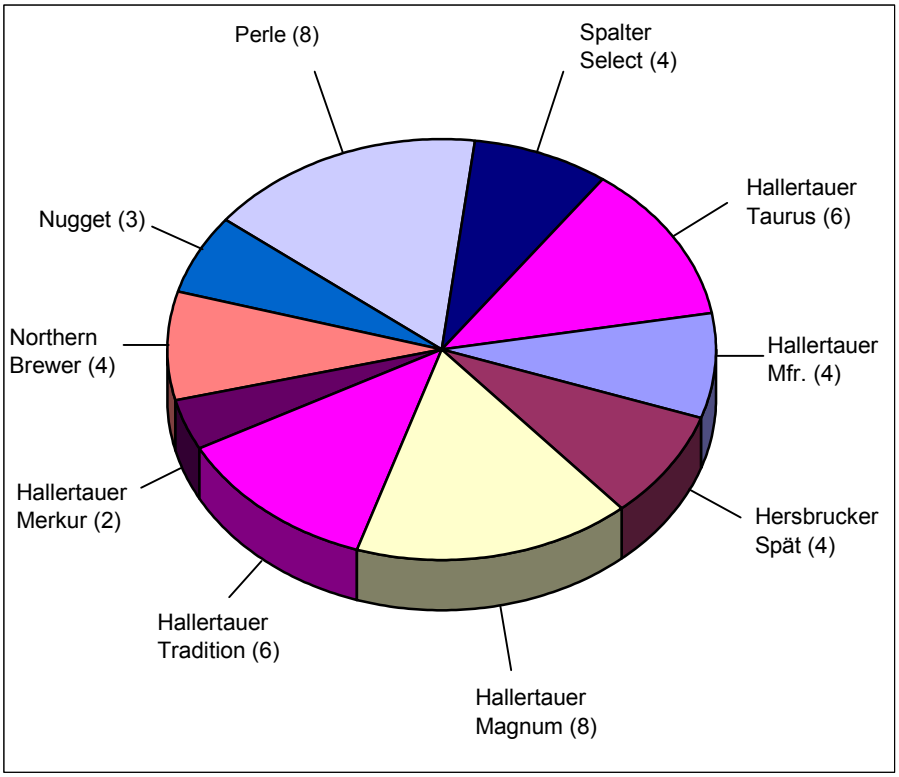
Since 2000 there has been a supplementary agreement to the hop supply contracts, in which the alpha-acid contents are taken into consideration. The price agreed in the contract applies if the alpha-acid content is within a neutral range. If this neutral range is exceeded or is fallen short of there is a surcharge or a price reduction. It is precisely laid down in the duties record book of the Work Group for Hop Analytica how the samples are to be treated (division of samples, storage), which laboratories carry out further analyses and which tolerance ranges are permitted for the results of the analyses. Also in 2002 it was the task of the Hops Dept. H 1a, as in the years 2000 and 2001, to organise and evaluate the ring analyses in order to guarantee the accuracy of the alpha-acid analyses.

The following laboratories participated in the ring test in 2002:
- Hallertauer Hopfenveredelungsgesellschaft (HHV), Werk Mainburg
- Hallertauer Hopfenveredelungsgesellschaft (HHV), Werk Au/Hallertau
- NATECO$_2$, Wolnzach
- Hopfenveredelung HVG Barth, Raiser GmbH & Co KG, St. Johann
- Hallertauer Hopfenverwertungsgenossenschaft (HVG), Mainburg
- Bayerische Landesanstalt für Bodenkultur und Pflanzenbau, Hops Dept., Hüll
- Agrolab GmbH, Oberhummel
- Agrar- und Umweltanalytik GmbH (AUA), Jena

The ring test was started on 03.09.2002 and ended on 29.11.2002 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. Every Monday the samples were ground at the HHV Mainburg with a hammer mill, divided in Hüll with a sample divider, vacuum-packed and brought to every single laboratory. On the following weekdays one sample was analysed every day. The results of the analyses were sent back to Hüll a week

later and evaluated. Altogether 49 samples were analysed in 2002. Diagram 7.3 shows the configuration of the varieties.

Diagram 7.3: Configuration of varieties in the ring analysis 2002



The evaluation was passed on to every single laboratory as quickly as possible. As examples the diagrams 7.4 and 7.5 show the ring tests with the highest and lowest standard deviations.

Diagram 7.4: Ring analysis with the lowest standard deviation

No. 27: HPE (22nd October 2002)

Labor	KW		mean	s	cvr
1	8,58	8,58	8,58	0,000	0,0
2	8,62	8,54	8,58	0,057	0,7
3	8,53	8,42	8,48	0,078	0,9
4	8,39	8,49	8,44	0,071	0,8
5	8,34	8,47	8,41	0,092	1,1
6	8,37	8,59	8,48	0,156	1,8
7	8,42	8,36	8,39	0,042	0,5
8	8,48	8,62	8,55	0,099	1,2

mean	8,49
sr	0,086
vkr	1,0
sR	0,096
vkR	1,1
r	0,24
R	0,27
Min	8,39
Max	8,58

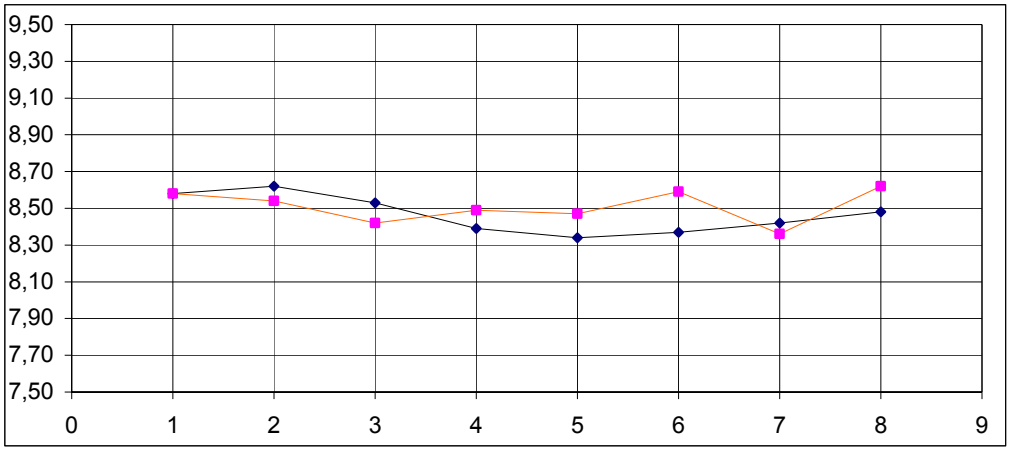
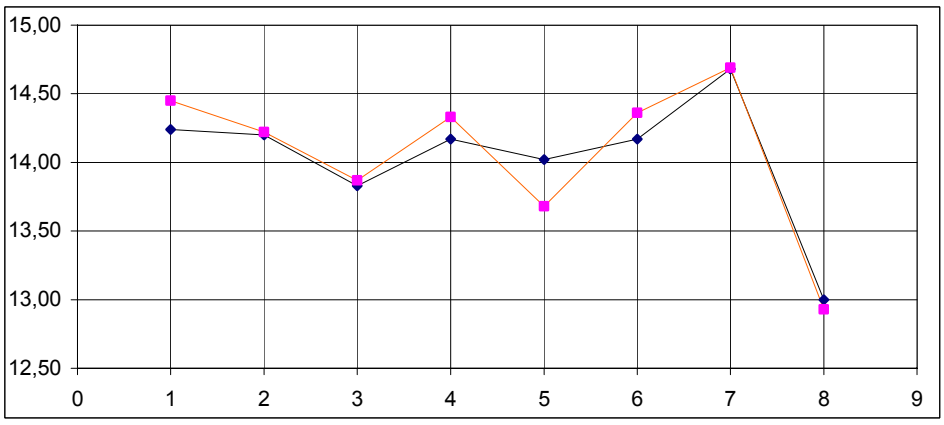


Diagram 7.5: Ring analysis with the highest standard deviation

Nr. 17: NU (1st October 2002)

Labor	KW		mean	s	cvr
1	14,24	14,45	14,35	0,148	1,0
2	14,20	14,22	14,21	0,014	0,1
3	13,83	13,87	13,85	0,028	0,2
4	14,17	14,33	14,25	0,113	0,8
5	14,02	13,68	13,85	0,240	1,7
6	14,17	14,36	14,27	0,134	0,9
7	14,68	14,69	14,69	0,007	0,0
8	13,00	12,93	12,97	0,049	0,4

mean	14,21
sr	0,126
vkr	0,9
sR	0,294
vkR	2,1
r	0,35
R	0,82
Min	12,97
Max	14,69



As a runaway test between the laboratories the Grubbs Test was calculated according to DIN ISO 5725. This time a runaway was found twelve times. Table 7.5 shows the tolerance limits (d critical) from the methods collected by the European Brewery Convention (EBC 7.4, conductometric titration) (Schmidt, R., NATECO$_2$, Wolnzach) and their exceedings in the years 2000, 2001 and 2002).

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

	up to 6.2 % alpha-acids	6.3 % - 9.4 % alpha-acids	9.5 % - 11.3 % alpha-acids	over 11,4 % alpha-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

In 49 samples there were 14 exceedings of the permitted tolerance limits in 2002 which corresponds to 29 % of the samples. However, this could mainly be traced back to one laboratory.

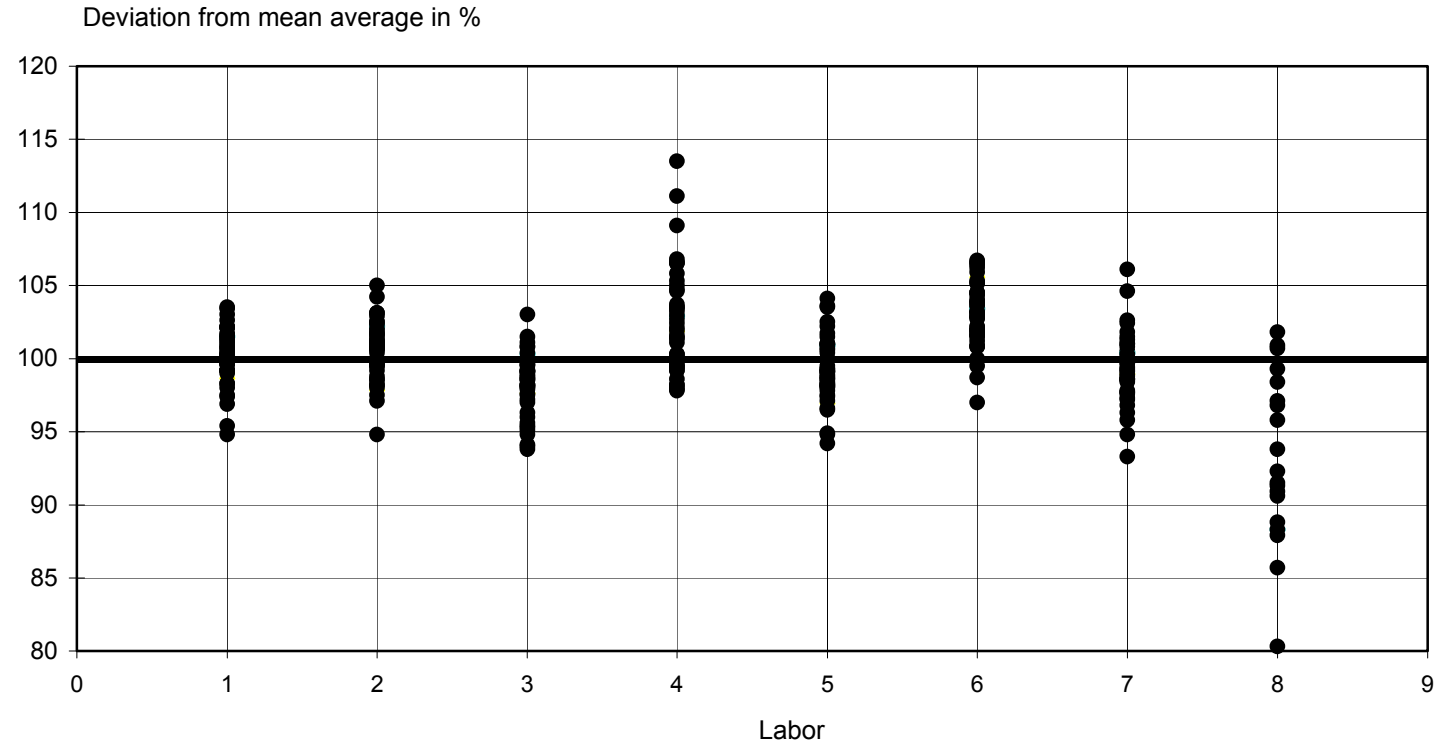
Resumé of the ring test

With 14 exceedings in 2002 there were a considerable number of deviations from the tolerance limits.
All the analysis results for each laboratory are listed in Diagram 7.6 as relative deviations from the mean average (= 100 %). This shows there are very good trends whether a laboratory tends to be too high or too low. With the help of the diagram it can be seen that the values measured by Laboratory 4 are too high and by Laboratory 8 too low.

7.6 NIR calibration

The ring test was also used to test and extend the existing NIR calibrations. In the Work Group for Hop Analytica (AHA) it was decided that there was no point in extending the existing NIR calibration built up on conductometer value as no better accuracy can be achieved by adding new data records. Since the year 2000, work has been carried out to build up a NIR calibration based on HPLC data. The AHA will decide when this calibration can be used in the practice.

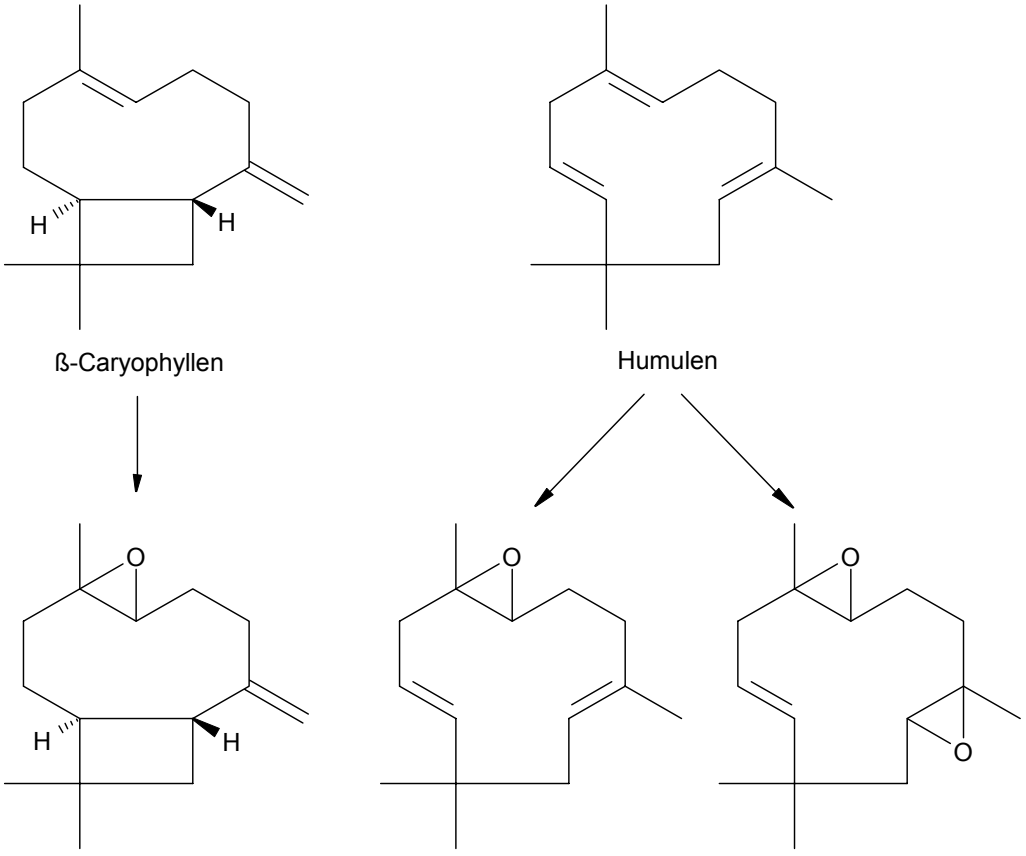
Diagram 7.6: Analysis results of the laboratories relative to the mean average



7.7 Dissertation "Analysing the ageing components in the essential oil of hops by means of SPME"

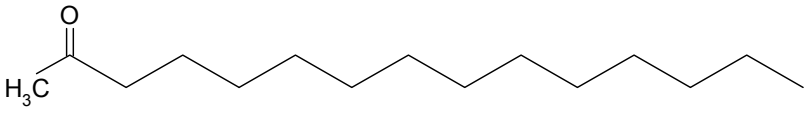
€ 2000 were kindly made available by the firms Hallertauer Hopfenveredelungsgesellschaft mbH and NATECO$_2$ for a dissertation with the subject "Analysing the ageing components in the essential oil of hops by means of SPME". Mr. Plass from the Fachhochschule Weihenstephan has been working on this subject. The dissertation was begun in October, 2002 and will be finished in March, 2003. As ageing components in the essential oil of hops in particular the oxides of ß-caryophyllene and humulene should be mentioned, these are ß-caryophyllene-oxide, humulene-oxide I und humulene-oxide II. Another indication of ageing is the substance 2-pentadecanone, the origin of which has not yet been clarified (Diag. 7.7).

Diagram 7.7: Ageing components in the essential oil of hops



ß-Caryophyllen | Humulen

ß-Caryophyllenoxid | Humulenoxid I | Humulenoxid II



2-Pentadecanon

As only ß-caryophyllene-oxide and 2-pentadecanone are commercially available, in the dissertation endeavours were made to analyse these two substances. With the help of standard addition it was possible to analyse ß-caryophyllene-oxide and 2-pentadecanone. An increase in these components could be observed in aged hops. A summary of the findings will be included in the next Annual Report as at the moment the work is not yet finished.

7.8 Testing for residues of plant protectives in hops of the 2002 crop

The annual inspections for residues of plant protectives in hops give a very good survey over the actual situation. Contrary to many assumptions hops are free from harmful residues of plant protectives.
Due to the high costs for overall analyses (approx. € 1,500 per sample) the extent of the analyses again had to be restricted to six samples this year. However, a large number of the analyses will in addition be carried out in the residue laboratories of the Hopfenveredelungswerke.

7.8.1 Selecting the samples

Spread over the weighing-in and certifying season 2002, altogether 110 hop samples from all the important varieties of the Hallertau production region were delivered to the Hops Dept. of the Bavarian State Research Centre for Agronomy (LBP) by the Hopfenring Hallertau e.V. The samples were only marked with the name of the variety and the bale number. Consequently the LBP does not know the names of the hop farms involved.
At the LBP two hops samples were selected from these samples for each of the five hop varieties listed in Table 7.6 and a mixed sample was made. For the variety Hallertauer Taurus (TU) the sample for analysis was only taken from one hop lot. The extensive residue analyses of a mixed sample from two single samples are justified as the lots delivered to the buyers (breweries) are generally put together from several individual lots. The analyses were carried out at the Principal Agricultural Research Institute (HVA) of the Technical University of Munich (TUM) in Freising-Weihenstephan.

Table 7.6: Analyses for residues of plant protectives - 2002 crop

Active compounds listed acc. to pest or disease	Max. amount permitted ppm	Milligram per kilogram= ppm					
		R 1/02 SE	R 2/02 HM	R 3/02 NU	R 4/02 HA	R 5/02 HE	R 6/02 TU
Peronospora							
Azoxystrobin	20	nn	nn	nn	nn	nn	nn
Captan, Folpet	120	nn	<0,2	<0,2	nn	nn	nn
Captafol	0,1	nn	nn	nn	nn	nn	nn
Cymoxanil	2,0	nn	nn	nn	nn	nn	nn
Dithiocarbamate	25	nn	nn	nn	nn	nn	nn
Fentin-acetat	0,5	nn	nn	nn	nn	nn	nn
Fosethyl	100	nn	nn	nn	nn	nn	nn
Copper compounds	1000	623	233	231	214	727	417
Metalaxyl	10	nn	nn	nn	nn	nn	nn
Phosphoric acids	*)	6,0	9,3	nn	nn	nn	nn
Mildew							
Fenarimol	5,0	nn	nn	nn	nn	nn	nn
Myclobutanil	3,0	nn	nn	nn	nn	nn	nn
Fenpropymorph	0,1	nn	nn	nn	nn	nn	nn
Triadimefon	15	nn	nn	nn	nn	nn	nn
Triadimenol	15	nn	nn	nn	nn	nn	nn
Trifloxystrobin	50**)	nn	0,61	nn	nn	nn	nn
Triforin	30	2,5	nn	nn	nn	nn	nn
Botrytis							
Dichlofluanid	150	nn	nn	nn	nn	nn	nn
Procymidon	0,1	nn	nn	nn	nn	nn	nn
Vinclozolin	40	nn	nn	nn	nn	nn	nn
Hop aphid							
Bifenthrin	10	nn	nn	nn	nn	nn	nn
Cyfluthrin	20	nn	nn	nn	nn	nn	nn
Lambda-Cyhalothrin	10	nn	nn	nn	nn	nn	nn
Cypermethrin	30	nn	nn	nn	nn	nn	nn
Deltamethrin	5	nn	nn	nn	nn	nn	nn
Diazinon	0,05	nn	nn	nn	nn	nn	nn
Endosulfan	0,1	nn	nn	nn	nn	nn	nn
Imidacloprid	2,0	nn	<0,1	nn	<0,1	<0,1	nn
Mevinphos	0,5	nn	nn	nn	nn	nn	nn
Omethoat	10	nn	nn	nn	nn	nn	nn
Parathion-methyl	0,1	nn	nn	nn	nn	nn	nn
Permethrin	0,1	nn	nn	nn	nn	nn	nn
Pirimicarb	0,05	nn	nn	nn	nn	nn	nn
Propoxur	0,1	nn	nn	nn	nn	nn	nn
Pymetrozine	5**)	nn	nn	nn	nn	nn	nn

Table 7.5 continued

Active compounds listed acc. to pest or disease	Max. amount permitted ppm	Milligram per kilogramme = ppm					
		R 1/02 SE	R 2/02 HM	R 3/02 NU	R 4/02 HA	R 5/02 HE	R 6/02 TU
Common spider mite							
Amitraz	50	nn	nn	nn	nn	nn	nn
Azocyclotin/Cyhexatin	50	nn	nn	nn	nn	nn	nn
Brompropylat	5	nn	nn	nn	nn	nn	nn
Dicofol	50	nn	nn	nn	nn	nn	nn
Fenbutatinoxid	0,1	nn	nn	nn	nn	nn	nn
Fenpyroximate	10	nn	nn	nn	nn	nn	nn
Hexythiazox	3	nn	nn	nn	nn	nn	nn
Propargit	30	nn	nn	nn	nn	nn	nn
Alfalfa weevil							
Acephat	0,1	nn	nn	nn	nn	nn	nn
Carbofuran	10	nn	nn	nn	nn	nn	nn
Methamidophos	2	nn	nn	nn	nn	nn	nn
Methidathion	3	nn	nn	nn	nn	nn	nn
Herbicide							
Monolinuron	0,05	nn	nn	nn	nn	nn	nn

*) No maximum amounts of residue laid down
**) Suggested maximum amount

SE = Spalter Select
HM = Hallertauer Magnum
NU = Nugget
HA = Hallertauer
HE = Hersbrucker Spät
TU = Hallertauer Taurus

7.8.2 Assessing the results

As in previous years only few active substances were detected by the residue analyses in the hops harvested in 2002. In all cases the values were considerably below the legally permitted maximum amounts in accordance with the current regulation on maximum amounts.

7.8.3 Resumé

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

Table 7.7: Residue situation in hops of the 2002 crop

Active compound (brand name)	Fre-quency	ppm min.- max.	ppm max. amount	ppm US toler-ance
Captan, Folpet (Folpan)	2	<0,2	120	120
Copper compounds	6	214 - 727	1000	ex.
Phosphoric acids (Aliette)	2	6,0 - 9,3	*	*
Trifloxystrobin (Flint)	1	0,6	50	11
Triforin (Saprol neu)	1	2,5	30	60
Imidacloprid (Confidor)	3	<0,1	2,0	6,0

* = no maximum amount set
ex. = exempt

7.9 Checking that the variety is authentic

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

Checking varieties for the food control authorities (district administration offices)	28
Complaints thereof	0

8 Publications

Engelhard, B. (2002): Pflanzenschutz im Hopfen 2002. - Hopfen-Rundschau **53** (5): 98-111.

Engelhard, B. (2002): Höhere Temperaturen und weniger Niederschläge und deren langfristige Auswirkungen auf die Hopfenproduktion. - Hopfen-Rundschau **53** (8): 184-186.

Kammhuber, K. (2002): Organisation und Auswertung von Ringanalysen zur Qualitätssicherung bei der α-Säurenbestimmung von Hopfen. - Schule und Beratung **8:** IV 1-4.

Neuhauser, H., Rödel, G. & **Roßbauer, G.** (2002): Schneidgerät für Hopfenanbau in Niedriggerüstanlagen. - Zeitschrift für Landtechnik **1**: 20-21.

Niedermeier, E. (2002): Pflanzenstandsbericht vom 23.05.-23.06.2002. - Hopfen-Rundschau **53** (7): 160.

Niedermeier, E. (2002): Pflanzenstandsbericht vom 24.06.-24.07.2002. - Hopfen-Rundschau **53** (8): 188.

Roßbauer, G. (2002): Kapitel Hopfen. - Lehrbuch Agrarwirtschaft, Fachstufe Landwirt.

Roßbauer, G. (2002): Fachkritik zur Hopfenschau Moosburg 2002. - Hopfen-Rundschau **53** (10): 225-228.

Roßbauer, G., Dorfner, H. (2002): Spritzenprüfung für Gebläsespritzen wird Pflicht! - Hopfen-Rundschau **53** (3): 58.

Roßbauer, G., Niedermeier, E. & Brummer, A. (2002): Nmin-Untersuchungen 2002. - Hopfen-Rundschau **53** (6): 124-125.

Schmidt, R., **Kammhuber, K.** (2002): Erfahrungen mit Alpha-Untersuchungen in Hopfenpartien für die Abwicklung und Kaufpreisberechnung nach Alphatabelle. - Hopfen-Rundschau **53** (9): 208-212.

Seigner, E. (2002): Züchtung marktangepasster Hopfensorten. - Brauwelt **142** (9-10): 307-308.

Seigner, E., Seefelder, S. & Felsenstein, F. (2002): Untersuchungen zum Virulenzspektrum des Echten Mehltaus bei Hopfen *(Sphaerotheca humuli)* und zur Wirksamkeit rassenspezifischer Resistenzgene. - Nachrichtenblatt des Deutschen Pflanzenschutzdienstes **54** (6): 147-151.

Seigner, E., Seefelder, S., Radic-Miehle, H., Lutz, A. & Engelhard, B. (2002): Hop Research at Hüll – Breeding of hop varieties meeting the demands of the world market – tradition meets innovation. – Hop Bulletin **9** (1): 15-20.

Seefelder, S., Lutz, A., Seigner, E. & Engelhard, B. (2002): Werkzeug der Hopfenzüchtung – DNA-Marker, Tools in hop breeding – DNA markers. – Hopfen-Rundschau. Internationale Ausgabe 2002/2003: 39-43.

Spindler, B., **Weihrauch, F.** (2002): Erster Nachweis von *Platycheirus sticticus* (Meigen, 1822) aus Bayern (Diptera, Syrphidae). - Volucella **6**: 237-240

Weihrauch, F., Engelhard, B. (2002): Praxiseinführung einer Bekämpfungsschwelle für die Gemeine Spinnmilbe *(Tetranychus urticae* Koch*)* im Hopfenbau. - Mitteilungen aus der Biologischen Bundesanstalt für Land- und Forstwirtschaft Berlin-Dahlem **390:** 333-334.

At the Bavarian State Research Centre for Agronomy Hop Research and Hop Consultancy – Wolnzach / Hüll

the following persons were employed during 2002:

H – Hops Dept.

Head of Dept.:	**Engelhard Bernhard**
Deputy:	Roßbauer Georg

Special Field H 1 – Hüll
- Breeding, Plant Protection, Quality -

Head of Dept.:	**Engelhard Bernhard**
Deputy:	Dr. Seigner Elisabeth

Section: Quality, Chemistry, Technology (H 1a)

Staff:	Dr. Kammhuber Klaus	
	Petzina Cornelia	
	Weihrauch Silvia	
	Wyschkon Birgit	
	Neuhof-Buckl Evi	

Section: Plant Protection (H 1b)

Staff:	Ehrenstraßer Olga	
	Hesse Herfried	
	Huber Renate	
	Mayer Michael	until 17.11.02
	Weihrauch Florian	from 01.04.02
	Fischer Maria	
	Weiher Johann	

Section: Breeding methods (H 1c)

Staff:	Dr. Seigner Elisabeth
	Dr. Seefelder Stefan
	Dr. Radic-Miehle
	Bauer Petra
	Haugg Brigitte
	Hartberger Petra from 01.10.02
	Mayer Veronika from 26.06.02
	Lutz Anton
	Kneidl Jutta
	Dandl Maximilian
	Hock Elfriede
	Kohlhuber Walburga
	Maier Margret
	Mauermeier Michael
	Pflügl Ursula
	Presl Irmgard
	Suchostawski Christine
	Waldinger Josef
Office staff:	Biederer Hildegard
	Escherich Ingeborg
	Reischl Helga

Special Field H 2 – Wolnzach - Production, Consultancy -

Head of Dept.:	**Roßbauer Georg**
Deputy:	Engelhard Bernhard
Staff:	Dorfner Hermann until 31.10.02
	Janscheck Thomas until 30.11.02
	Münsterer Jakob
	Niedermeier Erich
Office staff:	Heilmeier Rosa