1963

ANNUAL REPORT

of

HOP INVESTIGATIONS
(CRe5, OAES 36)

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ANNUAL REPORT

of

HOP INVESTIGATIONS
(CRe5, OAES 36)

by
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Oilseed and Industrial Crops Research Branch
Crops Research Division
Agricultural Research Service
United States Department of Agriculture

in cooperation with the

Oregon Agricultural Experiment Station
Corvallis, Oregon

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INTRODUCTION

S. N. Brooks

This 1963 annual report of investigations carried out by the regional hop project headquartered at Corvallis, Oregon includes data collected and summarized during the period March 1, 1963 to February 28, 1964. It includes data in some cases which were collected by personnel at the Irrigation Experiment Station at Prosser, Washington. All data are reported under one of four main lines of study or line projects. Detailed discussions and summarizing data are presented for each experiment or phase as a separate section within a line project report. Additional data or notes which are important enough to be included as a matter of permanent record are appended to the report.

Some of the line projects are conducted cooperatively by investigators located at Oregon State University. In these cases, it is necessary that a line project report be prepared by more than one person. Where this has occurred an attempt has been made to give each project leader full credit for his contribution to the report.

The work summarized in this report is supported by public and private funds. Cooperative research is carried out by Crops Research Division, ARS, USDA; Oregon Agricultural Experiment Station; and United States Brewers Foundation through the Agricultural Research Foundation under Memorandum of Understanding. In addition certain phases of the federal breeding program are cooperative with the agricultural experiment stations in California, Idaho and Washington also under Memorandum of Understanding. This report does not summarize work done at any of the institutions which does not involve direct cooperation of federal personnel.

The immediate staff of the hop research project in 1963 consisted of the following persons. This list is made up of regularly employed personnel who were associated with the cooperative State-Federal hop research program and thus contributed directly to the work reported herein. Personnel doing independent research at Oregon State University and field assistants hired for intermittent or seasonal jobs on the cooperative program are not included.

Dr. S. N. Brooks, Research Agronomist, USDA,
Dr. C. E. Horner, Plant Pathologist, USDA and OSU,
Mr. S. T. Likens, Research Agronomist, USDA,
Mr. C. E. Zimmermann, Plant Physiologist, USDA,
Mr. H. L. Dooley, Asst. in Plant Pathology (part time), OSU,
Mrs. J. M. Barnes, Secretary, USDA,
Mr. Bernes Frey, Agric. Aid, USDA,
Miss Gail Nickerson, Research Lab. Tech., OSU,
Mrs. Hulda Bauer, Laborer (part time) OSU,
Mrs. Vie Nemec, Lab. Assistant (part time)OSU,
Mr. Phillip Giffin, Laborer (part time) OSU,
Mr. John Giffin, Laborer (part time) OSU,
Miss Penelope Hawkins, Lab. Technician (part time) OSU,
Miss Carol Minton, Lab. Assistant (part time) OSU.

The hop project was pleased to have Dr. R. A. Neve, hop breeder (now head of department) from Wye College, England, spend 3 months here in the spring and summer of 1963. While he was here, Dr. Neve studied sex chromosome types in our collection of wild American material.

Several papers were published by hop research personnel during the past 12 months, and additional manuscripts were prepared for publication. These are:

Technical:

Likens, S. T. and G. B. Nickerson. Two point conductometric titration of hop α-acids. Wallerstein Lab. Comm. 26(89): 39-46. 1963.

Horner, C. E. Chemotherapeutic effects of streptomycin on establishment and progression of systemic downy mildew infection in hops. Phytopath. 53: 472-474. 1963.

Brooks, S. N. and Y. P. Puri. Atmospheric conditions influencing pollen shedding in hops. Crop Sci. 3: 530-531. 1963.

Brooks, S. N. Relation of training date to pollen shedding in male hops, Humulus lupulus L. Crop Sci. 3: 275-277. 1963.

Anderson, J. Harland, and S. T. Likens. Observations of the effects of hops on fermentation. MBAA Tech. Quart. 1(1): 10-19. 1964.

Horner, C. E. History of hop downy mildew control. Mod. Brewery Age 66: 48-50, May, 1964.

Brooks, S. N. Hop downy mildew -- a look to the future. Mod. Brewery Age 66: 51-52, May, 1964.

Manuscripts prepared:

Horner, C. E. Hop diseases in Oregon and their control. (to be presented at the International Hop Disease Conference, East Malling, England, and to be published in the proceedings)

Zimmermann, C. E., S. N. Brooks, and S. T. Likens. Gibberellin A_3 induced growth responses of hops. (Humulus lupulus L.) (to be published in Crop Sci.)

Likens, S. T., and G. B. Nickerson. Detection of certain hop oil constituents in brewing products. (to be published in 1964 Proc. ASBC)

Brooks, S. N., D. D. Evans, and S. T. Likens. Sprinkler irrigation and fertilizer response of hops. (to be published in Agron. J.)

Puri, Y. P., and S. N. Brooks. Megasporogenesis and embryo development in the hop. (to be submitted to Crop Sci.)

Puri, Y. P., and S. N. Brooks. Microsporogenesis and pollen characteristics of the hop. (to be submitted to Crop Sci.)

World production of hops in 1963-64 amounted to about 190,000,000 pounds in the northern hemisphere and 4,000,000 estimated in the southern hemisphere for a total of about 194,000,000 pounds, almost 8% above the previous record of 180,600,000 pounds in 1959-60. Final figures are not yet available since the southern crop does not come off until February or March. Drought, wind, and frost of catastrophic proportions in Tasmania reportedly reduced the Australian crop by 50%. Conditions apparently were good in the other hop producing countries, and fair to good crops were produced. Increased production in almost all of the major producing countries accounted for the increase in 1963-64. Only Jugoslavia appears to have significantly reduced production in 1963-64. However, data for Canada, Hungary, Australia, and New Zealand are not available at this writing.

According to AMS reports, exports of U. S. hops for the period September, 1963 to January, 1964 amounted to 12,605,489 pounds which is about 243,000 pounds more than in the same period last year. Imports during the same period were 4,881,012 pounds this year compared to 3,589,760 pounds last year.

U. S. Breweries used 11,045,261 pounds of hops (September-January) which is up about 190,000 pounds over last year for the same period. In spite of a slowly declining ratio, total hop usage continues to climb because of increased beer production. World production of beer is also increasing.

According to an AMS and OSU crop report (Dec. 23, 1963) the 1963 U. S. hop crop totaled 51,422,000 pounds, 16% above last year, 45% above the short 1961 crop, and 15% above average. (Tables 1 and 2). Only California had a smaller crop than last year, down 3%. Most of the increase was in Washington where production reached a record high of 32,136,000 pounds and accounted for 62% of the U. S. total compared with the average of 58%. The Washington crop was up 27% from last year and was 24% above average, primarily because acreage was the largest on record.

Table 1. Hop acreage and yield per acre, 1962, 1963, and 1957-61.

State	Acreage harvested			Yield per acre		
	Average 1957-61	1962	1963	Average 1957-61	1962	1963
	- Acres -			- Pounds -		
Idaho	3,160	3,400	4,000	1,768	1,940	1,770
Washington	16,400	18,000	20,600	1,580	1,410	1,560
Oregon	4,460	3,800	4,000	1,278	1,380	1,350
California	5,260	4,100	4,100	1,453	1,710	1,660
United States	29,280	29,300	32,700	1,530	1,510	1,573

Table 2. Hop production, average prices received, and farm value, 1962, 1963, and 1957-61.

State	Production			Price per pound		Farm value	
	Average 1957-61	1962	1963	1962	1963	1962	1963
	- 1,000 pounds -			- Cents -		- 1,000 dollars -	
Idaho	5,601	6,596	7,080	49.0	53.0	3,232	3,752
Washington	25,912	25,380	32,136	44.0	45.5	11,167	14,622
Oregon	5,644	5,244	5,400	46.0	45.0	2,412	2,430
California	7,658	7,011	6,806	59.0	58.0	4,136	3,947
United States	44,816	44,231	51,422	47.4	48.1	20,947	24,751

Idaho also had a record high acreage which, with near average yields, produced that State's largest crop on record, 7,080,000 pounds, 7% above 1962 and 26% above average. California's crop, (6,806,000 pounds) was down from last year because of a smaller yield per acre, although the yield was above average. Acreage was 22% below average, more than offsetting any gain from above average yields.

Hop yards in Oregon produced a total of 5,400,000 pounds in 1963, 3% larger than 1962, but 4% below the 1957-61 average, according to the Oregon Crop and Livestock Reporting Service. Hop growers harvested 200 more acres in 1963, which more than offset the lower average yield per acre to give this year's larger crop. Oregon's 1963 hop production is valued at 2.4 million dollars, about equal to last year.

Throughout most of the producing States, a cool, wet spring was generally unfavorable for vine growth and resulted in mildew infestations in many yards. However, generally good growing weather prevailed during July and August and all areas had good to excellent weather for harvest. Yields of Late Cluster hops were generally disappointing in Washington, although Early Cluster yields were considered good. Early harvested crops in California showed some mildew damage and, because some yards did not mature properly, hops were small, soft, and lightweight. Climatic data for Corvallis, Oregon are given in Table 3.

Table 3. Climatological data taken at Hyslop Agronomy Farm, near Corvallis, Oregon, in 1963 and during previous years.

Month 1962	Avg. Max. Temp. (°F) 1963	Norm.	Avg. Min. Temp. (°F) 1963	Norm.	Avg. Mean Temp. (°F) 1963	Norm.	Precipitation (inches) 1963	Norm.
Oct.	61.74	64.69	43.48	43.45	52.61	54.28	4.62	3.53
Nov.	54.40	53.13	39.33	37.51	46.87	45.36	7.89	5.44
Dec.	47.29	48.06	35.77	34.66	41.53	41.70	2.90	6.15
1963								
Jan.	41.48	45.34	25.68	32.53	33.58	38.96	1.64	6.42
Feb.	56.07	50.54	38.96	35.07	47.51	42.80	5.23	5.10
Mar.	53.77	55.34	35.52	36.98	44.65	46.17	6.30	4.06
Apr.	54.63	62.32	38.90	40.49	46.77	51.41	4.64	2.10
May	66.71	68.80	44.45	44.95	55.58	56.86	3.94	1.85
June	70.37	73.44	48.07	49.34	59.54	61.42	.98	1.29
July	74.03	81.31	50.03	51.88	62.03	66.66	.52	.32
Aug.	78.74	80.95	51.61	51.41	65.18	66.24	.65	.38
Sept.	77.4	76.8	51.1	48.9	64.3	62.8	.94	1.30
Yearly total							37.94	40.25
Yearly mean	63.39	61.39	42.26	41.91	52.80	51.73		

	Rel.humid. @8AM (%)		Evaporation (in.)		No. clear		No. ptly. cloudy		No. cloudy		No. rainy		Avg.wind velocity MPH	
	1963	Norm.	1963	Norm.	1963	Norm	1963	Norm	1963	Norm	1963	Norm	1963	Norm
Month 1963														
Apr.	89.73	79.98	2.612	2.554	1	9	11	12	18	9	27	14	2.18	2.15
May	82.00	77.02	4.312	4.066	9	11	14	12	8	8	13	12	2.11	1.62
June	75.41	76.07	5.200	4.664	6	10	13	11	11	9	13	9	2.17	1.88
July	80.77	71.29	6.516	4.434	4	18	20	10	7	3	10	3	2.40	2.02
Aug.	85.77	76.20	8.160	6.088	11	17	17	9	3	5	9	3	1.99	1.72
Sept.	90.68	81.47	4.679	3.966	14	15	13	10	3	5	8	6	1.57	1.82
Total					45	80	88	64	50	39	80	47		
Mean	84.06	77.	5.246	4.295	8	13	15	11	8	7	13	8	2.07	1.87

CRe5-1 (OAES FC:36) BREEDING AND EVALUATING NEW AND IMPROVED VARIETIES OF HOPS

S. N. Brooks

The work done under this line project consists of development of improved varieties of hops, studies of techniques of breeding or evaluating genetic lines, basic studies of inheritance or inherent variation in the plant itself, and studies on the botany of hops. The report is divided into three sections:

(1) That phase dealing with crossing and initial selection of seedlings,
(2) Preliminary and advanced evaluation of selections for field performance, and
(3) That phase of this project dealing with botanical and genetic studies.

BREEDING AND SELECTION

Exchange of Germ Plasm

No introductions were received into the hop breeding program in 1963, and no material was sent to other countries. Current requests from Taiwan for commercial varieties, and from England for Wild American material, will be filled in 1964.

1963 Selections

Five clones in the 1961 nursery at Corvallis were selected for continuation and will be increased for preliminary evaluation. Accession numbers and parentages are given in table 1.

Table 1. Selections saved at Corvallis in 1963.

Accession No.	Cross No.	Parentage
C 61001	60069	1/4 Str; 5/64 Fu; 3/64 Bel; 1/32 ea. OR, LG, EG, LC; 1/64 KG; 39/64 X
C 61002	60070	1/8 LG; 1/16 Fu; 13/16 X
C 61003	60028	1/2 Ha; 3/8 Fu; 1/8 X
C 61004	60033	3/8 LG; 3/16 Fu; 1/8 EKG; 1/16 Bav; 1/4 X
C 61005	60058	1/2 WA; 1/2 X

Material sent to Prosser in 1962 was examined by C. E. Nelson. Twelve selections which performed well were fairly early maturing. Since hop growers want to have a range of maturities, and it is difficult to get good, early varieties, these selections were marked for inspection again in 1964. The entire nursery will be kept another year. Performance notes for 1963 are appended to this report.

Nurseries Established in 1963

No material was sent to Prosser, Washington in 1963, because the seedlings had not all produced sufficient rhizome growth for propagation.

Instead an additional year's observations were made on the 1961 nursery material at Corvallis. On the basis of mildew reaction and vigor 130 female clones were selected to be included in the 1964 Prosser nursery. These are listed in the Appendix.

A seedling nursery of 587 clones from 38 crosses made in 1962 was planted under low trellis at a 4' x 8' spacing. The nursery was made up as follows:

Table 2. Planting plan of 1963 seedling nursery.
(Rows numbered East from Smith Lane)

Row	Cross number and number of plants in progeny
48	62004 - 52
47	62006 - 52
46	62011 - 52
45	62013 - 52
44	62005 - 48
43	62008 - 30; 62014 - 16; 62009 - 5; 62016 - 1
42	62003 - 28; 62015 - 14; 62012 - 8
41	62001 - 3; 62007 - 5; 62034 - 6; 62035 - 4; 62010 -30
40	62002 - 29; 62017 - 3; 62018 - 3; 62019 - 8; 62021 - 9
39	62020 - 13; 62023 - 3; 62025 - 3; 62027 - 8; 62028 - 15; 62030 - 2; 62031 - 3; 62032 - 1; 62033 - 1; 62043 - 2
38	62036 - 26; 62040 - 5; 62041 - 1; 62042 - 2; 62029 - 12
37	62037 - 32

Seedling Reaction of 1962 Crosses to Downy Mildew

(C. E. Horner)

Approximately 3000 seedlings representing progenies from 43 crosses were evaluated for resistance to systemic downy mildew crown infection.

Procedure:

Seedling were grown in the greenhouse from February to August. Aerial stems were clipped and the soil pushed away from one side of the upper crown.

Inoculum was obtained by washing downy mildew spores from naturally infected leaves and shoots collected in the field. Inoculum was derived from several lines and varieties to include possible races of the pathogen. Spore suspensions were filtered to remove debris and placed at 20°C. to germinate. When spores were actively germinating, 5 ml of spore suspension was deposited against the exposed crown of each plant by use of an automatic pipette. This method of inoculation had proved to be more rapid and to result in fewer escapes than previous methods (1962 report p. 10.)

Twelve weeks after inoculation all plants were dug, washed and individually checked for systemic crown infection.

Results:

Seedlings were derived from 5 groups of crosses: (1) backcrosses of Late Cluster, Early Cluster, Brewers Gold, Hallertau, and Backa with mildew resistant males, (2) Fuggle x Wild American males, (3) Wild American x Wild American males and females from 4 states, (4) 107-I, 135-I (mildew resistant) and Bullion x high alpha acid males, and (5) Pollen storage tests.

Backcrosses

A total of 981 seedlings from 16 crosses was available for analysis. Table 1 shows the downy mildew reaction of progenies from backcrosses of Early Cluster, Late Cluster, Brewers Gold, Backa, and Hallertau with resistant males.

Table 1. Backcrosses, 1963

Cross Number and Female Parent		No. of Plants Tested	No. Resistant	No. Susceptible	% Resistant	No. Kept
Late Cluster	1	3	3	0	100.0	3
	2	58	29	29	50.0	29
	3	44	28	16	63.6	28
Total		105	60	45	57.1	60
Brewers Gold	4	287	217	70	75.6	57
	5	99	48	51	48.5	48
	6	82	59	23	71.9	54
	7	6	4	2	66.7	5
Total		474	328	146	69.2	164

Table 1. Backcrosses, 1963 (cont.)

Cross Number and Female Parent		No. of Plants Tested	No. Resistant	No. Susceptible	% Resistant	No. Kept
Hallertau	8	66	37	29	56.1	30
	9	7	5	2	71.4	5
	10	69	50	19	72.5	30
Total		142	92	50	64.8	65
Backa	11	92	72	20	78.3	52
	12	11	8	3	72.7	8
	13	116	80	36	69.0	54
	14	19	16	3	84.2	16
Total		238	176	62	74.0	130
Early Cluster	15	21	14	7	66.7	14
	16	1	1	0	100.0	1
Total		22	15	7	68.2	15
Grand Total		981	671	310	68.4	434

Fuggle x Wild American

These crosses yielded 808 seedlings for analysis, a high percentage of which were resistant as shown in Table 2.

Table 2. Fuggle x Wild American, 1963.

Cross Number	No. of Plants Tested	No. Resistant	No. Susceptible	% Resistant	No. Kept
19	159	152	7	95.6	8
20	338	309	29	91.4	13
21	208	170	38	81.7	9
22	37	29	8	78.4	0
23	38	29	9	76.3	3
24	2	0	2	0.0	0
25	26	23	3	88.5	3
Total	808	712	96	88.1	36

Wild American x Wild American

Eleven crosses yielded 812 seedlings for analysis. Table 3 shows that the crosses varied considerably in the percentage of resistant seedlings.

Table 3. Wild American x Wild American, 1963

Cross Number	No. of Plants Tested	No. Resistant	No. Susceptible	% Resistant	No. Kept
17	38	22	16	57.9	3
18	219	178	41	81.3	3
26	19	10	9	52.6	0
27	194	138	56	71.1	8
28	84	41	43	48.8	15
29	156	88	68	56.4	12
30	12	10	2	83.3	2
31	67	58	9	86.6	3
32	3	2	1	66.7	1
33	10	9	1	90.0	1
34	10	6	4	60.0	6
Total	812	562	250	69.2	54

High Alpha Acid Crosses

Only 96 seedlings from 3 of the 5 crosses were successfully grown. Table 4 shows that a high percentage of these were resistant.

Table 4. High Alpha Acid Crosses, 1963

Cross Number	No. of Plants Tested	No. Resistant	No. Susceptible	% Resistant	No. Kept
35	4	4	0	100.0	4
36	40	26	14	65.0	26
37	52	41	11	78.8	32
Total	96	71	25	74.0	62

Pollen Test Crosses

Four crosses using stored pollen yielded 122 seedlings for downy mildew testing.

Table 5.

Cross Number	No. of Plants Tested	No. Resistant	No. Susceptible	% Resistant	No. Kept
40	96	71	25	74.0	5
41	5	5	0	100.0	1
42	4	4	0	100.0	2
43	17	13	4	76.5	2
Total	122	93	29	76.2	10

Discussion and Conclusions:

Nearly every year improvements have been made in the procedures used for testing mildew reaction of seedlings. Minor refinements of the currently used procedures will allow us to test large numbers of plants. The data from the 1963 tests lead me to believe that many plants escaped infection since the proportion of resistant plants is unusually high. I believe this problem can be overcome in future tests by providing environmental conditions more favorable for infection during the first 3-4 days after inoculation than existed in the tests reported above.

Crosses made in 1963

Seeds from 24 crosses and open-pollinated sources were collected at Corvallis in 1963. In addition, open-pollinated seeds from two of Prof. Zattler's (Hüll) downy mildew resistant clones were received from Dr. R. A. Neve of Wye College, England.

The seed lots were treated similarly to last year with an additional spraying of Captan formulation to reduce growth of micro-organisms. Following 6 weeks at 38°F. they were pre-germinated for 24 hours and planted in flats in the greenhouse.

The soil mixture used for the 1963 crosses was somewhat different than in past years in that it was made up of used mushroom-growing medium at a ratio of 1:1 in addition to about 1,000 lb./a of 13-13-13 and 1.5 T/a. lime added to the topsoil. Watering is to be by sub-irrigation to reduce seedling casualties.

Crosses in 1963 were as follows:

A. Back-crossing program (BC):

Females	Characters to be improved
Late Cluster	Downy mildew resistance
Early Cluster	Downy mildew resistance
Brewers Gold	Downy mildew resistance
Hallertau	Downy mildew resistance and vigor
Backa	Downy mildew resistance and vigor

Males	Reasons used as parents
526-4 or 524-2	Wild Americans with good vigor
123-S	Very vigorous and resistant to downy mildew
421-1, 2	Very vigorous and resistant to downy mildew
121-2	Very vigorous and resistant to downy mildew

Remarks:

1. Downy mildew resistant male seedlings will be grown and crossed back to parental varieties for several (2-5) generations.
2. Purpose is to duplicate quality of varieties acceptable to brewing industry in varieties improved in downy mildew resistance and, in case of Hallertau and Backa, in vigor.

B. Combination of downy mildew resistance and high α-acid (Rα):

135-I (1123 DN) x 119-1, 2
(Highly resistant) (18% α)

Remarks:

1. Additional crosses in this series will be made in 1964 using 135-I and 107-I (highly resistant), and Bullion (resistant) with 119-1, 2 and 120-1, 2,

both high ∝-acid males.
2. Selection will be made for downy mildew resistance and high ∝-acid content, singly and in combination.

C. Reconstruction of 128-I (∝):

Bullion (1023 DN) x 219-4

1. Pedigree of 128-I is 1/2 Bullion, 1/4 Samling, 1/4 Unknown. Male parent of 128-I is gone. Pedigree of 219-4 is 1/4 Brewers Gold, 1/4 Samling, plus 1/2 other germ plasm.
2. Additional crosses will be made in 1964 using 123-S (a male which is 1/2 Bullion) on 61-S, 62-S, and 64-S (all females which are 1/2 Samling).

D. Breeding for yield (SY):

Females	Characters
103-I (10-S)	Medium maturity, very good vigor, downy mildew resistant
Fuggle	Early maturity, medium vigor, downy mildew resistant
Hallertau	Medium maturity, poor vigor, downy mildew susceptible

Males	Characters
106-S	Very early maturity, poor vigor, medium ∝-acid
110-S	Medium maturity, medium vigor, medium ∝-acid
119-1, 2	Very late maturity, very good vigor, high ∝-acid.

Remarks:

1. Yield and vigor will be tested at different fertility levels to elucidate growth efficiency and interaction with environment.
2. Data will be obtained also on maturity, ∝-acid, and downy mildew reaction.
3. Selection will be made for downy mildew resistance, and particular attention will be paid to early maturity. Seedlings will be screened and selected according to usual procedures.

Table 1

Crosses for 1963

Cross No.		Parentage
63001	BC	122 - I 19208 x 121-2 C 19062 M
63002	BC	122 - I 19208 x 421-1, 2 C 19040 M
63003	BC	122 - I 19208 x 524-2 I 58006 M
63004	SY	222 - I 19209 x 106-S C 19170 M
63005	SY	222 - I 19209 x 110-S C 19173 M
63006	SY	222 - I 19209 x 119-1, 2 C 19058 M
63007	BC_2	311 - I 19001 x 5-29-4 I 19001 x C 19062 M
63008	BC	311 - I 19001 x 123-S C 19182 M
63009	SY	322 - I 56001 x 106-S C 19170 M
63010	SY	322 - I 56001 x 110-S C 19173 M
63011	SY	322 - I 56001 x 119-1, 2 C 19058 M
63012	BC	322 - I 56001 x 526-4 I 58015 M
63013	BC	422 - I 56002 x 123-S C 19182 M
63014	BC	422 - I 56002 x 121-2 C 19062 M
63015	BC	422 - I 56002 x 421-1, 2 C 19040 M
63016	BC	522 - I 59001 x 121-2 C 19062 M
63017	BC	522 - I 59001 x 123-S C 19182 M
63018	BC	522 - I 59001 x 421-1, 2 C 19040 M
63019	α	1023 - DN I 55081 x 219-4 C 51061 M
63020	Rα	1123 - DN C 19151 x 119-1, 2 C 19058 M
63021	SY	10-S C 19105 x 119-1, 2 C 19058 M
63022	SY	10-S C 19105 x 110-S C 19173 M
63023	SY	10-S C 19105 x 106-S C 19170 M
63024	ZN	7 K 491 x O.P. (Zattler material from Wye)
63025	ZN	2 L 118 x O.P. (Zattler material from Wye)
63026	LC	I 19208 x O.P.

Table 2 Notes on Greenhouse planting of 1963 crosses

Cross No.	6 wk. germ.	Germ. date wks.	Plant date	No. planted	Emerg @ 10 days	% Emerg.	Repl.	No. albino	Gen. remarks
63001	-	8 ?	3-18	300	48	16	-		20% dbl heads, 5% w/o epicotyl
2	-	9 ?	3-19	77	4	5	-		
3	-	9 ?	3-19	194	5	3	-		(Cross 1,2 & 3 should not have been
4	+	6	3-5-64	600	392	65	+		(planted till later.
5	+	6	"	600	349	58	-		25% w/light yellow leaves.
6	+	6	"	600	326	54	+		
7	+	6	"	540	251	46	-		5% w/narrow leaf.
8	+	6	"	180	124	69	-		2% w/narrow leaf & yellow.
9	+	6	"	600	354	59	+		10% dormant? w/crowns.
10	+	6	"	600	410	68	-		
11	-	7	3-10	600	293	49	+	69	
12	+	6	3-10	60	36	60	-		5% w/o epicotyl, 2% yellow leaf
13	-	7	3-11	229	126	55	-	13	20% w/dry leaves, DO?
14	-	8	3-13	600	491	82	-		
15	-	7	3-11	600	497	83	+		
16	- ?	7	3-11	600	204	34	+		3% w/dbl heads.
17	-	9	3-18	360	56	16	-		2% w/long narrow leaves.
18	-	9	3-18	384	84	22	-		poor germination
19	+	6	3-10	600	395	66	+		2% narrow leaf & yellow.
20	-	8	3-13	600	342	57	+		1% narrow leaf, DO serious?
21	-	8	3-13	538	269	50	-		2% narrow leaf w/dbl head.
22	+	6	3-11	600	323	54	+(all)		5% yellow narrow leaf.
23	+	6	3-11	600	384	64	+		
24	+	6	3-11	600	378	63	+	12	
25	+	6	3-11	600	409	68	+	32	
26	+	6	3-10	4500	2346	52	+		25% w/white blotched leaves, 2% top burn, 1% yellow narrow leaf.

< 1% w/o epicotyl < 1% w/dbl head.

Soil mix

8 parts by vol fsl
2 " " " peat
1 " " " mushroom OM.
25 g 13-13-13 fert
60 g hyd. lime (to pH 6.3)

Seeds planted 1/2 to 3/4 in. deep.

Flats drenched with 1000 ppm Captan on March 17, 1964 and immediately after planting on 3/18 & 19.

Colchicine Treated Hops

Objectives:

To develop 4-n Fuggle hops which can be crossed with several male plants to obtain 3-n Fuggle-like genotypes.

Methods:

Water solutions of either 0.6% or 0.75% colchicine were painted on terminal buds of potted Fuggle plants for 3 or 4 days in June, 1963. In subsequent weeks Miss Penny Hawkins examined the laterals from these buds according to the following techniques:

The leaves taken for examination should be between 2-3 mm. They are very close to the growing point and are carefully removed with tweezers, having parted the protecting bracts. These leaves are immersed in a saturated solution of p-dichlorobenzene in a labelled tube for not less than 1 and not more than 2 hours. This is a prefixative which shortens the chromosomes. It is very important to label the lateral from which the leaves have come, and have the leaves labelled with the same code. The leaves are fixed in 1:3 acetic alcohol; the prefixative is pipetted out of the tube and acetic alcohol put in its place. The leaves should be fixed for at least 12 hours. This will keep them for some time.

The leaves are removed from the fixative and dried on a filter paper. The leaves are then put in 2 or 3 drops of acetic-orcein, N hydrochloric acid in a cavity slide. After the leaves have been put in, the slide is gently warmed until the stain begins to retract at the edges, and then left for about 10 minutes.

A small piece of leaf is put in a drop of acetic orcein on a plain slide, covered with a cover glass (No.1, 22 mm sq), and treated as follows:

Warm;
Blot gently;
Run in a very little more stain and warm again gently;
Place on a flat surface and spread the cells by tapping the cover glass with a needle using short vertical strokes (while doing this hold the cover glass in place with finger tips on one end);
Run in more stain if necessary, heat, and place between several sheets of blotting or filter paper (apply vertical pressure with the thumb directly above the squash area to flatten the cells);
Hold the slide over the spirit flame as long as you dare, making sure the preparation does not boil.

Acetic-orcein is used as 1% solution in 45% acetic acid. Because of deterioration in dilute acid, it is kept in a stock solution of 2.2% in glacial acetic acid. This is made up by dissolving 2.2 gms orcein in 100 c.c of glacial acetic acid, with gentle boiling. Then cool and dilute by adding 45 cc of this solution to 55 cc of distilled water. Filter if necessary (or just let it settle.)

10:1 acetic-orcein, N hydrochloric acid is made by adding one part of N. HCl to ten parts of 1% orcein in 45% acetic acid.

Brief results:

Plant A. Treatment of 0.6% three times a day for 4 days, June 4-7: Material examined on July 15. No 4-n tissue on the lateral examined.

Plant B. Treatment of 0.75% for 3 days, June 4-6, three times a day: First lateral examined, one 4-n cell found.

Plant C. Treatment of 0.75%, 3 times a day for 3 days, July 4-6: First two laterals were examined and a mixture of 2-n and 4-n tissue found on both. One lateral numbered C1. was struck on July 17.

Plant D. Treatment of 0.60%, 3 times a day for 3 days, June 11-14. Two laterals from the same node examined on July 22. One lateral, D1 contained some tetraploid tissue. None was found in D2.

Plant E. Treatment of 0.60% on June 5-7 (4 times): Tetraploid tissue found in the lateral E.1.

Examination of a 2nd lateral in A1. resulted in no tetraploid tissue found.

Summary:

About 40 buds of potted Fuggle plants were treated with colchicine in June for the purpose of inducing tetraploidy. Treatments consisted of painting-on either a 0.60% or a 0.75% concentration 3 times a day for 3 or 4 days. Thirty buds survived and were examined for ploidy in subsequent weeks.

Some success was attained in inducing the formation of 4n cells, but many of the buds (or propagules from them) have been sorted out because examination showed that they were not chimeras. Those that have shown mixtures of 4n and 2n tissue are being continued with the hope of concentrating the 4n tissue. The ultimate success of this phase of the program depends upon getting at least one propagule with a sufficiently high degree of tetraploidy that the germ line is involved. It will then be crossed with a 2n male to produce a 3n Fuggle-like variety.

EVALUATION

Objectives:

1. To provide preliminary quality evaluation of new selections and make observations on vigor and disease reaction.

2. To make preliminary field evaluation of new selections in replicated variety trials.

3. To provide advanced field and quality evaluation of experimental varieties.

4. To increase planting stock of promising experimental varieties for ultimate distribution.

Results:

Preliminary Quality Evaluation

Twenty-one samples of experimental lines were submitted for brewer evaluation in 1963. Four of these were furnished by C. B. Skotland. All had 4.5% alpha-acid except 2 which had produced more alpha-acid in previous years and were included. An additional 2 samples were submitted only to R. G. Wright because of limited amounts of hops.

The samples were all dried at 140°F, and approximately 0.5 pounds of SO_2 per 100 pounds of fresh hops were introduced into the drying air. Drying times for the several lots ranged from 5.5 to 9 hours.

Quality data supplied by S. T. Likens are included in table 1, followed by chromatographs of the oil samples. The column used for the oil separations was 1/8" x 25' aluminum with 2% butanediolsuccinate on chromosorb.

Results of USBA physical evaluation are given in tables 2, 3, 4, and 5.

Discussion:

Samples submitted to USBA this year were objectionable in several respects. We experienced some difficulty in electrical power during drying this year which undoubtedly accounts for part of the problem. In addition there were comments regarding immaturity in some cases. Because of the poor appearance of the 1963 samples, the project has discussed ways of improving bale samples in future years. Following is a list of suggestions made by S. T. Likens:

1. Our primary problem is one of production, that is, in order to put up a satisfactory sample, it should be at least 1/2 lb. which would require at least 20 lb. green hops. I would not presume to question how this should be accomplished, however I feel we should explore every possibility.

2. The second problem, as I see it, is to better gauge the maturity of each genotype. Immediately, we should be able to improve this aspect by more frequent observations and/or more detailed notes. In the longer run, I think

it may be possible to develop a miniature chemical test, at least for ∝-acid. I will look into this.

3. The third operation of consequence in preparing satisfactory samples is picking. We would obviously improve sample appearance by hand picking but would lose the pickability data. I feel the pickability information is necessary and would suggest we continue use of the machine.

4. Drying is probably the most difficult problem we face, considering the necessity of handling several genotypes simultaneously when their drying characteristics may be quite different. I think we can make several changes to improve the ease and reliability of this operation. Let's consider the following procedure:

a. Pick up to 4 genotypes in the A.M. and move them immediately to the dryer to prevent the possibility of sack burn.
b. Build 8 ea., 4' x 6' x 1.2' trays with screen bottoms and load 1 genotype per tray.
c. The sulfuring operation has been worked out by Dr. Brooks and me, but we still need to buy a flow meter gauge. I will take care of this.
d. Use reversed air flow in order to prevent cones from bouncing if the air flow is too high.
e. Dry at 130° straight through. I think this is best for oil preservation (aroma).
f. Remove the trays as the individual genotype is dry.

5. Thin layers exposed to atmosphere on both top and bottom, such as we would have in the trays, should allow adequate moisture distribution by the third day (36-48 hours).

6. Since the committee is most accustomed to normal bale-density and since lupulin damage is least, we should bale at 11-13 lb./cu.ft. After 3-7 days the top board on the bales should be cut with a band-saw and the bale sliced with a knife. The 1/2 lb. bales should be trimmed, wrapped and labeled as usual.

7. While awaiting shipment, all samples should be kept at -5°C.

8. Shipment to USBA committee members should be air express to insure that some samples do not lie around in hot mail rooms.

This may be considered as biasing judgement by processing in a manner which may not be commercially practical. However, this should produce samples indicating the potential of the genotype, after which the processing requirements could be determined. The additional effort such a processing program would require seems small in proportion to the advantages.

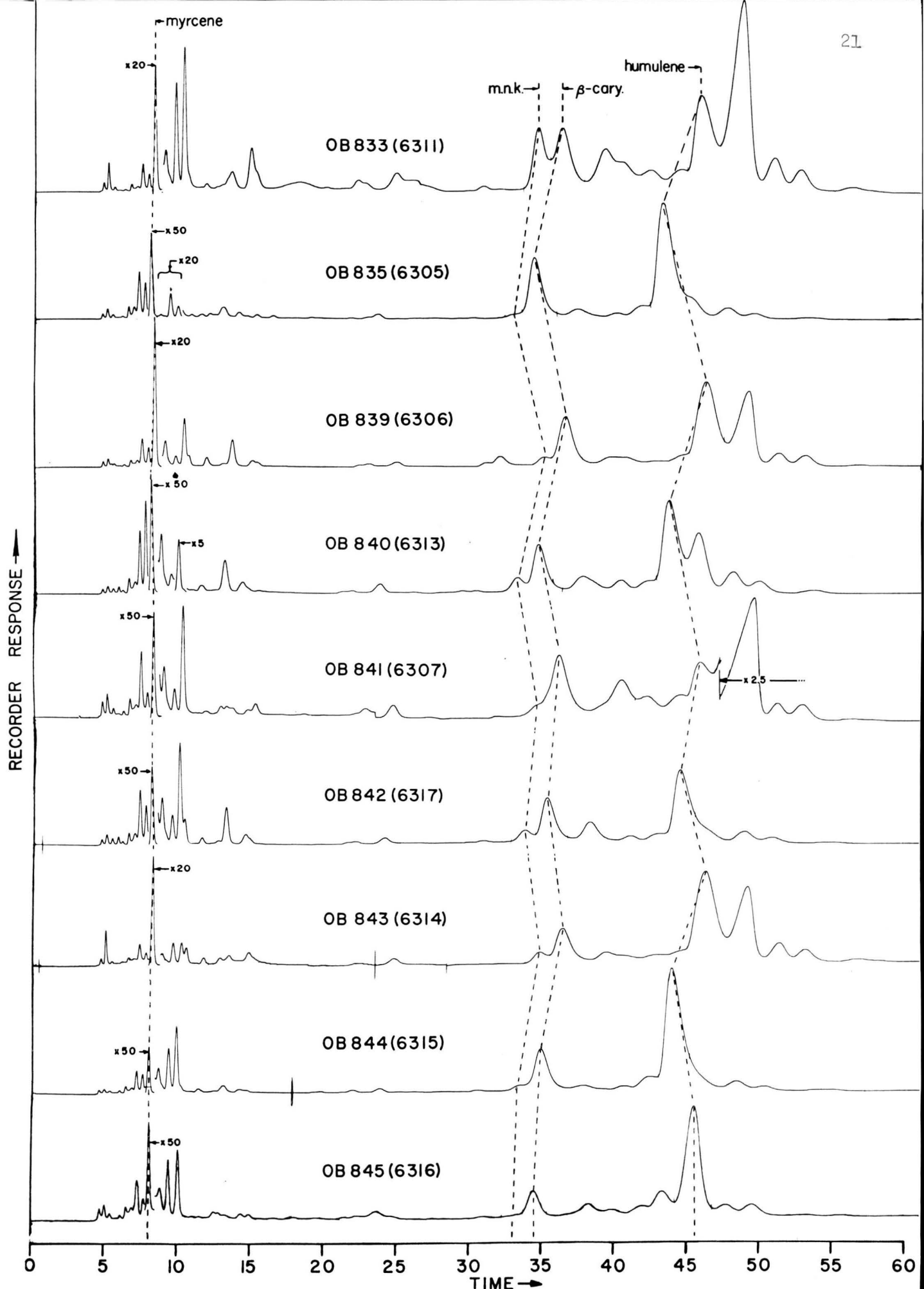
Table 1. Quality data on coded hop samples submitted in 1963

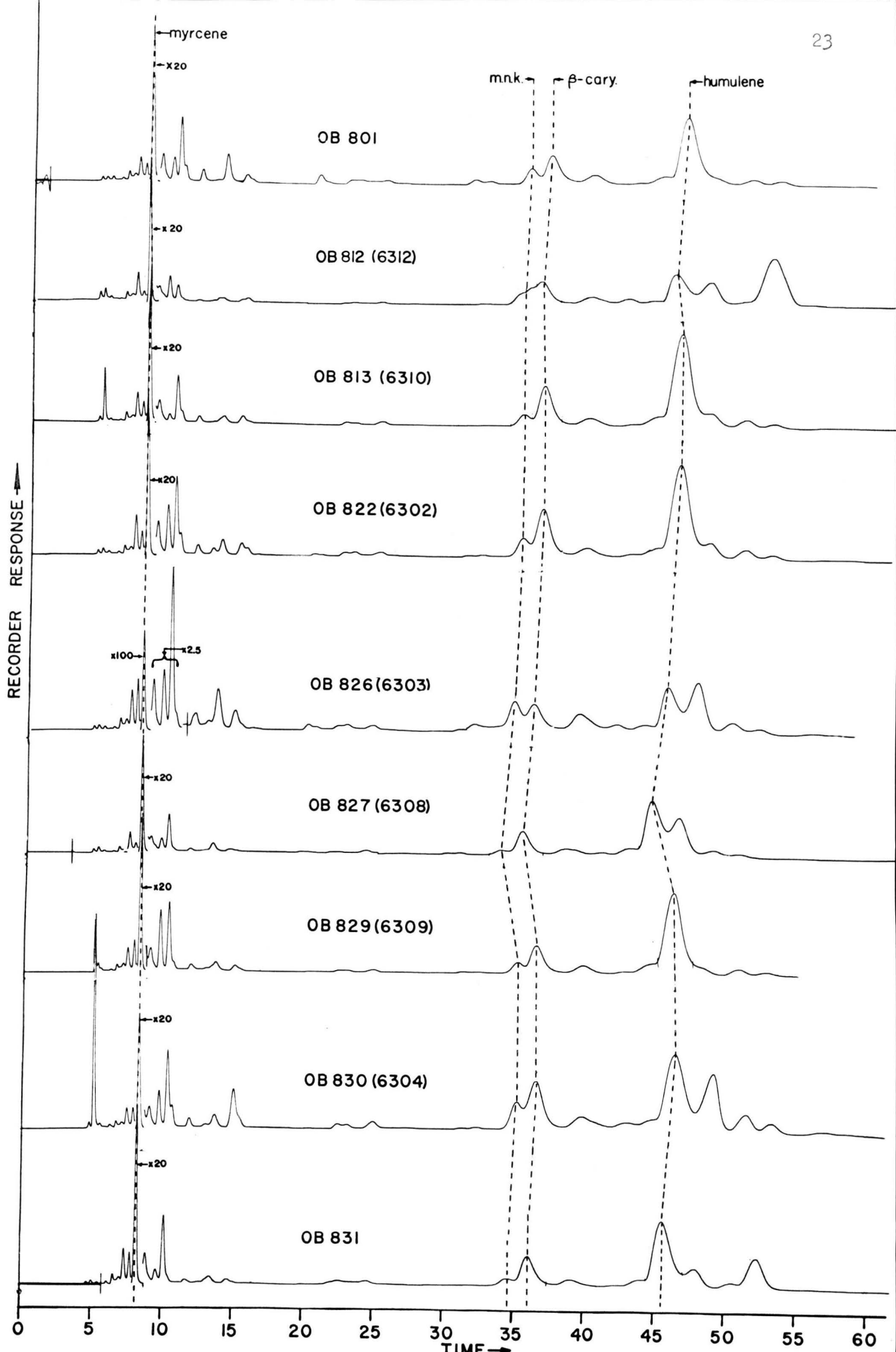
Sample	Code No.	Moisture	Oil content	% α	% β	Harvest date	Pickability
OB 822	6302	8.85	1.19	6.71	6.25	9/13	Poor pickability
OB 826	6303	9.10	2.44	10.43	5.15	9/13	Good pickability
OB 829	6309	8.40	0.98	4.72	5.25	9/13	Poor pickability
OB 813	6310	9.65	1.82	8.99	6.79	8/30	Good pickability
OB 833	6311	8.25	0.44	4.86	3.86	9/17	Average pickability
144-I	6319	11.50	1.21	4.83	3.90	9/4	Good pickability
OB 827	6308	9.65	1.18	8.16	3.41	8/30	Poor pickability
OB 835	6305	8.60	0.88	7.11	2.32	9/17	Very good pickability
OB 840	6313	9.75	1.45	5.68	4.73	9/17	Very poor pickability
OB 842	6317	10.50	0.75	4.67	5.10	9/23	Poor pickability
OB 844	6315	10.00	1.04	6.30	3.32	9/4	Average to poor pickability
OB 845	6316	9.65	0.61	4.95	4.13	9/9	Very poor pickability
OB 830	6304	9.25	0.72	7.08	3.39	9/9	Average to poor pickability
OB 839	6306	9.25	0.93	3.71 1/	4.60	9/9	Average to poor pickability
OB 841	6307	9.40	0.84	3.67 2/	3.19	9/9	Average pickability
OB 843	6314	8.95	1.16	7.58	3.37	9/17	Pickability unknown
128-I	6318	10.85	2.53	13.45	4.26	9/17	Very good pickability
L-1	6320	7.35	0.81	8.90	4.96	9/4	From CBS, Prosser, Washington
L-8	6321	6.85	0.75	9.70	5.34	9/9	From CBS, Prosser, Washington
E-Z	6322	7.85	0.98	9.18	4.73	9/4	From CBS, Prosser, Washington
E-21	6328	6.85	0.97	9.19	4.66	9/4	From CBS, Prosser, Washington
OB 801 3/		9.45	0.66	10.27	5.82	9/4	Insufficient sample for USBA, poor pickability
OB 831 3/		10.35	1.45	8.03	4.73	9/4	Insufficient sample for USBA, very good pickability

1/ In yield trial; 4.9 in 1961, 6.4 in 1962.

2/ In yield trial; 5.5 in 1962.

3/ Sent to RGW only.


myrcene
m.n.k.
β-cary.
humulene
x20
OB 833 (6311)
x50
x20
OB 835 (6305)
x20
OB 839 (6306)
x50
x5
OB 840 (6313)
x50
x2.5
OB 841 (6307)
x50
OB 842 (6317)
x20
OB 843 (6314)
x50
OB 844 (6315)
x50
OB 845 (6316)
RECORDER RESPONSE
0
5
10
15
20
25
30
35
40
45
50
55
60
TIME


myrcene
x20
m.n.k.
β-cary.
humulene
OB 801
x 20
OB 812 (6312)
x20
OB 813 (6310)
x20
OB 822(6302)
x100
x2.5
OB 826(6303)
x20
OB 827 (6308)
x20
OB 829(6309)
x20
OB 830 (6304)
x20
OB 831
RECORDER RESPONSE
0
5
10
15
20
25
30
35
40
45
50
55
60
TIME

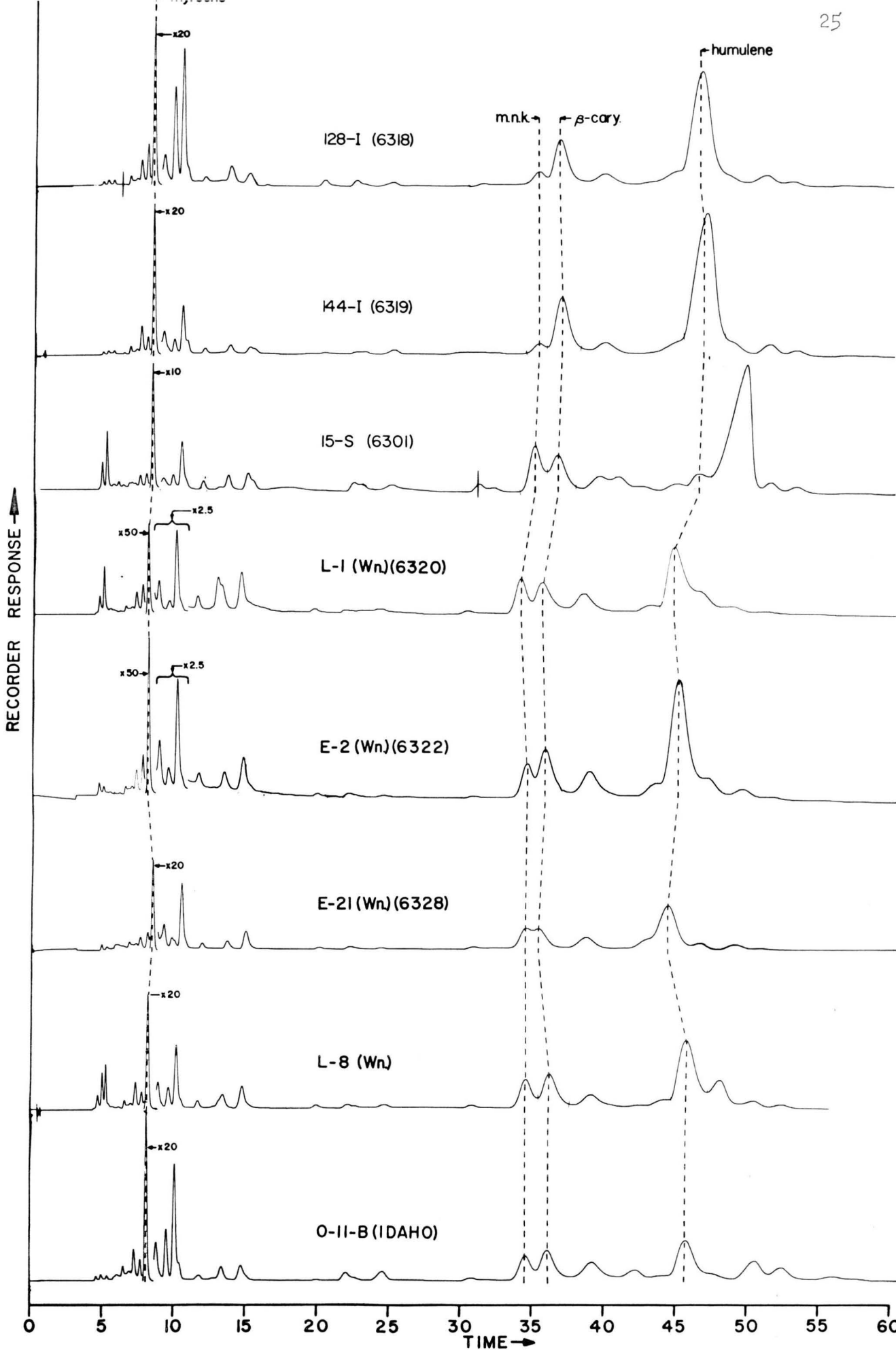

humulene
m.n.k.
β-cary.
128-I (6318)
144-I (6319)
15-S (6301)
L-1 (Wn)(6320)
E-2 (Wn)(6322)
E-21 (Wn)(6328)
L-8 (Wn)
O-11-B (IDAHO)
x20
x10
x2.5
x50
RECORDER RESPONSE
0
5
10
15
20
25
30
35
40
45
50
55
60
TIME

Table 2. Hand evaluation by USBA of 1963 hop samples for each criterion.

	Olympia	F & M Schaefer	Anheuser-Busch	Schwarz Labs.	Canadian Breweries	Falstaff	FVK	P. Ballantine & Sons	FEC	Remarks
OB827(6308)										
Appearance	3.5	4	4	4.3	4	4	3	3		
Cone size	3	4	3.5	4	2	4	2	3		
Lupulin	7	10	6.5	12	10	12	8	12		
Aroma	9	14	7	15	16	12.5	11	13		
Desirability	7	10	9	12	12	9	8	10		
	29.5	42	30	47.3	44	41.5	32	41		
OB835(6305)										
Appearance	2	3	3	3.7	2	3.5	1	2		
Cone size	3	3	3	4	2	4	2	3		
Lupulin	9	7	7.5	12	9	11.5	12	5		
Aroma	14.5	12	7	18	12	13	15	13		
Desirability	11	8	9	13.5	7	8.5	11	7.5		
	39.5	33	29.5	51.2	32	40.5	41	30.5		
OB840(6313)										
Appearance	2	3	2.5	3.7	2	3	2	1		
Cone size	3	2	2.5	4	3	3	2	1		
Lupulin	8	7	7	9	8	8.5	8	2		
Aroma	5	15	5	12	12	11	12	10		
Desirability	4.5	12	8	10.5	6	7 ②	8	0		
	22.5	39	25	39.2	31	32.5	32	14 ①		
OB842(6317)										
Appearance	2.5	2	1.5	3.3	1	2.5	1	0		
Cone size	3	3	4	4	2	3	1	1		
Lupulin	6.5	10	6.5	7.5	5	10	7	6		
Aroma	7.5	5	8	10	6	11	8	0		
Desirability	6.5	5	5.5	4.5	5	7	6	0		
	26	(25)	25.5	29.3	19	33.5	23	(7) ①		
OB844(6315)										
Appearance	3.5	3	4.5	3.7	3	4	4	Too green to evaluate		Electrical failure during drying
Cone size	3	4	3.5	5	2	3	2			
Lupulin	5.5	10	9.5	10.5	9	10.5	7			
Aroma	6.5	12	11.5	20	6	12.5	10			
Desirability	5.5	9	6.5	15	6	7.5	8			
	24	38	35.5	54.2	26	37.5	31			
OB845(6316)										
Appearance	2	2	2.5	3	2	1.5	2	1		Electrical failure during drying
Cone size	2.5	2	3	5	2	2	3	3		
Lupulin	5	5	6.5	7.5	5	7	6	0		
Aroma	2.5	0	7.5	5	8	9.5	8	4		
Desirability	2.5	0	4.5	1.5	5	5.5	7	0		
	(14.5)	9 ①	24	22	22	25.5	26	8 ①		

( ) on total score reflects disparaging remarks such as "not commercial", "unsatisfactory", etc. ① poor kilning, spoiled sample. ② excessive seeds

Hand evaluation by USBA of 1963 hop samples for each criterion - cont.

	Olympia	F & M Schaefer	Anheuser Busch	Schwarz Labs.	Canadian Breweries	Falstaff	FVK	P.Ballantine & Sons	FEC	Remarks
OB822(6302)										
Appearance	3	3	3	3.7	1	3	3		2.5	
Cone size	3	4	2	3	2	3.5	3		3	
Lupulin	11.5	12	12	12	10	12	12		10	
Aroma	14.5	5	8	5	6	12	15		1	
Desirability	11	6	6	7.5	7	7.5	12		0	
	43	30	31	31.2	26	38 ⑨	45		16.5	
OB826(6303)										
Appearance	2	3	2	4	1	3	1		3	
Cone size	3	3	2.5	4	2	3.5	2		3	
Lupulin	13.5	14	13.5	15	12	14.5	15		12	
Aroma	7	17	9.5	15	7	17	18		15	
Desirability	6	12	7	12	10	13.5	14		11	
	31.5	49	34.5	50	32	51.5	50		44	
OB829(6309)										
Appearance	2	3	3.5	3.7	2	3.5	2		3	
Cone size	2	4	3.5	3	2	3	2		2	
Lupulin	6	12	9	9	8	11.5	12		5.5	
Aroma	10.5	16	13.5	10	8	13.5	16		9	
Desirability	8	12	11.5	7.5	8	5.5	13		6.5	
	28.5	47	41	33.2	28	37	45		26	
OB813(6310)										
Appearance	3.5	4	4	4.3	2	4	3		3	
Cone size	3	3	3.5	3	2	3.5	3		3	
Lupulin	11	12	13	13.5	9	12.5	14		10	
Aroma	3.5	12	13.5	15	5	15.5	16		10	
Desirability	4	9	11.5	12	4	11	13		7.5	
	(25)	40	45.5	47.8	22	46.5	49		33.5	
OB833(6311)										
Appearance	3	2	3	4	3	1.5	1		1.5	
Cone size	3	4	3.5	5	3	2.5	2		1	
Lupulin	5.5	8	10.5	9	7	10	8		3.5	
Aroma	4.5	8	13.5	12	11	9.5	7		3	
Desirability	4.5	6	9.5	10.5	10	5.5	5		5	
	(21)	28	40	40.5	34	29	23		13	
144-I(6319)										
Appearance	4	4	4.5	4.7	3	4.5	4		4.5	
Cone size	4	4	4	5	2	2	2		3	
Lupulin	7.5	10	11.5	9	8	10.5	7		3.5	
Aroma	5.5	4	11.5	10	2	7.5	7		3	
Desirability	5	5	9	7.5	3	5	5		5	
	26 ②	27	40.5	36.2	18	29.5	25		19 ⑧	

② apparently slack-dried.
⑧ immature
⑨ excessive seed

Hand evaluation by USBA of 1963 hop samples for each criterion - cont.

	Olympia	F & M Schaefer	Anheuser Busch	Schwarz Labs.	Canadian Breweries	Falstaff	FVK P. Ballantine & Sons	FEC	Remarks
OB830(6304)									
Appearance	2.25	4	1.5	3	1	3.5	4	3	Electrical
Cone size	2.5	4	3.5	3	2	2.5	5	5	failure
Lupulin	10.5	10	8.5	12	9	8	7	11	during
Aroma	14.5	14	5.5	15	6	9.5	12	15	drying
Desirability	11.5	12	5	10.5	4	4.5	10	15	
	41.25	44	24	43.5	22	28 ⑨	38	49	
OB839(6306)									
Appearance	3	2	2.5	3	3	3	4	5	Electrical
Cone size	2.5	3	3	4	4	4.5	5	5	failure
Lupulin	9	8	11	12	6	10	9	15	during
Aroma	10.5	12	11.5	20	13	12	8	16.5	drying
Desirability	8.5	8	8.5	13.5	5	0	7	15	
	33.5	33	36.5	52.5	31	29.5	33	56.5	
OB841(6307)									
Appearance	2.5	4	3.5	3.7	2	4	3	4.5	Electrical
Cone size	3	4	3	3	3	4	5	4	failure
Lupulin	9	10	13.5	15	7	12	10	10	during
Aroma	3.5	10	10.5	10	9	15	5	5	drying
Desirability	5	10	7.5	1.5	5	0	6	9	
	23	38	38	33.2	26	35	(29)	32.5 ②	
OB843(6314)									
Appearance	2	3	3	3.3	2	2.5	4	3.5	
Cone size	2.5	4	4	4	3	2.5	4	2	
Lupulin	9	10	10	15	9	10	9	6	
Aroma	8.5	13	15	18	11	13	7	6.5	
Desirability	8	10	8.5	12	7	6.5	6	6	
	30	40	40.5	52.3	32	34.5	30	24	
128-I(6318)									
Appearance	3.5	3	4	4.7	2	2.5	3	5	
Cone size	4	5	4.5	3	2	5	2	2	
Lupulin	10.5	12	10.5	15	14	13	7	5	
Aroma	4	17	13.5	15	7	18.5	8	5	
Desirability	5	12	7.5	7.5	4	13.5	7	0	
	(27)	49	40	45.2	29	52.5	27	17	
L-1(6320)									
Appearance	3	2	2.5	4	1	3.5	2	3	
Cone size	2.5	3	2.5	4	1	3	2	3	
Lupulin	11.5	8	9.5	15	12	11.5	10	5	
Aroma	14	10	14	20	14	14	7	15	
Desirability	11	6	9	13.5	8	11	6	11	
	42 ③	(29)	37.5	56.5	36	43	27	37 ③	

② apparently slack-dried
③ too much shatter
⑨ excessive seed

Hand evaluation by USBA of 1963 hop samples for each criterion - cont.

	Olympia	F & M Schaefer	Anheuser Busch	Schwarz Labs.	Canadian Breweries	Falstaff	FVK	P.Ballantine & Sons FEC	Remarks
L-8(6321)									
Appearance	3	4	3.5	4.3	3	3.5	3	3	
Cone size	3	4	4	5	4	5	2	2.5	
Lupulin	11.5	10	13	15	13	12.5	10	9	
Aroma	14	13	14	20	12	16.5	12	13.5	
Desirability	10.5	11	8.5	15	9	11	8	11	
	42	42	43	59.3	41	48.5	35	33 ③	
E-2(6322)									
Appearance	1.25	3	1.5	3.3	1	2	3	2	
Cone size	2.5	2	4	5	2	3	4	2	
Lupulin	9	12	8	13.5	12	11	8	11	
Aroma	4.5	0	11	5	12	13.5	10	15	
Desirability	4.5	0	8	1.5	7	8	7	11	
	21.75 ④	(17)	32.5	28.3	34	37.5	32	41	
E-21(6328)								not rated, baby	
Appearance	2.5	4	2	4	0	2	3		
Cone size	2.5	3	3	5	1	2	2		
Lupulin	10.5	8	13	15	12	11.5	10		
Aroma	10	16	14	18	5	14	12		
Desirability	7.5	13	9	13.5	4	9	10		
	33 ⑤	44	41	55.5	22	38.5 ③	37		
OB807									
Appearance							5	3	Electrical
Cone size							5	4	failure
Lupulin							12	10	during
Aroma							5	9	drying
Desirability							6	10	
							(33)	36 ⑥	
OB831									
Appearance							5	3	Electrical
Cone size							5	4	failure
Lupulin							10	10	during
Aroma							10	15	drying
Desirability							9	12	
							39	44	

③ too much shatter
④ evidence of mold and spider
⑤ shattered and not well dried
⑥ not well dried

Table 3. 1963 USBA evaluation of hop samples

	Olympia	Schaefer	Anheuser Busch	Schwarz	Canadian Breweries	Falstaff	Ballantine FVK	Ballantine FEC	Average
OB827	29.5	42	30	47.3	44	41.5	32	41	38.4
OB835	39.5	33	29.5	51.2	32	40.5	41	30.5	37.2
OB840	22.5	39	25	39.2	31	32.5	32	14	29.4
OB842	26	(25)	25.5	29.3	19	33.5	23	7	23.5
OB844	24	38	35.5	54.2	26	37.5	31	--	35.2 (7 only)
*OB845	(14.5)	9	24	22	22	25.5	26	8	18.9
OB822	43	30	31	31.2	26	38.0	45	16.5	32.6
OB826	31.5	49	34.5	50	32	51.5	50	44	42.8
OB829	28.5	47	41	33.2	28	37.0	45	26	35.7
OB813	(25)	40	45.5	47.8	22	46.5	49	33.5	38.7
OB833	(21)	28	40	40.5	34	29.0	23	13	28.6
144-I	26	27	40.5	36.2	18	29.5	25	19	27.6
*OB830	41.25	44	24	43.5	22	28.0	38	49	36.2
*OB839	33.5	33	36.5	52.5	31	29.5	33	56.5	38.2
*OB841	23	38	38	33.2	26	35.0	(29)	32.5	31.8
OB843	30	40	40.5	52.3	32	34.5	30	24	35.4
128-I	(27)	49	40	45.2	29	52.5	27	17	35.8
L-1	42	(29)	37.5	56.5	36	43.0	27	37	38.5
L-8	42	42	43	59.3	41	48.5	35	33	43.0
E-2	21.75	(17)	32.5	28.3	34	37.5	32	41	30.5
E-21	33	44	41	55.5	22	38.5	37	--	38.7 (7 only)

* Poor drying because of electrical failure.
( ) Off aroma, not commercial, or other remarks regarding quality

Table 4. Ranking of 1963 hop samples according to USBA evaluation.

Harvest date		Olympia	Schaefer	Anheuser Busch	Schwarz	Canadian Breweries	Falstaff	Ballantine FVK	Ballantine FEC	Average	
8/30	OB827	10	6	16	10	1*	6	10	4*	6	
9/17	OB835	5*	13	17	7	6	7	5*	10	8	
9/17	OB840	18	10	19	14	9	16	11	16	17	
9/23	OB842	13	19	18	19	20	15	20	19	20	
9/4	OB844	16	11	12	4*	13	11	13	—	13	baby
9/9	OB845	21	21	20	21	16	21	18	18	21	
9/13	OB822	1*	15	15	18	14	9	3*	15	14	
9/13	OB826	8	1*	13	8	7	2*	1*	3*	2*	
9/13	OB829	11	3*	3*	16	12	12	4*	11	11	
8/30	OB813	15	8	1*	9	17	4*	2*	7	3*	
9/17	OB833	20	17	7	13	4*	19	21	17	18	
9/4	144-I	14	18	5*	15	21	18	19	13	19	immature
9/9	OB830	4*	4*	21	12	18	20	6	2*	9	
9/9	OB839	6	14	11	5*	10	17	9	1*	7	
9/9	OB841	17	12	9	17	15	13	15	9	15	
9/17	OB843	9	9	6	6	8	14	14	12	12	
9/17	128-I	12	2*	8	11	11	1*	16	14	10	
9/4	L-1	2*	16	10	2*	3*	5*	17	6	5*	
9/9	L-8	3*	7	2*	1*	2*	3*	8	8	1*	
9/4	E-2	19	20	14	20	5*	10	12	5*	16	
9/4	E-21	7	5*	4*	3*	19	8	7	—	4*	baby?

* First 5

Table 5. USBA physical evaluation (rank) for past 3 years of samples examined in 1963.

Selection	1961	1962	1963	Disposition
OB827	17	---	6	To be discarded
OB835	4	---	8	To be yield tested
OB840	11	17	17	To be held (BB)
OB842	---	---	20	Evaluate '64
OB844	---	---	13	Evaluate '64
OB845	---	---	21	Evaluate '64
OB822	13	---	14	To be yield tested
OB826	2	---	2	To be yield tested
OB829	14	---	11	To be discarded
OB813	15	2	3	To be yield tested
OB833	7	13	18	To be discarded
OB830	16	---	9	To be yield tested
OB839	1	5	7	To be yield tested
OB841	---	9	15	To be yield tested
OB843	---	---	12	Evaluate '64
144-I	---	---	19	Being tested, Wn.
128-I	---	1	10	To be continued (?)
I-1	---	11	5	Being tested, Wn.
I-8	---	6	1	Being tested, Wn.
E-2	---	8	16	Being tested, Wn.
E-21	---	7	4	Being tested, Wn.

Table 6. Selections discarded in 1960-62 on basis of preliminary quality evaluation.

1960	1961	1962
Poor quality (USBA):	Low α-acid:	Low α-acid:
C50017 (BB513-2)	C57004 (OB804)	C57002 (OB802)
C19128 (40-S)	C54049 (OB805)	C57007 (OB808)
C56017 (OB834)	C57005 (OB806)	C58113 (OB837)
C19032 (OB819)	C57008 (OB809)	C55055 (OB812)
	C57010 (OB811)	
Low α-acid:	C58102 (OB816)	Poor quality (USBA):
C57003 (OB803)	C19022 (OB820)	C19020 (OB818)
C19103 (8-S)	C51026 (OB821)	
C19165 (95-S)	C58104 (OB823)	
C57012 (OB814)	C58105 (OB824)	
C19233 (OB817)	C58108H (OB828)	
C56021 (OB838)	C58110 (OB832)	
	C19119 (24-S)	
Poor agronomic characters:	C19194 (142-S)	
C57006 (OB807)		
C58101 (OB815)	Poor quality (USBA):	
C58106 (OB825)	BB519-5	
	C57009 (OB810)	

Preliminary Field Evaluation

No results were obtained from the "Preliminary Yield Trial"in 1963.

Advanced Field and Quality Evaluation

The 3-acre planting of 128-I at Weathers Ranch in the Willamette Valley was very well taken care of in 1963. Yield of dry hops was reported at more than 7 bales per acre and chemical analyses indicated 12% alpha-acid and 2.5 mls of oil per 100 grams.

A disease condition first noted in 128-I in California about 4 years ago was tentatively identified this year as Split Leaf Blotch virus. The condition was severe in Oregon on 128-I and was evident in Hallertau and Fuggle. Reports from England indicate that the disease was much more serious there in 1963 than it had been for some time. Apparently environmental conditions last season were more favorable than usual for disease symptom expression in both countries.

Since environment appears to play an important role in disease severity, it cannot be predicted what the situation will be in 1964. It is possible that Split Leaf Blotch will not express itself to as great a degree. However, the only solution to the problem is elimination of infected plants. If 128-I is released for commercial production, disease-free plants will have to be found from which to propagate replacements for all diseased plants now being grown in Washington, Oregon, and California.

Both plantings of 128-I in Washington (Allwardt Ranch and Seedless Ranch) were babies in 1963 because the original plantings had been either moved or used for propagation. The plants looked good at both places, except Split Leaf Blotch infection was apparent.

The 100-hill planting of HL Fuggle at Stauffer Ranch near Hubbard, Oregon was in excellent condition during late season. No data were obtained, but the plants were uniform, vigorous, and compared favorably with commercial Fuggle.

Variety Increase

The 3-acre yard on the Smith Farm near Corvallis was used to grow plots of 128-I, regular Hallertau, and Swiss Hallertau for maintenance of planting stocks. Two hundred cuttings of 128-I from this planting were sent to the Agricultural Extension Service in California for a trial planting at Cascade Hop Ranch near Yuba City.

Increase plantings such as this provide material for miscellaneous studies which present themselves from time to time. This planting was used in 1963 to furnish plants for a twine treatment experiment.

BREEDING BEHAVIOR, GENETICS, AND BOTANY

Cross Incompatibility

Data and observations obtained over a period of years indicate that certain crosses consistently produced large amounts of viable seed; whereas, other crosses seldom produce much seed. In some instances crosses between specific individuals are next to impossible to make.

An indication of incompatibility is the amount of whole or viable seed produced from a controlled pollination and the number of empty or aborted ovules. Following is a tabulation of compatibility relations between specific individuals used in the 1963 crossing program.

These data are included here only to constitute a permanent record; no conjectural discussion or analysis will be presented at this time. However, the problem of cross incompatibility is important and should be investigated sometime, and these data will furnish a basis for such an investigation.

Table 1. Notes on quality of seed from crosses made in 1963.

Cross No.	Female	Male	% Hulls
63001	122 (LC)	121-2	<50
63002	122 (LC)	421-1,2	<75
63003	122 (LC)	524-2	<50
63004	222 (Fu)	106-S	<25
63005	222 (Fu)	110-S	<50
63006	222 (Fu)	119-1,2	<25
63007	311 (BG)	5-29-4	<50
63008	311 (BG)	123-S	>25
63009	322 (Ha)	106-S	<25
63010	322 (Ha)	110-S	<50
63011	322 (Ha)	119-1,2	<25
63012	322 (Ha)	526-4	>75
63013	422 (Ba)	123-S	>50
63014	422 (Ba)	121-2	>75
63015	422 (Ba)	421-1,2	>25
63016	522 (EC)	121-2	<25
63017	522 (EC)	123-S	>50
63018	522 (EC)	421-1,2	>25
63019	1023 DN (Bu)	219-4	<25
63020	1123 DN (135-I)	119-1,2	<25
63021	10-S (103-I)	119-1,2	>25
63022	10-S (103-I)	110-S	<25
63023	10-S (103-I	106-S	>75

Table 2. Percent hulls in seed of crosses involving each female.

♀	0 - 25%	25 - 50%	50 - 75%	75 - 100%
LC		122 x 121-2 122 x 524-2	122 x 421-1,2	
Fu	222 x 106-S 222 x 119-1,2	222 x 110-S		
BG		311 x 5-29-4 311 x 123-S		
Ha	322 x 106-S 322 x 119-1,2	322 x 110-S		322 x 526-4
Ba		422 x 421-1,2	422 x 123-S	422 x 121-2
EC	522 x 121-2	522 x 421-1,2	522 x 123-S	
Bu	1023 DN x 219-4			
135-I	1123 DN x 119-1,2			
103-I	10-S x 110-S	10-S x 119-1,2		10-S x 106-S

Table 3. Percent hulls in seed of crosses involving each male.

♂	0 - 25%	25 - 50%	50 - 75%	75 - 100%
421-1,2		422 x 421-1,2 522 x 421-1,2	122 x 421-1,2	
121-2	522 x 121-2	122 x 121-2		422 x 121-2
110-S	10-S x 110-S	222 x 110-S 322 x 110-S		
106-S	222 x 106-S 322 x 106-S			10-S x 106-S
119-1,2	222 x 119-2 322 x 119-2 1123 DN x 119-2	10-S x 119-1,2		
123-S		311 x 123-S	422 x 123-S 522 x 123-S	
524-2		122 x 524-2		
526-4				322 x 526-4
219-4	1023 DN x 219-4			
5-29-4		311 x 5-29-4		

Description of Hop Varieties Grown in the United States

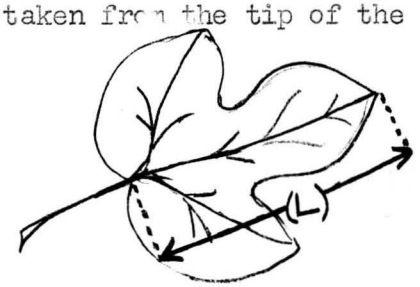
Objectives:

To furnish a description of the plant morphological, chemical, growing and brewing characteristics of hop varieties now being grown in the United States.

Materials and Methods:

The following account describes the methods used to determine leaf measurements and classification criteria set up to distinguish morphological differences:

(1) Length — This is taken from the tip of the middle lobe to the base of the leaf.

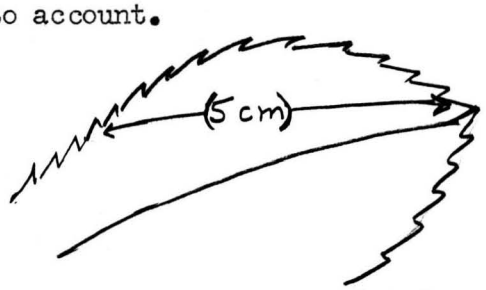


(2) Width — This is measured at the widest part of the leaf. With cup-shaped leaves which have buckled when they were pressed it is difficult to get a true measurement.

(3) Pubescence — The pubescence has been separated into the 3 groups distinguished by E. L. Davis. There were intermediate types, the dividing lines were made thus:
Type 1. Hairs only found on veins running to the tip of a dentation.
Type 2. Hairs found on veins running to the tip of a dentation and also on veins off this vein and those running to the cleft between dentations.
Type 3. Hairs are found in the islands between the smallest veins. When only one or two could be found the 3 is put in brackets.

(4) Number of dentations on the middle lobe — When there are secondary lobes, the dentations are counted from above them. When there is only one secondary lobe the dentations are counted on the side opposite to it.

(5) Dentations in 5 cms — This measurement does not take the curve of the leaf into account.



(6) Number of lobes — Example: 3-2-1-1a. This leaf has 3 primary lobes, their veins branch at the base of the leaf.
Two secondary lobes, these branch off the primary lobes so close to the base of the leaf that they are nearly or equally large.

One tertiary lobe. This has branched off any lobe except the apical one, some way up the vein.
The designation "1a" refers to a secondary lobe on the apical lobe.

(7) Depth of lobe clefts — This is the distance from the point of the cleft to the line joining the tips of the lobes forming the cleft. On the data sheets the measurements for one side of the leaf are on one line, and complementary clefts are recorded in pairs one above the other.

Results:

Data obtained on leaves collected in 1962 are summarized in Table 1. The leaves used were from different yards or areas as follows:

Late Cluster — 9 Wash., 2 Idaho, 1 Oregon;
Early Cluster — 8 Wash., 3 Idaho, 1 Oregon;
Fuggle — 3 Oregon;
Bullion — 1 Oregon, 1 Wash.;
Brewers Gold — 2 Oregon;
Hallertau — 2 Oregon;
Backa — 1 Oregon;
128-I — 2 Oregon, 1 Wash.

On the basis of the data, varieties can be tentatively classified on leaf morphology (Table 2). It should be pointed out that the classifications do not always hold true. For example, expression of lobing pattern is influenced by climatic and soil conditions, and development of secondary and tertiary lobes may vary considerably. Pubescence type, numbers of dentations per unit length, and ratios of lobe cleft to leaf length and width may be more uniform than other characters, but even these show some discrepancies.

Summary:

Mature hop leaves collected from several varieties in different yards in Oregon, Washington, and Idaho in 1962 were subjected to a detailed study of morphology. Data were obtained on lobing pattern, pubescence type, dentations on central lobes, length, width, and ratios of various measurements.

It appears to be possible to distinguish varieties on the basis of some of the morphological measurements, but additional study is needed to verify any conclusions reached to date. Data on number of dentations in 5 cm. of the central lobe, pubescence type, lobing pattern, and ratios of depth of lobe cleft to leaf length and width appear to offer the most promise for varietal identification.

The data obtained so far will be evaluated in light of recent published reports from Japan and Belgium and combined with data yet to be obtained on other varietal differences before a classification key can be constructed.

Table 1. Morphological measurements made on hop leaves collected from commercial hop yards and experimental plots in Oregon, Washington and California in 1962. All leaves were mature leaves from main vines at height of 5-6 feet.

	Total No. leaves examined	No. yards sampled	Dentations on middle lobe		(L) Leaf length (Mm)	(W) Leaf width (Mm)	(LC) Depth of lobe cleft (Mm)	% leaves in pubescence type. 1/			Lobing pattern				Ratio	Ratio	Ratio
			Total	5cm.				I	II	III	% with primary only	% with secondary only	% with secondary and tertiary	% with secondary middle lobe	L/W	LC/W	LC/L
Late Cluster	173	12	21.3	10.9	158	190	68	<1	77	23	11	66	23	16	.82	.36	.43
Early Cluster	167	12	20.2	11.1	160	192	70	---	81	19	13	54	33	29	.83	.36	.44
Fuggle	38	3	16.1	8.5	153	186	61	11	89	---	30	68	2	---	.84	.33	.40
Bullion	29	2	18.4	8.6	187	261	82	52	48	---	---	21	79	---	.72	.31	.44
Brewers Gold	25	2	17.9	9.0	174	247	83	48	52	---	---	8	92	---	.72	.34	.48
Hallertau	22	2	17.8	7.6	153	183	70	---	100	---	<5	91	<5	---	.84	.39	.46
Backa	9	1	15.1	6.2	154	174	75	---	100	---	---	100	---	---	.85	.43	.49
128-I	39	3	19.9	10.5	144	194	63	---	100	---	3	87	10	---	.75	.33	.44

1/ I = Hairs on main veins only
II = Hairs on main and secondary veins
III = Hairs on veins and in islands between veins

Table 2. Tentative classification of hop varieties on basis of leaf morphology. Classifications are based on usual situations since varieties may occasionally fit other categories.

Dentations in 5 cent.	Pubescence type	Lobing pattern of leaves	Ratio of lobe cleft depth to width	Ratio of lobe cleft depth to length
< 8 Hallertau, Backa	Equal I and II — Bullion, Brewers Gold	Many with primary only, few with tertiary — Fuggle	< .35 Fuggle, Bullion, Brewers Gold, 128-I	< .43 Fuggle
8-10 Fuggle, Bullion, Brewers Gold	Mostly II — Fuggle	Mostly with secondary and few tertiary — Hallertau, Backa, 128-I	.35-.37 Late Cluster, Early Cluster	.43-.45 Late Cluster, Early Cluster, Bullion, 128-I
> 10 Late Cluster, Early Cluster, 128-I	All II — Hallertau, Backa, 128-I	Mostly secondary and tertiary, few with primary only — Bullion, Brewers Gold	> .37 Hallertau, Backa	> .45 Brewers Gold, Hallertau, Backa
	Mostly II and III — Late Cluster, Early Cluster	Mostly with secondary and tertiary and many with secondary on central lobe — Late Cluster, Early Cluster		

CR e5-2 (OAES Bot.:36) HOP DISEASES
THEIR ETIOLOGY, EPIPHYTOLOGY AND CONTROL.

C. E. Horner

Reaction of Varieties and Breeding Lines to Downy Mildew.

Downy mildew was moderately severe in the 1963 growing season. Notes on the field reaction of varieties and clones were taken as part of a cumulative record which will be useful in planning future crosses and making selections.

Objectives:

1961 Annual Report, p. 37.

Procedure:

Each hill of each clone was examined and the number of infected shoots recorded. The hill was then rated as Resistant (R), Intermediate (I), Susceptible (S), or Very Susceptible (VS).

Results:

Of 254 plants evaluated in the Breeding Blosk, 156 were resistant, 54 susceptible and 44 intermediate in reaction to downy mildew. A detailed table of reaction to downy mildew is found in the appendix to this report.

In the Nursery Block 496 hills were evaluated. Of these, 222 were resistant, 180 susceptible, and 94 intermediate in reaction to downy mildew. Detailed data are tabulated in the appendix.

Data on evaluation of Wild American clones, Male Line, Selections, and Observation Blocks are detailed in the appendix.

Verticillium Studies

Verticillium wilt continues to increase in economic importance, although as a disease of hops it is not yet widespread. The Fuggle variety appears to be the most susceptible of the commercial varieties grown in the U.S. Two distinct morphological types of the Verticillium fungus causing wilt diseases are recognized: a type that produces microsclerotia as its dormant propagative body, and a type that produces "dauermycelium" which consists of darkly pigmented mycelial strands. In Europe and Asia these two types are recognized as separate species: Verticillium dahliae Klebahn and V. albo-atrum Reinke & Berthold. In the U. S. most authorities lump the two types under V. albo-atrum. In England and Continental Europe the severe Verticillium wilt disease of hops is caused by V. albo-atrum and in the U.S. all Verticillium pathogens found infecting hops prior to 1963 were of the V. dahliae type.

In 1963 diseased Fuggle hops were found to be infected with V. albo-atrum, the type not previously found in hops in the U.S. Because of the

great economic importance of this pathogen of hops in Europe, Laboratory and field tests were undertaken to learn more about the Verticillium pathogens of hops.

Objectives:

Tests were undertaken to:

(1) Compare the morphological and cultural characteristics of Verticillium clones recovered from diseased hops.

(2) Determine the pathogenicity of several isolates of Verticillium to hops, including the new "dauermycelial" strain.

Procedure:

(1) Single spore clones of Verticillium dahliae from hops, peppermint and potato and V. albo-atrum from hops and potato were grown at 15°, 20° and 25°C. on three different nutrient media: potato dextrose agar, Czapk's sucrose nitrate, and a prune agar described by Talboys in England as a media suitable for differentiation of Verticillium species

(2) Clones of V. dahliae from hops, mint, and potato, and a clone of V. albo-atrum from hops were increased aseptically on barley straw, a substrate that induces formation of resting structures. Rooted cuttings of the hop varieties Early Cluster, Late Cluster, Brewers Gold, and Fuggle and 128-I were planted in field plots infested with the 4 Verticillium clones. The experimental design consisted of 8 replications of single hill plots.

Results:

(1) Comparison of growth and morphology of Verticillium types on different media at 15, 20 and 25°C.

All clones grow well on all 3 media microsclerotia and "dauermycelium" formed earliest on prune agar, confirming the results of Talboys. All clones of V. dahliae grow more slowly at 15 and 20°C. than the V. albo atrum types. At 25°C. V. dahliae clones grew more rapidly than V. albo-atrum clones. These results agree with published differences in temperature effects on growth of the two types.

Microscopic observations of all clones growing on all 3 media confirmed that the clone recovered from hops was morphologically identical with the V. albo-atrum found on hops in Europe.

(2) Results from the field test of Verticillium types for pathogenicity to hop varieties will not be available until 1964.

Conclusions:

A type or species of Verticillium different from those previously recovered from hops in the U.S. was found and proved to be morphologically identical with the type causing severe disease in European hop gardens. The importance of this new strain of Verticillium will not be known until

pathogenicity and host range tests are completed. Because the newly discovered strain is so similar to the type so economically important in Europe, it is important to determine its pathogenicity to hop varieties grown commercially in the U. S.

Control of Verticillium Wilt

A field trial was established to determine if soil fumigation would be effective and economically feasible for the control of Verticillium wilt in hop yards. Vapam and Telone at 75 gallons per acre and Vorlex at 50 gallons per acre were applied to 5 replications of plots containing 55 hills each. Applications were made in September, 1963 and the treated area was replanted to Fuggle hops in March 1964. Data will be taken on the incidence and severity of disease annually for a 3 year period.

CR e5-4 (OAES FC:36) IMPROVING YIELD AND QUALITY OF HOPS BY PRODUCTION AND MANAGEMENT PRACTICES.

C. E. Zimmermann

The major objective of this line project has been the development of effective cultural and management practices for growing hops. An understanding of the physiological processes associated with yield and quality of hops has provided an additional means of interpreting field data obtained from cultural trials. Knowledge of various physiological changes is also of value to breeding, disease, and quality studies.

In 1963 project studies were confined to the following lines of work:

(1) Investigations relative to cone pickability in hops.
(2) Effect of permanent grass cover on Fuggle hops.
(3) Use of herbicides on new hop plantings.
(4) Effect of trellis heights on performance of hop varieties.
(5) Study of endogenous gibberellins in hop cones.
(6) Test of treated paper twine.
(7) Effect of hormones on root development of hop rhizomes.

Investigations relative to Cone Pickability in Hops.

Objectives:

A. To establish a method for the objective measurement of susceptibility to cone breakage during hop picking.

B. To determine the extent to which various factors involved in the production of hops influence pickability.

1. Maturation
2. Varieties
3. Physiology
4. Fertility

Reasons for undertaking the work:

See 1962 Annual Report, p. 34.

Nature and extent of previous work:

See 1961 Annual Report, p. 39.

Procedure:

Two blocks of 'Fuggle' hops were treated when vines were 5 to 6 ft. long, with 5 ppm of an ester gibberellate formulation at the rate of 100 gallons per acre. One block received an additional treatment, at the time cones were developing (August 6), which consisted of 20 ppm indole-3-acetic

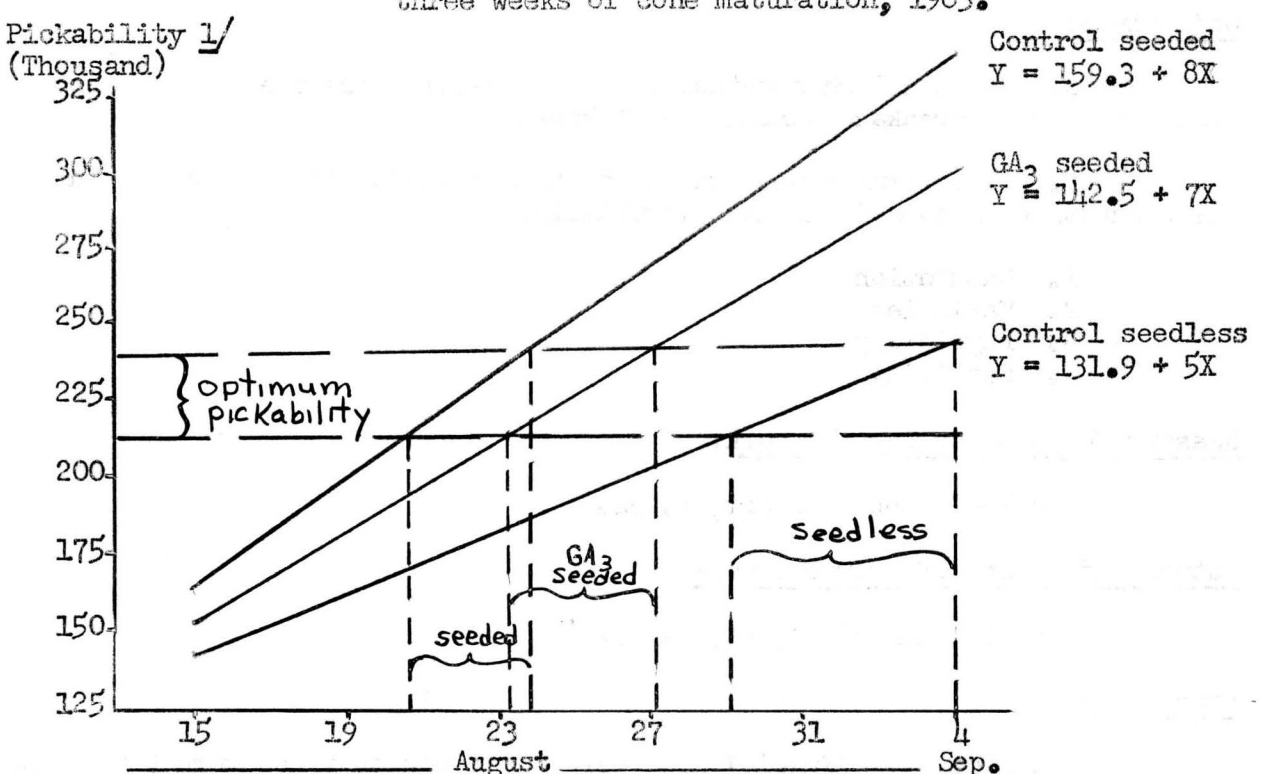
acid. Samples and data were collected periodically from these two blocks and also from comparable blocks of control seeded and seedless Fuggle hops. Pluckability values were obtained by sampling 20 plants, to include 5 readings from one secondary branch on each plant. Quality data were obtained by S. T. Likens. This study was conducted in cooperation with S. T. Likens, see A.R. CR e5-5.

Experimental results:

Data obtained are summarized in Table 1. Seeded Fuggle treated with gibberellic acid (GA_3) had a smaller cone size (by weight) than the control hop and also required less force to detach from the vine. Seedless Fuggle produced the smallest cones. Accumulation of oil in GA_3-treated and control hops was similar until harvest (August 26), but GA_3 hops continued to increase in oil content, reaching a high of 3.2 mls 10 days after the normal harvest period. Alpha acid content was similar in all cases.

An objective assessment of pickability was attempted in 1963 by relating cone breakage (shatter) and cone detachment (pluckability). Pickability was determined as the product of percent shatter and gram-force for detachment. Changes in pickability of seeded, seedless Fuggle and GA_3-treated seeded Fuggle during cone maturation are shown in Figure 1. This approach in relating pickability with maturity was not attempted for practical application, but as a means to evaluate the influence of direct and indirect effects on shatter.

Figure 1. Change in Pickability of three different Fuggle hops during the three weeks of cone maturation, 1963.



1/ High pickability value, a product of percent shatter and gram force pluckability, would indicate poor pickability. Seeded hops were harvested by machine on Aug. 26 and seedless on Sep. 4.

Table 1. Quality and physical changes of Fuggle hops as influenced by seed content and exogenous hormones, 1963.

Sampling date	% D.M.	mg D.M. Cone	Oil Content[1]	% Whole[2]	Pluckability[3]	% alpha (dwb)[4]	% beta (dwb)[4]
Control-Seeded Fuggle, East Farm							
8/12	19.0	118	0.57	66.1	---	---	---
15	19.0	121	0.97	49.8	347	7.0	3.2
19	20.7	113	1.29	48.5	364	7.8	3.4
22	21.5	135	1.74	42.6	396	8.1	2.9
26	21.1	129	2.40	29.0	---	8.3	3.1
29	21.9	128	2.43	34.0	419	7.3	2.4
9/3	23.4	139	2.85	28.1	445	8.7	2.5
6	21.3	112	2.97	9.2	348	8.3	3.3
7	---	---	---	10.1	401	---	---
11	24.2	117	2.98	12.5	372	8.1	3.1
Control-Seedless Fuggle, Smith Yard							
8/13	17.9	84	0.61	65.9	---	7.0	3.4
15	18.7	88	0.71	53.7	304	6.5	3.3
19	19.5	90	1.11	57.8	362	7.8	3.4
22	22.3	98	1.38	45.3	314	7.2	2.6
26	20.3	80	1.97	48.5	---	7.1	3.2
29	21.0	99	2.22	39.5	---	6.7	3.7
9/3	23.4	98	2.65	41.5	399	8.8	3.0
6	21.8	82	2.76	9.1	351	8.6	3.8
12	22.1	104	2.99	15.4	351	7.2	3.0
Treated-Seeded Fuggle, East Farm ("Gibrelate" 5 ppm @ 5 ft.)							
8/12	18.2	80	0.91	70.4	---	7.6	3.5
15	20.1	91	0.83	56.0	324	7.3	3.0
19	21.2	107	1.26	47.4	331	8.0	3.5
22	20.8	94	1.76	37.9	339	8.0	2.5
26	21.2	109	2.32	35.5	---	9.2	2.9
29	22.3	106	2.76	36.4	401	6.9	3.7
9/3	24.1	127	2.87	34.4	362	8.7	3.0
6	22.1	91	3.21	8.9	349	8.7	3.9
11	22.4	94	3.18	12.5	331	8.4	3.5
Treated-Seeded Fuggle, East Farm ("Gibrelate" 5 ppm @ 5 ft. + 20 ppm IAA @ cone)							
8/13	19.8	123	0.76	58.0	---	6.6	3.2
15	21.2	118	0.86	53.0	347	6.7	3.0
19	20.5	103	1.18	44.2	368	7.9	3.4
22	21.5	89	1.70	44.8	381	7.5	3.0
26	21.7	117	2.15	34.8	---	8.9	2.4
29	21.9	128	2.79	38.1	432	6.5	3.8
9/3	23.4	121	2.92	29.4	399	7.2	2.8
11	22.7	95	3.18	17.6	396	8.2	2.9

1/ Oil Content expressed as ml oil/100g D.M.
2/ % Whole from 300g green hops (wt. whole cones/300).
3/ Pluckability expressed as gm-force needed to pick cone from petiole. (average of 100 readings)
4/ Spectrophotometric determination on ground, lab-dried hops.

We attempted this approach in 1961 and 1962 with a tumbling machine to compare cone toughness and in 1963 a precision dynamometer was used to determine the toughness of the cone petiole. These are only 2 factors related to the machine pickability of hops and one is aware of variation in growth form and cone lateral morphology between varieties that also contribute to differences in pickability. Assuming there was a similarity in overall morphology of the 3 Fuggle hops in Figure 1, then differences in pickability were due to changes in pluckability and/or shatter. There was a significant positive correlation between percent shatter and pluckability of control seeded Fuggle during cone maturation. GA_3-treated hops had a more favorable pickability value than control hops and this difference was accomplished through a lower picking force requirement of GA_3 hops. An off-station trial with seeded Fuggle treated with 10 ppm GA_3 applied at the 5-foot stage showed 25% less plucking force than control Fuggle. Favorable pickability of seedless Fuggle was due to a decrease in both percent shatter and the force necessary to detach cones.

A pluckability average for a variety will give some indication as to its machine pickability. Plucking force of seeded hops and seedless hops was noted to be in the average range of 500 to 600 and 400 to 500 grams respectively (Table 2).

Pickability ratings during machine harvest took into consideration amount of shatter loss, sidearm and cluster loss, physical appearance of picked cone, leaf and stem content, and an evaluation of the picked vine. Differences in plant morphology (length of sidearms, brushiness, type of cone cluster etc.) between varieties influenced the pickability ratings of those which had comparable pluckabilities, such as OB-835 and OB-842. In other cases, such as OB-840 a variety can have poor pickability because cones are highly susceptible to shatter even at a low plucking force. See this A.R., CR e5-1

The objective method employed to determine pickability, as the product of percent shatter and gram-force plucking, was further tested on seeded Fuggle during a 24 hour period. Hop growers, in general, are aware of the difference in pickability of hops during daylight and dark hours. Hop harvesting with portable picking machines is usually accomplished during darkness (1900 to 0300 hrs.) due to a noted increase in picking efficiency. Figure 2 shows the relationship of pickability to environmental changes. Pickability improves near sunset, at which time the relative humidity increases and temperature decreases. During the period between sunset and sunrise, percent dry-matter of the cones showed a slight decrease and both plucking force and shatter decreased.

Pluckability and shatter data were obtained from a replicated experiment on seeded Fuggle treated with foliar application of Mg, Fe and Mn chelates plus a surfactant. Plots received a five inch irrigation prior to the chelate application on July 24. Data were only obtained from the 2 pound per acre rate, since higher rates caused some phytotoxicity, (Table 3). A statistical significance (P.05) difference was noted in plucking force due to treatment. There was no difference between control and Fe-treated hops, but the Mg and Mn treatment required significantly less force to detach cones and Mn resulted in hops having the lowest force requirement. Improved pickability of Mg and Mn fertilized hops was due to a significant decrease in the force required to detach cones.

Table 2. Pluckability measurements and pickability ratings of seeded hops determined during machine harvest, 1963.

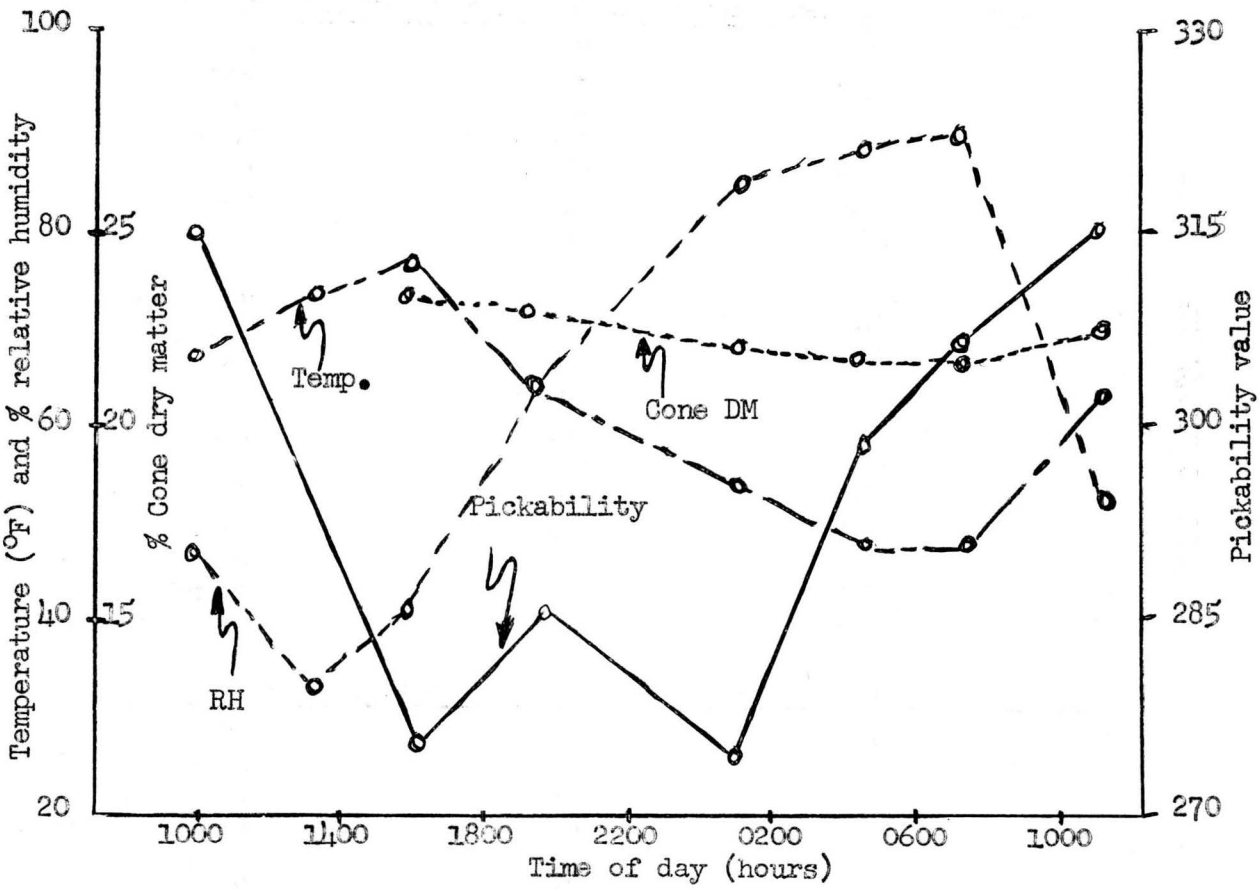
Variety	Picking Date	Pluckability 1/	Pickability 2/
Seventeen seeded hop selections and 2 seeded commercial varieties:			
OB 801	9/4	669	Poor
OB 812	8/30	---	Poor
OB 813	8/30	---	Good
OB 822	9/13	992 + 3/	Poor
OB 826	9/13	846 +	Good
OB 827	8/30	---	Poor
OB 829	9/13	891 +	Poor
OB 830	9/9	944 +	Average to poor
OB 831	9/4	444	Very good
OB 833	9/17	602 +	Average
OB 835	9/17	578	Very good
OB 839	9/9	889 +	Average to poor
OB 840	9/17	552	Very poor
OB 841	9/9	646	Average
OB 842	9/23	560	Poor
OB 843	9/17	578	----
OB 845	9/9	693	Very poor
Fuggle	8/27	492	Average
Late Cluster	9/23	695	Average to poor
Four seedless commercial hop varieties and 3 seedless advanced lines:			
Fuggle	9/4	418	Average
Late Cluster	9/13	657	Poor
Brewers Gold	9/17	460	Very good
Hallertau	8/27	413	Average to good
144-I	9/4	392	Good
135-I	9/9	400	Poor
128-I	9/17	466	Very good

1/ Gram-force to detach cone from its petiole (average of 20 readings)
2/ Visual evaluation
3/ Average includes 1000 g. readings which were in excess of the 1000 g. capacity of the dynamometer.

Table 3. Data obtained from minor element trials on seeded Fuggle, 1963.

Treatments	Pluckability (grams)	Shatter (% whole)	Pickability value
Control	401	10.1	360.5
Fe EDDHA (2 lbs./A)	386	8.6	352.8
Mg EDTA "	358	5.9	336.9
Mn EDTA "	333	5.8	303.7

Figure 2. Pickability of seeded Fuggle in relation to environmental changes during a 24 hour period, September 5 and 6, 1963.



Summary and conclusions:

Gibberellic acid at 5 ppm. applied to seeded Fuggle hops when vines were 5-feet long, improved pickability by decreasing toughness of cone petiole, decreased cone size, and increased oil accumulation during the period following standard harvest. Indole acetic acid applied to GA_3-treated hops did not alter pickability or quality from that noted with GA_3 alone.

Detachment force of cones and percent shatter of seeded Fuggle were positively correlated. Varietal differences in plucking force were related to machine-harvest pickability ratings.

Foliar application of magnesium and manganese chelates to hops during the growing season significantly increased pickability of seed Fuggle.

Improved pickability of hops, expressed through a decrease in shatter and/or plucking force, was accomplished and noted by the following: hormones, darkness, change in trellis heights, seed content, genetics, nutrition, and maturity.

Effect of Permanent Grass Cover on Fuggle Hops.

Objectives:

(1) To determine the effect of permanent grass cover, without cultivation, on seeded hop production.

(2) To study the influence of permanent grass on soil compaction.

Reasons for undertaking the work:

Spring cultural operations are often performed when soil conditions are unfavorable for heavy tractor traffic. The soil adjacent to the permanently spaced hop hills are subject to heavy pressure from tractor wheels during the performance of management practice. Hardpans or plow soles have been noted in several hop yards with a heavy soil condition. Soils in most hop yards are low in organic matter and receive only a small additional supply of O.M. annually, usually contributed by a winter cover crop. These hardpans may influence the penetration of hop roots and restrict their ability for nutrient and water uptake. A permanent grass cover would also eliminate the necessity of frequent field cultivations and further reduce the cost of hop production.

Nature and extent of previous work:

English workers have conducted trials with hops grown in permanent grass and concluded that the grass was competitive with hops for nutrients and moisture and also developed favorable conditions for downy mildew infection. Herbicides were not used in their study as a means of controlling weeds between hills in a row. The use of grass between the hop hills was found to be undesirable. Permanent grass has been used successfully in Northwest orchards and vineyards to improve physical properties of soil.

Procedure:

A permanent cover crop trial was established on four year old Fuggle hops in the fall of 1963 with 3 treatments, replicated 6 times in a randomized block design. The trial was established on an area which was fumigated with "D-D" for symphyllid control in 1959. Each treatment consisted of a three hill plot with a border. Treatments consisted of (a) ungrassed, normal cultivation (check); (b) grassed without sloping; and (c) grassed, with sloping. Figure 1 shows the plot description. Sloping or plowing is used to describe the early spring mechanical operation of removing a layer of soil from each side of the hop hill to cut off rhizomes and expose the hill for additional hand pruning. All treatments will be pruned, but the unsloped treatment will not have the rhizomes cut from the hop hill. The grass treatment, which is sloped, will be harrowed to push the displaced soil to the hill. Grass plots were seeded to "Illahee" creeping red fescue at the rate of 10 pounds per acre, on Sept. 25, 1963, with a 5' "Gandy" spreader. The 3' area between the 8' spaced plants was sprayed for weed control with 3.2 pounds of active Simazine per acre on Oct. 15, 1963. The herbicide phase of this study was conducted with the cooperation of the Weed Project, Farm Crops Dept., Oregon State University. The grass treatments will not receive any cultivation other than an annual fertilizer placement as a band 8" from the hop hills.

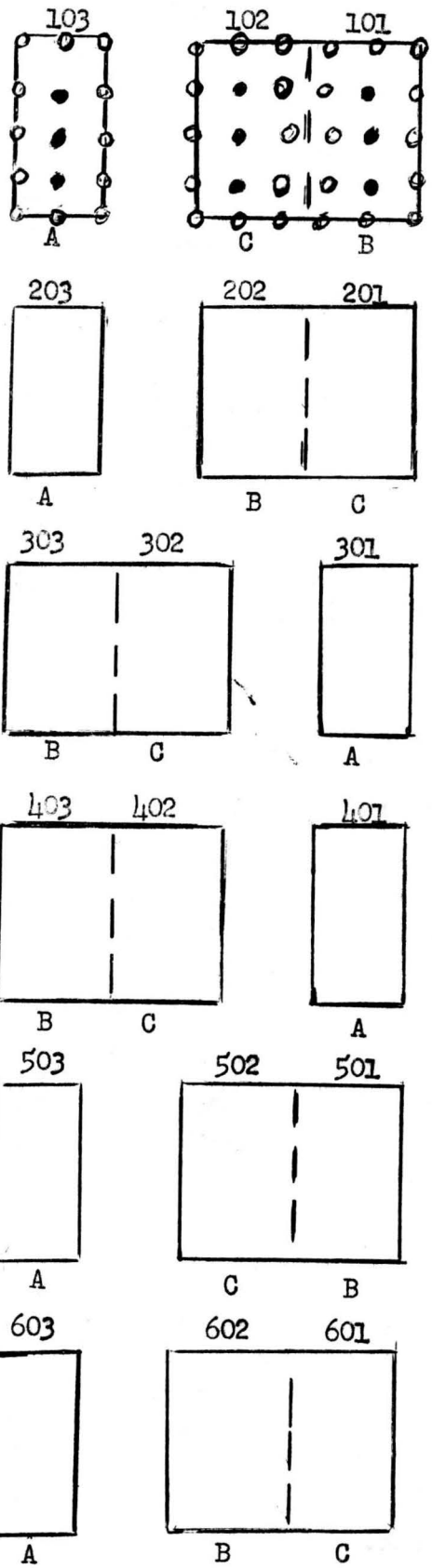
This trial will be conducted for three years, during which time hop yields and quality will be evaluated.

Soil bulk densities and conductivities were determined in the fall of 1963 and will be repeated in 1966 to determine changes in soil morphology. Soil samples were obtained on December 11, 1963, from three locations within each plot and at three depths within each core. The time of sampling was delayed until soil moisture was at field capacity. The three core locations and samples within core, are shown in figure 1. The core locations were determined as follows: one core was located in between the rows in an area which did not receive any wheel traffic, the second core was located in an area in which wheel traffic was within 12" of the location, and the third was located in an area of wheel traffic. The soil sample was obtained with a tool equipped with a brass ring having a capacity of 68.83 cu. centimeters. Infiltration rates were determined on each sample with a fabricated apparatus obtained from the Soils Department at Oregon State University. Infiltration rates were determined as milliliters of water per minute collected after five, ten, and twenty minute durations. The soil samples were dried at 100°C. for 24 hours and weighed for bulk density determination. The soil samples from the same level of each of the three cores within one plot were composited for organic matter determination.

Experimental results:

Data obtained on infiltration rates, organic matters, and bulk densities of the soil samples will not be summarized until the conclusion of the experiment. The average bulk density and organic matter control of composite samples from 3 core locations in each plot are listed in Table 1. The organic matter increases with sampling depth and appears to have an inverse relationship with bulk density. Field observations during the winter indicated that excellent weed control was obtained with the herbicide treatment. The grassed areas showed that a fair fescue stand was established, but also included annual bluegrass and groundsel. An attempt will be made to control undesirable species in the grassed area with periodic mowing during the summer months.

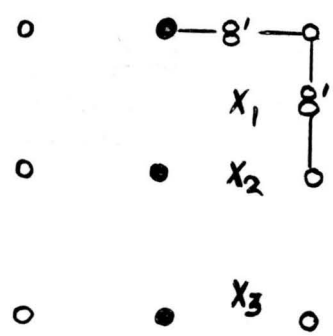
Figure 1. Plot diagram of Permanent Cover Crop Trial on Fuggle, 1963.



Treatments

A - Cultivated (check)
B - Grass, not sloped
C - Grass, sloped
- Harvested hills

Core location within plot



Three samples within core

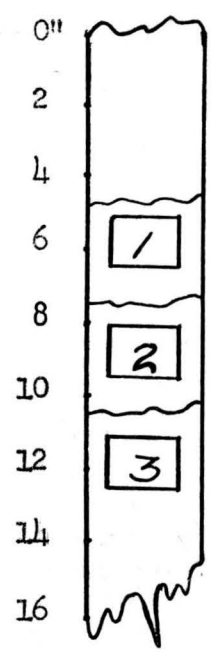


Table 1. Average bulk density (BD) and organic matter (OM) from 3 core locations, 1963.

Rep.		Grass Depth 1	Grass Depth 2	Grass Depth 3	Fallow Depth 1	Fallow Depth 2	Fallow Depth 3
I	OM	1.91	1.72	1.47	1.97	2.87	3.06
	BD	1.61	1.65	1.59	1.56	1.35	1.36
II	OM	1.85	2.29	2.80	1.97	1.72	1.47
	BD	1.58	1.42	1.33	1.60	1.64	1.57
III	OM	1.78	2.48	2.55	1.91	2.42	2.48
	BD	1.59	1.38	1.37	1.59	1.41	1.41
IV	OM	1.78	2.29	2.68	2.04	2.17	2.61
	BD	1.59	1.41	1.38	1.52	1.39	1.35
V	OM	1.78	1.66	1.97	1.47	1.47	2.04
	BD	1.59	1.57	1.40	1.59	1.41	1.38
VI	OM	1.72	1.59	2.04	1.53	1.40	1.27
	BD	1.51	1.42	1.38	1.64	1.66	1.60

OM - percentage organic matter
BD - grams per cubic centimeter

Use of Herbicides on New Hop Plantings.

Objectives:

To determine the phytotoxic effect of several herbicides on hop plantings established on different dates.

Nature and extent of previous work:

The herbicides used in this experiment have been shown to control shallow rooted weed species in several perennial crops. The experimental use of these herbicides on hops has not been conducted with rhizome plantings. Application of high concentrations of Diuron and Simazine has not displayed any phytotoxicity on established hop crowns (see Annual Report 1960, page 71).

Procedure:

This study is being conducted in cooperation with the weed project at the Farm Crops Department, Oregon State University. Fuggle rhizomes were planted December 16, 1963, in a randomized block consisting of five-hill plots and three replications. On December 18, 1963, Simazine and Atrazine were applied at different rates, followed by a spring application of Bromasil at different rates. Treatments are listed in table 1. The chemicals were applied in a three foot strip over the hop hills at 40 gallons solution per acre. At the time of application in December the area was covered with three weed species, namely groundsel, chickweed, and annual bluegrass. The herbicide Bromacil is an excellent control for quackgrass but due to its solubility, the time of application was delayed until spring rains had subsided.

A winter and spring planting of Fuggle hops was established in a randomized block with three replications in five-hill plots and subsequently treated with Bromacil in April. Table 2 lists the treatments for the winter and spring trial.

Table 1. Herbicide treatments applied to fall planting of Fuggle.

No.	Treatment	Lbs. active material/A.	Concent.	Material /plot	Plot location		
1	Simazine (Fall) + Bromacil (Spring)	2# 4#	80% 80%	2.5 g 5.0 g	104	203	308
2	Simazine (Fall)	4#	80%	5.0 g	107	208	306
3	Simazine (Fall)	8#	80%	10.0 g	102	206	307
4	Atrazine (Fall)	4#	80%	5.0 g	101	207	302
5	Atrazine (Fall)	8#	80%	10.0 g	108	202	301
6	Bromacil (Spring)	4#	80%	5.0 g	106	204	305
7	Bromacil (Spring)	8#	80%	10.0 g	103	205	303
8	Check	--	--	--	105	201	304

Notes: Rhizomes planted Dec. 16, 1963. Fall treatments applied Dec. 18, 1963, spring treatments applied Apr. 2, 1964.

Table 2. Bromacil treatments applied to winter and spring plantings of Fuggle.

Treatment	Lbs. active material/A.	Concent.	Material/plot	Plot location		
1. Bromacil	4	80%	5.0 g	103	201	303
2. Bromacil	8	80%	10.0 g	101	203	301
3. Check	--	--	--	102	202	302

Notes: Winter trial was planted Feb. 14, 1964, treated Apr. 2, 1964.
Spring trial was planted Mar. 26, 1964, treated Apr. 2, 1964.

Results from this trial will include data on weed control, residual effect of chemicals in soil, observations of chemical phytotoxicity. The productivity of hops will be evaluated together with overall growth behavior which might be attributed to chemical treatments.

Results and Discussion:

Simazine and atrazine applied in fall resulted in good weed control, but observations on other treatments could not be made due to the time of application. Data obtained this spring will be included in the 1964 Annual Report.

Effect of Trellis Heights on Performance of Hop Varieties.

Objectives:

See Annual Report, p. 41, 1962.

Nature and extent of previous work:

See Annual Report, p. 41, 1962.

Procedure:

See Annual Report, p. 41, 1962.

In 1963 pluckability data were obtained from this trial as additional information to determine differences in pickability. This phase of study is described in more detail in the A R under the heading, "Investigations into causes of cone pickability in hops." One secondary lateral from each plant in the experiment was removed at harvest and the gram-force necessary to break the peduncle was recorded on 5 cones of each lateral. Quality data were supplied by S. T. Likens.

Experimental Results:

The yield data are summarized in Table 1 for the last 2 years of this study.

Table 1. Yields per acre (pounds adjusted to a common dry-down percentage) of six hop varieties on three trellis heights in 1963. Averages for 1962 included.

Trellis Ht.	Fuggle	Late Cluster	Brewers Gold	144-I	135-I	128-I	1963 Avg.	1962 Avg.
16 ft.	1030	920	1740	1430	850	1600	1260a	1330a
18 ft.	900	920	1740	1660	1040	1580	1310a	1400a
20 ft.	1050	1080	1620	1560	1150	1800	1380a	1490a
1963 Avg.	990b	970b	1690a	1540a	1010b	1650a		
1962 Avg.	1120b	1080b	1380b	1760a	1150b	1960a		

Results from the second year of the height of trellis study were similar to those of 1962 in that varietal differences were exhibited. Brewers Gold, 128-I, and 144-I each yielded 3 bales per acre more than the other 3 varieties.

Table 2. Quality characteristics of hops grown on different trellis heights, 1963.

Trellis Ht.	Fuggle	Late Cluster	Brewers Gold	144-I	135-I	128-I	1963 Avg.	1962 Avg.
% α-acid (DWB)								
16 ft.	7.37	8.42	13.52	5.57	3.94	14.12	8.82a	5.77a
18 ft.	7.59	7.81	13.53	5.51	3.89	13.90	8.71a	5.62a
20 ft.	7.55	7.22	13.88	5.62	3.92	14.70	8.82a	5.60a
1963 Avg.	7.50c	7.82c	13.64b	5.57d	3.92e	14.24a		
1962 Avg.	5.67c	6.46c	7.57b	2.94d	2.67d	8.67a		
% β-acid (DWB)								
16 ft.	3.13	4.34	4.77	4.63	6.00	4.59	4.58a	4.26a
18 ft.	3.09	3.30	4.74	4.66	6.07	4.54	4.40a	4.17a
20 ft.	3.09	3.84	4.75	4.47	6.10	4.07	4.39a	4.16a
1963 Avg.	3.10e	3.83d	4.75b	4.59c	6.06a	4.40c		
1962 Avg.	2.77c	3.22c	4.16b	4.63ab	5.42a	4.98ab		

Means followed by the same letter are not significantly different at the 5% level according to Duncan's method.

Brewers Gold and 128-I both displayed high α-acid content in 1963, while other varieties showed a substantial increase in quality (Table 2) Variety 144-I has displayed an excellent agronomic character in the past, but until this year it has been below 4.5% α-acid.

Evaluation of hop pickability in 1963 was based on visual observations during mechanical harvest and on pluckability data obtained with a dynamometer. Data are summarized in Tables 3 and 4.

Table 3. Visual observation recorded during machine harvest of Height of Trellis Study, 1963.

Variety	Harvest Date	Cone Shatter	Detached Sidearms & Clusters	Detached Leaves	Overall Rating
Fuggle	Sep. 4	3	3	4	Ave.
L.C.	13	4	7	6	Poor
B.G.	17	1	1	1	V.good
144	4	2	1	2	Good
135	9	3	8	7	Poor
128	17	1	1	2	V.good

Note: Rating was based on a percentage basis, 0 would indicate none and 10 would be 100%. A detailed description of harvest observations is reported in the Appendix. The overall rating also considered physical properties not listed in the above table.

Table 4. Pluckability[1/] data determined at harvest from six hop varieties on three trellis heights in 1963.

Trellis Ht.	Fuggle	Late Cluster	Brewers Gold	114-I	135-I	128-I	Mean
16 ft.	473	562	457	332	371	438	438a
18 ft.	418	657	460	392	400	466	466b
20 ft.	467	562	460	380	386	480	456b
Mean	453b	594a	459b	368c	386c	459b	

1/ Expressed as gram-force necessary to detach a cone from its petiole. (Average of 60 readings).

Summary & Conclusions:

Trellis heights did not cause a "significant" yield change, but as in 1962 a 5% average yield increase was noted for each 2-foot increase in height. These differences may indicate a reduction in harvest efficiency at lower trellis heights since less cone loss was observed from hops grown at 18 feet than at 16 feet. Cone loss was pronounced for the more vigorous varieties grown on low trellis (Table 3).

A significantly lower plucking force was obtained for varieties grown on a 16-foot trellis (Table 4). Differences in pickability due to height were not directly related to pluckability but varied with vigor and growth form displayed by a variety grown on different trellis heights. Poor picking of Late Cluster and 135-I was evident at all heights but cone loss (as clusters and sidearms) decreased with an increase in trellis height for both varieties.

All varieties had more alpha-acid than last year in common with the general situation in Oregon. An incomplete summary showed all varieties except 135-I had more than 4.5% alpha-acid; Brewers Gold and 128-I had 13%.

Study of Endogenous Gibberellins in Hop Cones.

Objectives:

(a) To develop a laboratory procedure for detecting endogenous gibberellins on hop strobiles.

(b) To determine qualitative changes in endogenous gibberellins.

Reasons for undertaking study:

Exogenous applications of gibberellic acid (GA_3) to hops during an early vegetative stage of growth (Annual Report 1961) stimulates floral morphogenesis. An understanding of the hormone relation in floral differentiation will provide a means to better interpret plant response in various cultural trials. Qualitative and quantitative differences in gibberellins found in hop varieties could be used as a standard in evaluating progenies from a breeding program. Hormones are related to physical differences between seeded and seedless hops and may have an important role in the biosynthesis of quality components in hops.

Procedure:

Green hop samples were hand-picked, twice weekly, during the growing season from Fuggle hops. Samples were obtained from seeded, seedless untreated hops and seeded hops treated with two different formulations of GA_3. One set of samples collected during the week was extracted and the other frozen for later extraction. The extraction and separation of gibberellin-like substances from hops included the following procedure:

1. Homogenize 200 g. green hops in methanol and filter.

2. Adjust pH and extract with ethyl acetate to obtain neutral, basic and acidic fraction.

3. Acidic fraction is further separated with a cellulose column and developed with the following solvent order:
   (a) petroleum ether
   (b) chloroform
   (c) n-butanol
   (d) ethyl acetate
   (e) ethanol (3% ammonium hydroxide)

4. Concentrate fractions.

5. Spot and develop thin layer chromatographic coated with silica gel.

6. Spray plates with acid, heat and observe fluorescence with UV light.

Gibberellin activity of eluates determined with bioassay testing on Phinney's dwarf maize and Morse's Progress No. 9 dwarf pea.

Experimental results:

Gibberellin activity was noted in seeded, seedless and GA_3 treated hops. The presence of gibberellin-like substances was based on fluorescence characteristics, movement on the chromatographic plate, and growth elongation of bioassay plants. The separated gibberellin-like substances did not display chemical properties similar to GA_3. Nearly all of the noted gibberellin substances were separated from the acidic fraction and developed with chloroform. Additional substances were isolated from the ethyl ether fraction which was a "clean-up" of the water phase from the acidic fraction.

Discussion:

Preliminary studies would indicate that endogenous gibberellin-like substances are present in seeded and seedless hop strobiles. Cone samples from hops treated with GA_3 apparently did not contain the hormone two months after treatment. It was not determined if the GA_3 had undergone a chemical degradation or chemically altered to another gibberellin.

Gibberellins have been considered to be insoluble in non polar solvents, as chloroform. Recently it has been established the gibberellins 5 (GA_5) and 7 (GA_7) are soluble in chloroform in acid solution. The Rf values of gibberellin-like substances extracted from hops are similar to the value of GA_7 standard, (Rf0.70 with benzene-acetic acid-water solvent system). GA_5 has a Rf of 0.35 with the same system, but there is the possibility that the gibberellin found in the chloroform fraction may be A_5 or A_7, most likely A_7. English workers have found GA_5 in runner beans, but the presence of GA_7 in plants has not been noted to date.

Test of Treated Paper Twine

Objectives:

See 1962 Annual Report, p. 46.

Reasons for undertaking the work:

See above.

Procedure:

See above.

In 1962 two chemical treatments were included in the study whereas in 1963 an additional chemical treatment was included along with untreated coir string. The study included 2 replications with a 21-hill plot strung with 2 strings. This resulted in a total of 84 strings for each treatment. The study was conducted on Hallertau hops grown on a light sandy soil. Strings were anchored with a metal W-clip pushed into the soil with a hand tool to a depth of 8 to 10 inches. Study was initiated May 13, 1963 and terminated September 30, 1963.

Treatments included were as follows:

1. Treated paper, creosote -- WOT 5850,
2. Treated paper, 10% Dowicide -- WOT 5852,
3. Treated paper, 2% copper as copper napthanate -- WOT 5851,
4. Untreated coir,
5. Untreated paper.

Results and discussion:

Results were obtained by a physical examination of each string after four months, which is the period of time strings are necessary during the growing season. The results are summarized in the following table.

Treatment	% strings securely anchored in ground	% strings which broke with less than 50 lb. pull	% strings rotted off within 20 weeks
Paper (treated creosote -- WOT 5850)	64	6	30
Paper (treated 10% Dowicide -- WOT 5852)	10	19	71
Paper (treated 2% CuNapthanate --WOT 5851)	79	21	0
Coir (untreated, old, poor grade) 1/	16	16	68
Coir (untreated, new) 2/	70	20	10
Paper (untreated)	all rotted off within 6 weeks		

1/ only 64 strings tested.
2/ only 20 strings tested.

The untreated paper strings rotted off after being anchored a few weeks and within six weeks these strings were pulled out of the ground by the action of wind. At the end of six weeks a large percentage of the Dowicide treated strings were also rotted and pulled out of the ground. The Dowicide treatment consisted of 10% pentachlorophenol and in 1962 a chemical concentration of 5% resulted in the same amount of rot as obtained with the 10% concentration. The strings which broke after applied pressure would still be capable of supporting vine weight, but this test would indicate a difference in degree of rot due to the chemical.

Summary and conclusions:

Paper string treated with copper napthanate displayed a high degree of resistance to rot when anchored 8 to 10 inches in the soil. Observations made on this study conducted on sandy soil have confirmed our results obtained in 1962 with strings anchored in heavy soil. Pentachlorophenol treatment, at a 5 or 10% concentration, was unsatisfactory in preventing rot.

On the basis of this study, conducted for 2 growing seasons, it would appear that satisfactory results could be obtained with a sub-surface anchored hop twine if paper string was treated with copper napthanate or if a heavy grade of untreated coir string was used.

Effect of Hormones on Root Development of Hop Rhizomes

Objectives:

To determine the effect of several chemicals on root initiation and elongation of hop rhizomes.

Reasons for undertaking study:

This particular study was part of a preliminary greenhouse trial made for one year. The results will be used to modify future studies.

Hop plantings are usually established with rhizome cuttings and result in a good stand if planted in late fall or early spring. New plantings in Oregon do not reach maximum production until the third harvest year; therefore, growers have established "nurseries" from which they plant year-old-crowns instead of cuttings. Many times it is not possible to have nursery stock available of a particular variety for planting.

This study was initiated at the request of several Oregon hop growers to determine the effect of chemical growth regulators on hop rhizomes, whereby a more vigorous cutting would result in an initial yield increase and possibly resist symphylid damage.

Nature and extent of previous work:

It has been established that hop softwood cuttings (above ground shoots) had an increased root set when treated with 20 to 40 ppm indole-acetic (IAA) or indole-butyric acid (IBA). (See 1956 AR, p. 80). Studies on strawberries have indicated an increase in berry production from plants treated with IBA plus kinetin due to an increase in number and length of annual feeder roots.

Procedure:

There are numerous chemicals available for use in this type of study, but the number was limited to those which were favorable for rooting of hop softwoods and other comparable rootstock. The study was also limited to those chemicals which were most readily available. Five chemicals were selected and of these, two are known to promote root initiation, namely, indole butyric

acid and boron, whereas the other three chemicals, kinin (kinetin), gibberellin, and lipids are involved in plant elongation.

Table 1 is a listing of chemical treatments and concentrations used in the study. The chemicals were used alone and in combinations of two, but did not include combinations of three, four or five chemicals. The study included 15 chemical treatments, plus a tap water check, a commercial dust of indole butyric acid, "Rootone", and a normal planting of the untreated cutting. The amount of chemical absorbed by the cuttings was altered by different soaking times in the water solution, instead of using different concentrations. A 20-hour soak was thought to be optimum and 6- and 48-hour soaks were established as minimal and maximal durations.

Ten cuttings from each treatment, a total of 500 cuttings, were planted in a greenhouse soil rooting bed with a soil temperature of 55°F. and 50 to 65°F. air temperature. The soil temperature was lowered to be within range of field conditions in Oregon during the early spring hop planting operation. It is a known fact that optimum rooting occurs under controlled conditions, at a 75°F. soil temperature and a cooler air temperature, but this range is only approached in the field.

A duplicate rooting experiment was established in the field with all the chemical treatments at the 6- and 20-hour soaking time. It was hoped that the field study would serve as a check on the greenhouse study and also permit an evaluation of plant vigor during the coming season.

One set of 5 cuttings from each treatment was evaluated for root development after 3 weeks. The remaining set of 5 were evaluated after 6 weeks. Data were obtained on root length and number, along with shoot length and number. Data from the field trial will be obtained in 1964.

Table 1. Listing of chemical treatments for rooting study with hop rhizomes, 1964.

Chemical Treatments

1. Kinin (SD 8339)
2. Indole butyric acid
3. Gibrelate "400"
4. Boric acid
5. Carbowax (JW-777R70-1)
6. Kinin + Indole butyric acid
7. " + Gibrelate "400"
8. " + Boric acid
9. " + Lipid
10. Indole butyric acid + Gibrelate "400"
11. " " " + Boric acid
12. " " " + Lipid
13. Gibrelate "400" + Boric acid
14. " " + Lipid
15. Boric acid + Lipid
16. Water (check)
17. "Rootone" (no soaking)
18. Dry check (no soaking)

Chemical Concentrations

Kinin (SD 8339)	5 ppm
Indole butyric acid	40 ppm
Gibrelate "400"	50 ppm
Boric acid (as boron)	20 ppm
Carbowax (JW-777R70-1)	5000 ppm

Soaking Times for Each Treatment

Six hours
Twenty hours
Forty-eight hours

Experimental results:

One set of 5 cuttings from each treatment was evaluated on February 5, 1964 for total root number and length. Data are summarized in Table 2. Photographs were obtained to supplement the data for determining the extent of rooting. Since some of the chemical treatments included growth promoting compounds, it was necessary to also consider top growth. Table 3 is a summary of shoot growth determined 3 and 6 weeks after treatment. The extent of root growth after 6 weeks was similar to that obtained at the end of 3 weeks; therefore, a visual evaluation was obtained instead of actual measurements. A detailed description of all treatments is included in the Appendix.

Discussion and conclusions:

The physiological response necessary for root initiation is related to the concentration of auxin. Normally plant cuttings initiate roots at the base of the cut stem due to the higher concentration of endogenous auxin at this area due to polar transport of the compound within the plant. Exogenous application of a synthetic auxin, such as indolebutyric acid (IBA), results in a higher concentration within the cutting and in theory stimulates root initiation along the entire length of the cutting. These auxin-like compounds also have the property of inhibiting root elongation when present in high amounts.

The extent of rooting (Table 2) was greatest on cuttings soaked in IBA, either alone or in combination with other chemicals. The number of basal roots appeared to be related to the presence of IBA in the treatment, with IBA treatments having the largest number of basal roots and gibberellin treatments having the least amount, if any, of basal roots. In comparison the IBA treatments resulted in the shortest shoot growth, whereas gibberellins had the greatest shoot elongation (Table 3).

Gibberellin and IBA treatments displayed the greatest differences, beneficial or otherwise, but it appeared that the soaking times were excessive for the cutting to absorb an optimal amount of chemical. Even Though the IBA increased the root number, it also inhibited root growth and stimulated cell proliferation which was subject to rot.

Treatments 16 and 18 were of particular interest, since both were regarded as checks. Treatment 16 was a check on the chemical treatments, so it involved a tap water soak, but treatment 18 was planted as a dry cutting common to commercial practice. Treatment 16 had shoot emergence before treatment 18 and the shoot development was uniform for all cuttings. The soaked check also developed a good root system the length of the cutting, averaging 16 roots per cutting, while the dry cutting only developed a few short roots at the base and also produced uneven above ground shoots.

Conclusions at this time would be premature, pending field observations in 1964 and a repeat of the greenhouse experiment using shorter soaking times.

Table 2. Summary of root initiation and elongation on hop cuttings three weeks after treatment. Cuttings were planted Jan. 10, 1964. Total root number was based on 5 cuttings.

Chemical Treatment	Hours soak	Total number of roots						Ave. length of roots (in)	
		Internodal	Ave.	Nodal	Ave.	Basal	Ave.	Internodal	Nodal
1	6	47	9	21	4	0	0	2	2
	20	25	5	10	2	25	5	2	1
	48	22	4	10	2	34	7	3	1
2	6	138	28	100	20	15	3	1	1
	20	72	14	35	7	24	5	3	3
	48	64	13	33	7	27	5	3	3
3	6	71	14	17	3	0	0	2	1
	20	43	8	13	3	1	0	3	2
	48	20	4	16	3	2	0	2	2
4	6	50	10	6	1	12	2	2	0
	20	19	4	21	4	4	1	2	2
	48	33	7	9	2	13	3	2	1
5	6	48	10	22	4	10	2	1	3
	20	29	6	6	1	3	1	4	1
	48	27	5	12	2	5	1	3	3
6	6	166	33	87	17	9	2	2	0
	20	82	16	53	11	17	3	4	3
	48	34	7	40	8	10	2	2	3
7	6	46	9	30	6	1	0	2	0
	20	31	6	21	4	4	1	1	2
	48	50	10	14	3	17	3	1	2
8	6	75	15	30	6	4	1	1	2
	20	50	10	17	3	25	5	4	3
	48	51	10	19	4	18	4	3	1
9	6	70	14	31	6	2	0	0	0
	20	58	12	30	6	12	2	3	3
	48	-	-	-	-	-	-	-	-
10	6	129	26	45	9	2	0	2	0
	20	98	20	55	11	9	2	2	1
	48	98	20	31	6	1	0	2	2
11	6	105	21	43	9	5	1	2	0
	20	85	17	91	18	46	9	2	2
	48	106	21	61	12	16	3	2	1

Table 2. Summary of root initiation and elongation -- cont.

Chemical Treatment	Hours soak	Total number of roots: Internodal	Ave.	Nodal	Ave.	Basal	Ave.	Ave. length of roots (in): Internodal	Nodal
12	6	140	28	77	15	18	4	2	0
	20	137	27	88	18	55	11	1	0
	48	125	25	95	19	50	10	1	0
13	6	115	23	23	5	2	0	1	2
	20	61	12	29	6	0	0	1	1
	48	63	13	11	2	3	1	2	0
14	6	74	15	12	2	0	0	1	1
	20	43	9	24	5	0	0	1	1
	48	43	9	15	3	0	0	0	1
15	6	45	9	30	6	2	0	1	2
	20	33	7	12	2	22	4	1	2
	48	29	6	13	3	32	6	2	1
16	6	55	11	19	4	5	1	2	1
	20	63	13	27	5	5	1	1	1
	48	57	11	21	4	14	3	1	1
17	0	21	4	6	1	20	4	0	1
18	0	17	3	12	2	28	6	1	0

Note: Internodal and nodal indicate the location of root protrusion. Basal roots were those extending from the exposed pericycle at the base of the cutting. All basal roots were less than one inch in length.

Table 3. Summary of shoot number and length on hop cuttings, 3 and 6 weeks after treatment. Total shoot number was based on 5 cuttings.

Chemical Treatment	Hours soak	Number of aerial shoots: 2-5-64 Total	Ave.	2-26-64 Total	Ave.	Ave. shoot length (in): 2-5-64	2-26-64
1	6	10	2	8	2	14	18
	20	10	2	6	1	7	28
	48	11	2	9	2	8	22
2	6	2	0	5	1	15	29
	20	0	0	1	0	0	3
	48	2	0	1	0	2	10
3	6	11	2	9	2	16	28
	20	10	2	10	2	19	29
	48	16	3	6	1	13	40

Table 3. Summary of shoot number and length on hop cuttings -- cont.

Chemical Treatment	Hours soak	Number of aerial shoots 2-5-64 Total	2-5-64 Ave.	2-26-64 Total	2-26-64 Ave.	Ave. shoot length(in) 2-5-64	2-26-64
4	6	6	1	10	2	8	16
	20	10	2	9	2	8	20
	48	11	2	8	2	6	22
5	6	13	3	8	2	10	28
	20	8	2	6	1	9	23
	48	10	2	8	2	7	24
6	6	4	1	1	0	4	2
	20	1	0	0	0	2	0
	48	5	1	3	1	2	2
7	6	11	2	5	1	14	42
	20	20	4	6	1	11	37
	48	13	3	9	2	12	25
8	6	9	2	6	1	10	19
	20	11	2	11	2	9	14
	48	5	1	12	2	12	14
9	6	9	2	9	2	11	22
	20	12	2	7	1	8	36
	48	11	2	10	2	8	19
10	6	4	1	3	1	18	28
	20	3	1	1	0	3	2
	48	4	1	0	0	3	0
11	6	5	1	7	1	7	14
	20	2	0	3	1	6	25
	48	0	0	1	0	0	2
12	6	4	1	6	1	8	23
	20	1	0	1	0	2	2
	48	1	0	3	1	2	2
13	6	8	2	6	1	25	42
	20	9	2	9	2	21	29
	48	12	2	8	2	18	37
14	6	10	2	5	1	20	39
	20	8	2	6	1	19	43
	48	13	3	6	1	13	35
15	6	10	2	7	1	10	19
	20	8	2	9	2	9	20
	48	13	2	9	2	8	18
16	6	10	2	13	3	11	19
	20	11	2	6	1	9	28
	48	8	2	8	2	10	18
17	-	0	0	0	0	0	0
18	-	15	3	7	1	6	21

CR e5-5 (OAES AC:36) CHEMICAL INVESTIGATIONS RELATIVE TO THE EVALUATION OF HOPS.

S. T. Likens

Objectives:

No change in objectives outlined in 1962 AR, page 49.

This line project maintains 8 phases of work carried out under 8 work-plans:

AC-1. Factors influencing storageability, 69
AC-2. (USBA 8) Characterization of experimental lines by chemical analysis of strobiles, 74
AC-3. (USBA 23) Isolation of hop volatiles from brewing products, 78
AC-4. Investigation into analytical methods, 97
AC-5. Service work for cooperative agronomic and breeding trials, 102
AC-6. (USBA 20) Investigation into the cause of cone breakage, 105
AC-8. Influence of hops on fermentation products, 106
AC-9. Quality changes during drying and baling. 107
----- Miscellaneous (Hop extracts) 110

During 1963 major effort was concentrated on AC-2, AC-3, AC-5, and AC-6. While little was done on AC-1, AC-4, AC-8, and AC-9, these work-plan titles were maintained through 1963 (and will probably be retained through 1964) because they represent areas of work which will require attention if time and funds permit.

The report that follows will be in the order of the work-plan numbers.

AC-1 FACTORS INFLUENCING STORAGEABILITY

Objectives, Reasons, etc.

See AR 1962, pp. 50, 51.

Summary:

Last year's attempt to stabilize α-acid in storage by preferential destruction of myrcene (believed to catalyze α-acid degradation) was completed. Compressed hops were found to lose oil at an accelerated rate compared with loose hops. It was determined that this loss was predominately myrcene, as hypothesized. The preferential destruction of myrcene in compressed hops was not found to enhance α-acid storageability.

A major difficulty arose after storage deterioration had progressed from 3 to 6 months: the α-acid determination became unreliable. Interferences were extracted which invalidated the spectrophotometric method which had been used to begin the experiment. The gravimetric method was known to be unreliable with aged hops and results by the conductometric method would not have been comparable to the initial analyses by the spectro. method. (reliable method for the assessment of α-acid, which could predict brewing potential, is a pressing need of the entire industry.)

Several pounds each of 5 commercial varieties were collected and held in refrigerated storage pending experiments with storage tests of extracts from them. The brewing industry was unreceptive to any work along these lines and the extracts have not been prepared.

It is believed, however, that the hop-extract approach to extensive storage stability offers promising possibilities. For example, samples of Late Cluster and Brewers Gold hop oils which had been sealed in glass ampoules for 13 years were compared (gas chromatographically) with 1963 samples and found to be in excellent condition. Since the oil content of hops is among the first of the quality components to degenerate, this information encourages the initiation of experiments with hop-extracts in spite of the brewing industry's present attitude.

Results:

Table 1 provides the data necessary to complete Table 2, p. 53, AR 1962. The entire data indicate that after 160 days, or about 5 months, at 68-70°F. the myrcene content of compressed Brewers Gold was essentially gone while oil from the loose samples still contained 57% myrcene. It was beyond this point in the storage test which α-acid stability in the compressed group should have been demonstrably superior due to the lower concentration of catalytic myrcene. The absorption curves of petroleum ether extracts of both baled and loose samples indicated extensive degredation of α-acid (Table 2). Conductometric analysis of the final sample (318 days) indicated that the loose samples may have contained more α-acid than the baled samples (contrary to the hypothesis). These data only add support to the conclusion reached last year. (AR 62, p. 55).

One additional sampling was made on the Fuggle series at 251 days of storage at 68-70°F. (Table 3). As with the Brewers Gold experiments, this last date only supported the conclusions of last year (AR 62, p. 59).

Examination of 13 year-old hop oil samples:

Samples of Brewers Gold and Late Cluster hop oils which had been in glass ampoules at 38°F. and -5°F., alternately, since 1950 1/ were opened and examined. Both were found to be in excellent condition from the standpoints of color, viscosity, and absence of precipitated materials. The Brewers Gold sample was not as good as a 1963 sample with which it was compared, but the Late Cluster oil was of superior aromatic character to a 1963 sample.

Samples of each were subjected to gas chromatographic separation on a 27 foot, 3% Silicone SE.90: Alkaterge: Carbowax 20-M (3:1:1) packed column and found to have nearly identical characteristics with 1963 samples with which they were compared. (Figure 1).

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1/ Samples sent to Mr. D. E. Bullis in 1952 by Mr. R. G. Wright. Both were from ripe, dried samples.

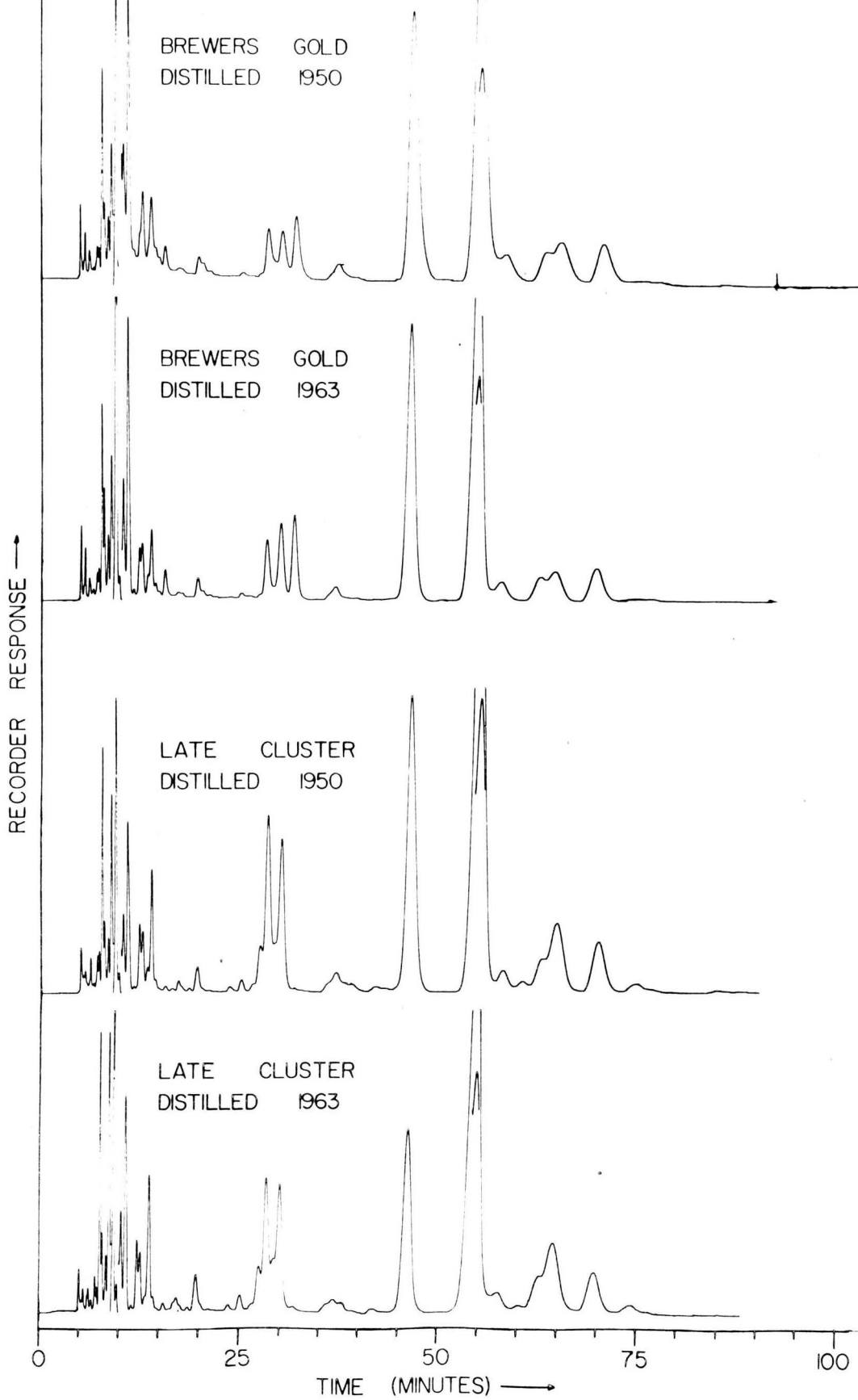

Figure 1. Comparison of fresh (1963) hop oil samples with samples distilled in 1950 and stored (sealed) 13 years. (1/8 " x 27', 3% Si SE 90, Alkaterge, Carbowax 20-M, 3:1:1 on 60/80 Chromosorb P, 144°C.)

Even the myrcene content appears to be very nearly that of the 1963 sample, indicating a complete lack of polymerization. In addition, there is no evidence of auto oxidation or molecular rearrangement of the hydrocarbon sesquiterpenes.

The particular column upon which these were separated is new and has not been evaluated with all markers, so that identification of only a few components is possible. The important point, however, is that no apparent change in the quality of the oil has taken place in 13 years storage.

Table 1. Detailed composition of oil from Brewers Gold storage tests of 1962 (see Table 2, p. 53, 1962 AR)

	Loose						Baled					
Days	Total	Myr.	Hum.	β-cary.	MNK	Other	Total	Myr.	Hum.	β-cary.	MNK	Other
251	1.07	.358	.166	.055	.027	.464	0.65	.086	.137	.036	.019	.371
318	0.56	.144	.093	.033	.025	.265	0.37	.028	.047	.017	.015	.266

Table 2. α-acid β-acid and oil content of loose and compressed Brewers Gold hops at termination of 1962 storage tests (see Table 4, p. 55, 1962 AR) 1/.

	α-acid (%) 1/		β-acid (%) 1/		Oil content(ml/100g) 2/	
Days	loose	baled	loose	baled	loose	baled
251	2.2	3.7	2.6	1.4	1.07(0.36)	0.65(0.09)
318	3.4(6.4)3/	2.4(5.5)3/	1.0	0.6	0.56(0.14)	0.37(0.03)

1/ Spectrophotometric analysis for α and β-acids considered unreliable at 160 days and later on basis that A_{275} exceeds 1/2 of A_{325}. At 251 days spectral absorbtion curve hardly recognizable.
2/ Numbers in parenthesis are myrcene content of the hops.
3/ Conductometric analyses.

Table 3. Effect of compression on the storageability of Fuggle hops. (see Tables 6 and 7, p. 57 1962 AR).

	α-acid (%)		β-acid (%)		Oil content(ml/100g) Total		Myrcene	
Days	loose	baled	loose	baled	loose	baled	loose	baled
Hand-picked:								
261	3.7	3.5	1.5	1.3	1.06	0.42	0.48	0.11
Machine-picked:								
261	3.2	3.0	1.5	1.1	0.93	0.56	0.38	0.11

AC-2 (USBA 8) CHARACTERIZATION OF EXPERIMENTAL HOP LINES BY CHEMICAL ANALYSES.

Objectives:

1. Characterization of parental stock.

2. Evaluation of crossing methods for maintenance or improvement of quality characteristics.

3. Quality evaluation of lines submitted for Brewers' inspection.

4. Extent of contribution of other bittering agents as the need arises.

5. Complete characterization of lines reaching off-station testing.

For further comment on objectives, duration, reasons, etc. of this work plan, see AR 1961, pp. 51-2 or "Progress Report to USBA" dated Nov.1, 1961.

Summary:

No new work was carried on towards characterization of parental material, however, plans for 1964 include collection and analysis of both male and female lines used as parental stock.

No new work was carried out on crossing methods in 1963, but plans for 1964 may include preliminary work on the heritability of hop oil characteristics by oil analysis of males and females with the intent of finding lines with exceptional oil characteristics which could be used for accentuating results of crosses.

Brewers' inspection samples were analyzed for α-acid, β-acid and oil content. Oil samples from all lines were subjected to detailed analysis, but in the absence of sufficient correlation between oil composition and brewing quality, no conclusions were made from these data. In view of the results of investigation into the amount of hop oil which enters the brewing process (see AC-3), it would appear that the hydrocarbon fraction should be ignored, and special attention given to analysis of these lines for their oxygenated components. This will be considered for 1964.

No work has been carried out on other bittering agents in hops, but a report by Dr. L. R. Bishop (ASBC 1964) reminds us that this is a practical aspect of hop chemistry which should not be ignored.

The only off station tests carried out this year were 3 samples of commercially-grown O-11 for Dr. R. R. Romanko (See AC 5).

Results:

Most work this year was done on experimental lines in the Observation Block (Brewers Inspection Samples). Table 5 lists the chemical quality features of each of the selections, and Table 6 provides detailed analyses of the oil from each selection. The actual chromatographs of each oil are included in this report under CRe5-1

Since many of these lines will be discontinued in 1964, either as discards, or because of being placed in the yield trial, a four-year summary of α-acid and oil content is presented in table 4.

Table 4. Four-year summary of α-acid and oil content of genotypes submitted for brewers' inspection in 1963.

Genotype	1960		1961		1962		1963		Disposition
	α-acid	oil	α-acid	oil	α-acid	oil	α-acid	oil	
OB 801	8.7	0.45	8.2	0.49	9.3	1.12	10.3	0.67	?
812					8.6	0.35	4.2	0.64	D
813			5.8	1.92	8.6	2.24	9.0	1.82	YT
822			6.3	1.19	*	*	6.7	1.19	YT
826	9.2	1.29	7.2	2.32	*	*	10.4	2.44	YT
827			6.3	1.64	*	*	8.2	1.18	D
829			6.0	0.62	*	*	4.8	0.98	D
830	9.4	0.54	6.6	0.81	*	*	7.1	0.72	YT
831	7.6	0.58	6.3	1.43	6.2	1.68	8.0	1.45	?
833			5.8	0.51	6.6	1.17	4.9	0.44	D
835			7.4	1.12	*	*	7.1	0.88	YT
839			4.9	0.90	6.4	0.89	3.7	0.93	YT
840			4.8	0.40	6.0	1.16	5.7	1.45	BB
841					5.6	1.10	3.7	0.84	YT
842							4.7	0.75	'64
843							7.6	1.16	'64
844							6.3	1.04	'64
845							4.9	0.61	'64
128-I	12.6	2.10			10.9	2.12	13.4	2.53	?
144-I							4.8	1.21	WN
15-S**	7.3	0.81	6.1	0.54	6.0	0.28	6.6	0.29	?
L-1	6.2		4.3	0.20	6.0	0.48	8.9	0.81	WN
L-8	5.9	0.40	6.6	0.22	9.5	0.69	9.7	0.75	WN
E-2	7.1	0.23	5.2	0.30	7.8	0.59	9.2	0.98	WN
E-21	5.4	0.36	5.4	0.38	7.3	0.60	9.2	0.97	WN
O-11**			5.5		10.5	1.71	9.5	1.19	IDA

D = Discard; YT = Yield Trial; BB = Breeding Block: WN = Washington
* = Accidentally destroyed in 1962.
** = Not submitted to brewers in 1963.

Table 5. USBA Inspection Samples, 1963.

Code	Selection	m.c.	α-acid[1]	β-acid[1]	Oil[2]	Myrcene[2]	Other components[2]	CoH
	OB 801	9.45	10.27	5.82	0.66	0.414	0.246	.74
6310	OB 813	9.65	8.99	6.79	1.82	1.103	0.717	.47
6302	OB 822	8.85	6.25	1.19	0.709	0.481	--	
6303	OB 826	9.10	10.42	5.15	2.44	1.762	0.678	.32
6308	OB 827	9.65	8.17	3.38	1.18	0.707	0.473	--
6304	OB 830	9.25	7.08	3.39	0.72	0.307	0.413	.37
	OB 831	10.35	8.03	4.73	1.45	0.931	0.519	.76
6311	OB 833	8.25	4.87	3.86	0.44	0.227	0.213	--
6305	OB 835	8.60	7.12	2.32	0.88	0.502	0.378	.37
6306	OB 839	9.25	3.71	4.60	0.93	0.473	0.457	--
6313	OB 840	9.75	5.68	4.73	1.45	0.941	0.509	--
6307	OB 841	9.40	3.67	3.19	0.84	0.403	0.437	--
6317	OB 842	10.50	4.67	5.11	0.75	0.462	0.288	--
6314	OB 843	8.95	7.58	3.37	1.16	0.471	0.689	--
6315	OB 844	10.00	6.30	3.32	1.04	0.504	0.536	--
6316	OB 845	9.65	4.94	4.13	0.61	0.427	0.183	--
6301	15-S	9.90	6.65	5.68	0.29	0.096	0.194	--
	O-11 B	9.05	9.52	4.43	1.19	0.751	0.439	.48
	L-1	7.35	8.90	4.96	0.81			.47
	L-8	6.85	9.70	5.34	0.75	0.370	0.380	.48
	E-2	7.85	9.18	4.72	0.98			.49
	E-21	7.65	9.19	4.65	0.97			.45
6318	128-I	10.85	13.45	4.26	2.53	1.359	1.171	.31
6319	144-I	11.50	4.83	3.90	1.21	0.633	0.577	.20
6312	OB 812	11.15	4.21	2.54	0.64	0.360	0.279	--
6309	OB 829	8.40	4.72	5.25	0.98	0.587	0.393	--

1/ Modified Spectro. method: 5g ground hops ext. with 100 ml toluene; 2 ml aliquot made to 10 ml with p.e., a 3 ml aliquot evaporated and residue made to 100 ml with alk. MeOH.

2/ Oil, myrcene and other components expressed as ml./100g. D.M.

Table 6. USBA Inspection Samples, 1963 -- Oil content and composition

Selection	Oil	% Composition 2/				
		% myr.	% hum.	% β-cary.	% MNK	% Others
OB 801	0.66	62.7	9.7	3.5	1.7	22.4
OB 813	1.82	60.6	13.0	4.4	1.1	20.9
OB 826	2.44	72.2	2.4	1.3	1.2	22.9
OB 830	0.72	42.7	12.2	6.1	2.7	36.2
OB 831	1.45	64.2	8.9	3.2	0.9	22.7
OB 835	0.88	57.1	9.6	4.6	0.5	28.1
OB 839	0.93	50.9	12.1	5.4	1.0	30.6
OB 827	1.18	59.9	9.5	3.8	0.7	26.0
OB 833	0.44	51.5	6.3	3.5	2.9	35.8
OB 840	1.45	64.9	6.6	3.3	0.9	24.3
OB 841	0.84	48.0	3.1	4.1	0.7	44.0
OB 842	0.75	61.6	7.8	4.4	1.3	24.9
OB 843	1.16	40.6	14.3	4.3	1.5	39.2
OB 845	0.61	70.0	8.5	1.7	0.4	19.4
15-S	0.29	33.3	3.3	5.5	6.0	51.9
O-11 Batt.	1.19	63.1	5.3	3.3	2.4	25.8
L-8	0.75	49.3	11.4	4.7	3.6	30.9
128-I	2.53	53.7	14.7	4.7	1.3	25.6
144-I	1.21	52.3	21.2	6.2	1.0	19.3
OB 812	0.64	56.3	5.5	3.0	1.3	33.9
OB 822	1.19	59.6	13.3	5.5	1.9	19.7
OB 829	0.98	59.9	12.1	3.4	1.3	23.3

1/ Oil content, expressed as ml. oil/100g. D.M.

2/ Composition determined by gas chromatography: 1 µl sample 1/8" x 25' BDS on 60/80 mesh chromosorb "P" + 2' Fore column, 28 psi N_2, HF detector (15 psi H_2/7.5 psi Air), attenuation 50 x 10^2.

AC-3 (USBA 23) ISOLATION OF HOP VOLATILES FROM BREWING PRODUCTS.

Objectives:

The object of this work plan is to develop a method for the isolation and determination of hop volatiles in beer in a manner which would be suitable for verifying their presence both qualitatively and quantitatively.

Duration, reasons, etc.

See AR 1962, pp. 69-70.

Most emphasis this year was placed on this work-plan with the result that the immediate objective of establishing a method for qualitative and quantitative estimation of major hop oil constituents in brewing products was accomplished.

Preliminary trials with a specially constructed simultaneous distillation-extraction unit definitely revealed the presence of several hop oil constituents in hopped wort, but was not satisfactory from the quantitative standpoint.

Based on these tests, and including refinements and using quantitative techniques, a method was developed which would isolate and estimate major hop oil components in wort and beer with a maximum sensitivity of about 2 ppb. each. This was believed to be more sensitive than organoleptic evaluation and therefore adequate for evaluating flavor characteristics.

Using this method 14 ppb. methyl dec-4-enoate, 3 ppb. undecanone-2, 13 ppb. methyl dec-4, 8-dienoate, and 3 ppb. humulene were found in wort. None of these remained in detectable amounts after fermentation and storage. This was verified by examination of 7 other retail beers. One other beer, however, was found to contain over 1000 ppb. hydrocarbons, hop oil constiuents and 42 ppb. oxygenated hop oil components. This was the only one of the 9 samples which had an unmistakable hop aroma.

A sample of heavily hopped ale was examined before hopping, after hopping and after fermentation. It was found to contain over 170 ppb. hop oil constituents in the wort, but only humulene (25 ppb.) and β-caryophyllene (1.3 ppb.) were detectable after fermentation.

The fact that essentially no hydrocarbons were found to be transferred to wort and that none were detectable in most beer, lead to the conclusion that this group of hop oil components are of little consequence in the development of new varieties.

Results:

I. PRELIMINARY TESTS:

Distillation and recovery system

Shortcomings of the Wright-Connery trap (Fig. 1-A) for recovery of steam-distilled hop volatiles were:

1. Partition occurred at the pentane:aqueous-alcohol interface at the bottom of the pentane layer. Components with any degree of affinity for the aqueous-alcohol phase had no opportunity to accumulate in the pentane.

2. All partition had to occur at a relatively small surface which would presumably require long distillation times before equilibrium could be reached.

3. The system was open to air and losses of polymerizable terpenes could be expected.

A new distillation unit was designed and built to overcome these difficulties (Fig. 1-B). This unit continually replenishes the pentane phase from the pentane reservoir to prevent its saturation by any component. This system also greatly increases the surface area of the interface by distributing it over the lower surface of the condenser. The third objection to the Wright-Connery unit is overcome by using a closed system and purging the system with N_2 until distillation begins, thus preventing contact with air. This unit was used for all data reported here.

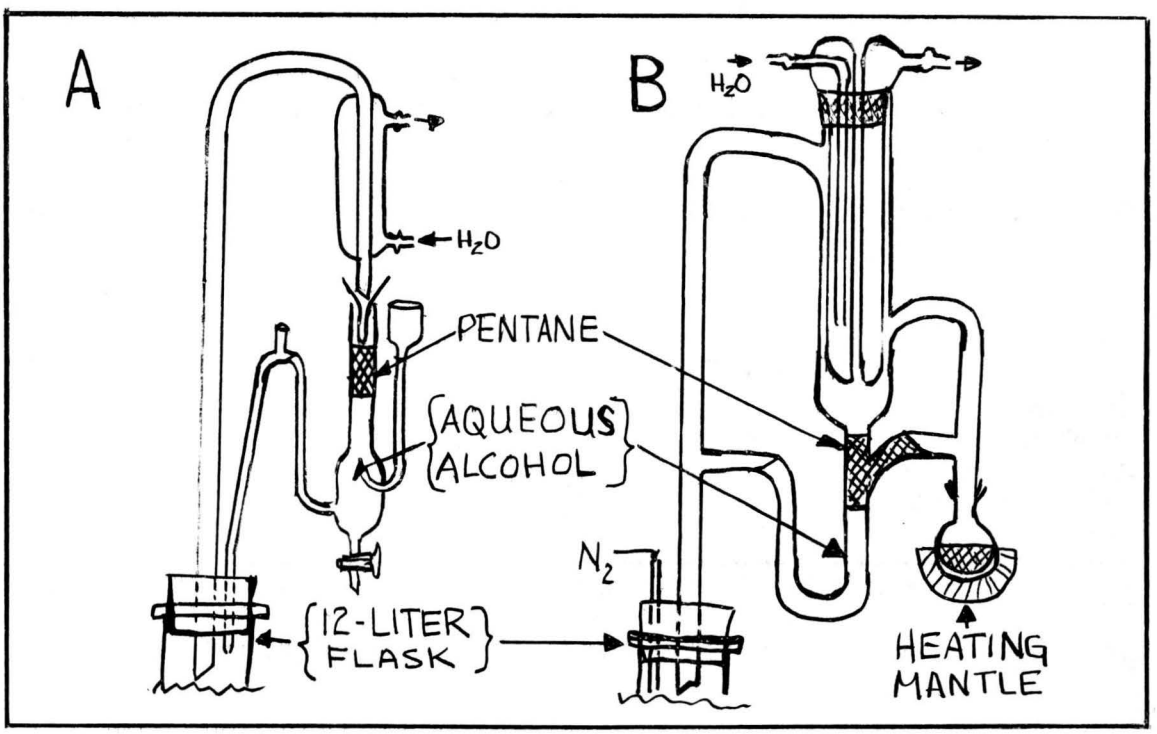

Figure 1. Comparison of the Wright-Connery trap (A) and the double recycling unit (B).

Recovery from artificial media.

Hop oil was added to various artificial systems and recoveries were calculated by determining the ratio of integrator counts per component which was added to the number of counts recovered. This method obviates errors arising from volatility and puts each component on an individual basis.

Seven ppm. hop oil were recovered from: (1) neutral water, (2) neutral 3.5% ethanol, (3) acidified (pH 4.5) 3.5% ethanol and 2 ppm. hop oil were recovered from (4) acidified (pH 4.5) 3.5% ethanol and from (5) acidified (pH 4.5) then neutralized (pH 7) 3.5% ethanol. Data obtained from this series is recorded in Table 7.

It was evident from the tests with 7 ppm. hop oil that the presence of alcohol did not influence recovery appreciably, but the low pH definitely reduced recovery. The second set of recoveries was run at 2 ppm. hop oil to determine if a certain proportion or a fixed amount of oil was lost during recovery. In acid media terpene recovery was low (as with 7 ppm.) but after acid was neutralized, recoveries were similar to those at 7 ppm. neutral. This indicated that 60 to 70% recovery of hop volatiles could be expected from beer provided it was neutralized prior to isolation.

It must be pointed out that 2 ppm. hop oil represents lower concentrations of each of the components, e.g., MNK at 3% in the oil would be 0.06 ppm. in the system.

Table 7. Hop oil recoveries from artificial systems in 1% of the component added.

	7 ppm			2 ppm	
Component	Neut. HOH	Neut. ETOH[1]	Acid[2] ETOH	Acid ETOH	Acid-Neut[3] ETOH
Myrcene	16	22,24	13	4	8
Humulene	80	66,74	50	38	62
β-Caryophyllene	75	64,56	41	40	52
Methylnonylketone	64	72,61	37	89	69
others	56	71,79	48	82	67

1/ 3.5% ethanol in 7 liters. Complete isolation made in duplicate.
2/ Acidified to pH 4.5 with acetic acid.
3/ Acidified to pH 4.5 then neutralized with ammonium hydroxide.

In general, recoveries have indicated that more loss is associated with the low boiling components than with the sesquiterpenes. However, the chromatographic process is more sensitive to the early emerging compounds, and as a result, a relatively uniform sensitivity of the isolation process exists throughout the spectrum of components. It is believed that 5 to 15 ppb. of a component in the system could be detected by this method.

Examination of wort

Hopped and unhopped wort samples were distilled and steam-distillable, pentane-soluble material collected. Gas chromatograms of the isolates (Figure 2) indicate the presence of several components of hop oil. Most of these are oxygenated compounds emerging between myrcene and β-caryophyllene as well as one peak at 20.6 minutes (also oxygenated). The presence of MNK is indicated at 20-50 ppb. in the wort. (Calculation of the peak at 12.6 minutes indicates 30 ppb. in wort). Neither β-caryophyllene nor humulene appeared at detectable levels, which again would be in the range of 10-30 ppb.

A second set of wort samples was obtained and to one portion of the unhopped wort was added 2 ppm. hop oil. Isolates from the unhopped wort, hopped wort and unhopped wort plus 2 ppm. hop oil were collected and chromatographed (Figure 3). The chromatogram from hopped wort indicates the presence of several components which are absent in unhopped wort. The chromatogram of unhopped wort plus hop oil clearly shows the presence of methylnonylketone at about 0.05 ppm. (50 ppb.) in the wort and an oxygenated component of hop oil origin at 11.7 minutes. These are consistent with the first wort analyses.

Also consistent with the first set is the small amount of β-caryophyllene and humulene (if any) which can be recognized in the hopped wort. β-caryophyllene was added at the rate of 0.10 ppm and the resulting peak contains approximately 10 times the area of the peak in hopped wort, suggesting that, if it is present, it is in the range of 0.01 ppm. (10 ppb.). Humulene was added at the rate of 0.30 ppm. and the resulting peak is 12 times that of hopped wort. It appears that nearly half that peak arises from malt and therefore the concentration of humulene in hopped wort must not exceed 0.08 ppm. (80 ppb.).

Examination of beer.

A sample of beer obtained just prior to bottling was analyzed and found to contain less hop oil than was detectable by the method. Two additional retail samples supported this finding (Figure 4).

Discussion of preliminary tests.

These tests indicate the potential of the method as being sensitive to a few ppb. The difficulties up to this point are:

1. Lack of reproducibility both of distillation and chromatography.

2. Incomplete resolution of chromatogrammed peaks.

3. Lack of definite quantitative character.

II. REFINEMENT AND EVALUATION OF METHOD.

Several changes were made in technique to improve the general method used for the preliminary tests:

1. Size of the pentane reservoir in distillation-extraction unit was reduced from 50 ml. to 5 ml. to avoid loss during evaporation of solvent.

2. Instead of removing nearly all solvent and trying to measure the amount of residue, the pentane extract was concentrated to 250 λl. This established a quantitative character and further protected from loss of solvent.

3. All analyses were completed (including G.C.) within 12 hours.

4. Gas chromatographic column was fitted with a replaceable forecolumn to prevent excessive change in column characteristics.

5. Separation into oxygenated and hydrocarbon fractions helped G.C. resolutions.

Details of methods:

Details of methods, including scale drawing of distillation-extraction unit, sample collection, sample preparation, distillation rates, solvent purification, silicic acid separation, handling of concentrates, chromatography, and calculation methods, are listed in the appendix of this report.

Model systems.

A series of buffered systems was tested to determine the optimum pH range for recovery of hop oil from dilute aqueous systems after initiating improvements in technique. The results (Table 8) indicated pH 5.8 to 6.6 yielded the best recoveries. On the basis of these tests, all later tests were carried out at pH 6.0 to 6.4.

One hour distillation gave slightly better recoveries than 2 hours (Table 9) but it was felt that the longer period might give more uniform results with wort and beer which contain much higher boiling components.

Up to this point all recoveries were made from systems containing 2 ppm. -- approximately one-third the concentration of hop oil that would generally be available to wort during hopping[1/]. Preliminary trials with water in which hops had been boiled, indicated that, to be useful, the method had to be sensitive to 10% or less of the amount of oil available to wort (AR 1961). Recoveries from a system containing 0.5 ppm. oil were lower than for 2 ppm., but were adequate for estimating within a few percent the amount of each component present in the system (Table 10). Chromatograms for the 0.5 ppm. recovery are reproduced (figure 5) to illustrate the uniformity of recovery over the range of components.

Examination of wort from an experimental brew.

Unhopped wort was subjected to distillation-extraction and a gas chromatogram of the resulting concentrate indicated the number and location of components derived from malt and adjuncts (figure 6). The chromatogram of hopped wort indicated that 4 components were acquired in significant amounts during hopping (peaks 4, 6, 7 and 8). When 0.5 ppm hop oil was

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1/ Addition of hops containing 0.5% oil at the rate of 0.31 lb./bbl. makes 6 ppm. oil available to the wort.

added to unhopped wort and a concentrate prepared, certain components in its chromatogram were easily distinguishable and coincided with peaks 4, 5, 6, 7, 8, 9, and 11 of hop oil and peaks 4, 6, 7, and 8 of hopped wort.

Silicic acid chromatography of the hopped wort concentrate indicated peaks 4, 6 and 7 were entirely oxygenated and peak 8 was hydrocarbon.

Peak 4 of the hopped wort, is therefore demonstrated to be methyl dec-4-enoate; peak 6 is undecanone-2; peak 7 is methyl dec-4,8-dienoate, but contains a contribution of about 10% from unhopped wort; peak 8 is entirely hydrocarbon and has the retention time of humulene. No hydrocarbon was found in hopped wort with the retention time of β-caryophyllene (peak 5), or farnesene (peak 10), nor of the oxygenated components represented by peak 11. A component with the retention time of myrcene was found to the extent of 6 ppb. in the hydrocarbon fraction of hopped wort, and its identity was considered uncertain.

Ten percent of the available methyl dec-4-enoate, 10% of the available undecanone-2, 15% of the available methyl dec-4,8-dienoate, and 0.6% of the available humulene were found to be extracted and retained by the wort.

One wort sample was held in storage at 35°F. for 9 days and compared with a fresh wort sample (figure 7). The hop oil content of wort was found to be quite stable under these conditions, and consistent between the 2 batches.

Examination of beer from an experimental brew.

When beer from the same source as the wort samples was examined for the presence of hop oil, it was found that components 4, 6, and 7 had disappeared and component 8 was obscured by fermentation products (figure 8). Silicic acid fractionation of the beer concentrate disclosed the presence of a hydrocarbon component corresponding to humulene (peak 8) at less than 1 ppb. in the original beer sample.

Recovery of 0.5 ppm. added hop oil from a second aliquot of beer (figure 8) verified that the distillation-extraction technique was satisfactory for demonstration of the quantities of hop oil components which had been anticipated. Fractionation into hydrocarbon and oxygenated groups indicated that all hop oil components from 4 through 11 were quantitatively identifiable.

The absence of hop oil constituents (except possibly peak 8) in either the whole concentrate from beer, or its hydrocarbon and oxygenated fractions demonstrated that hop oil components 4 through 11 were either absent prior to fermentation or were lost or transformed furing fermentation and storage. A summary of the analyses before fermentation and after storage is given in Table 11.

Examination of retail beers and ales.

Concentrates were prepared from 9 beers and ales representing a cross-section of domestic and imported products. The isohumulone content and aromatic properties of these brews indicated a broad range of hopping conditions (Table 12).

Of these, only sample 4 yielded a concentrate whose chromatogram showed the presence of detectable quantities of hop oil (figure 9). Separation on silicic acid revealed at least 6 hydrocarbons and 6 oxygenated components whose retention times matched hop oil components. A complete list of components found and estimated concentrations is given in Table 13.

The first 2 retail brands examined were the local brands illustrated in figure 4. Sample No. 3 was the experimental brew used in developmental work and the remainder were bottled retail beers and ales. Sample No. 9 was the retail counterpart of the experimental brew. A summary of chromatograms of each are illustrated in Figure 10. Their oxygenated and hydrocarbon fractions are given in figures 11 and 12. After examination of sample No. 4, a new chromatographic column was built and its characteristics were slightly different. As the column aged, the typical performance was reappearing with complete resolution of the peaks between 25 and 32 minutes and the peaks at 70 minutes.

Discussion:

About 80 percent of the oil available to the experimental brew was in the form of the hydrocarbons myrcene, β-caryophyllene, humulene and a small group with retention times similar to farnesene. Of these, myrcene may have occurred to the extent of 6 ppb. in wort but was absent in beer. Humulene was present to the extent of 3 ppb. in wort and possibly 1 ppb. in beer. All others were below detectable levels (2 to 6 ppb.). According to Howard and Stevens something in excess of 1000 ppb. total hydrocarbons is required for a flavor contribution to an unhopped beer containing 29 ppm. added isohumulone. It is highly improbable that hop oil hydrocarbons made a flavor contribution to this particular brew even considering the lower isohumulone content of 10 ppm.

About 7 percent of the oil available to the brew was in the form of the oxygenated components methyl dec-4-enoate, undecanone-2, methyl dec-4,8-dienoate, an unidentified component with the retention time of humulene, and 3 higher boiling components. Of these, only the first 4 were transferred from hops to wort in detectable quantities, and totaled 30 ppb. All were lost or transformed during fermentation. Howard and Stevens state that 300 ppb. oxygenated components are necessary for flavor detection. It must, therefore, be concluded that there is little likelihood that these major oxygenated components of hop oil (in their original form) exerted a detectable influence on the flavor of the unfinished beer.

The fact that 7 out of 8 additional beers and ales examined did not contain detectable quantities of major hop oil components, verifies that the experimental brew was not unique, and suggests that the conclusions may be generally applicable.

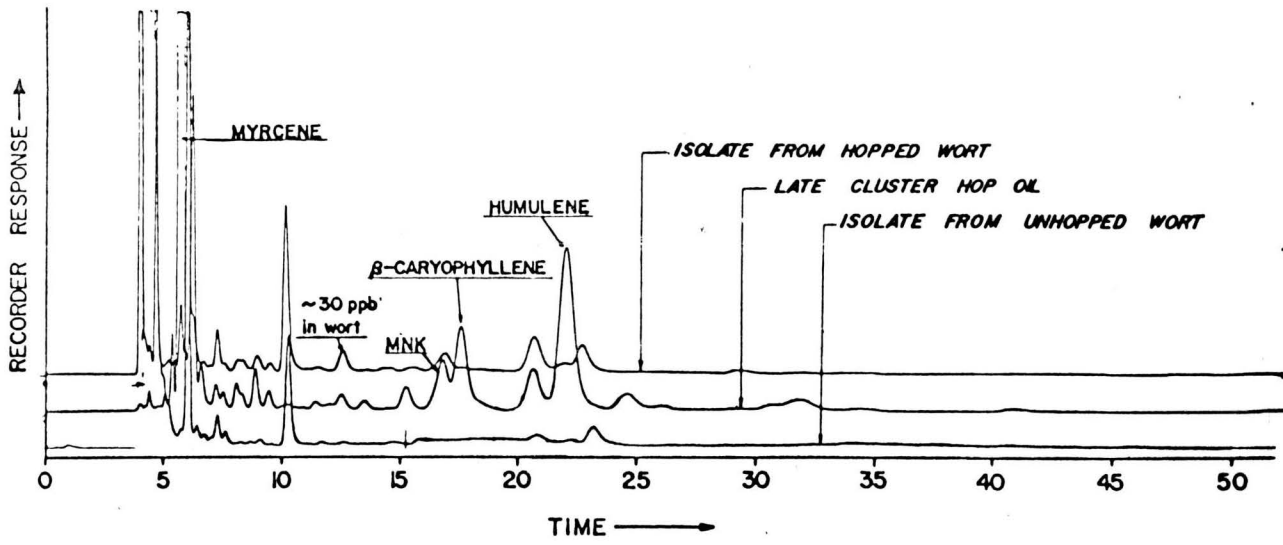

Figure 2. The presence of hop oil constituents in hopped wort (top) is indicated by the absence of many peaks in unhopped wort (bottom). The middle trace (hop oil) serves as a "standard" by which the hop oil components can be located.

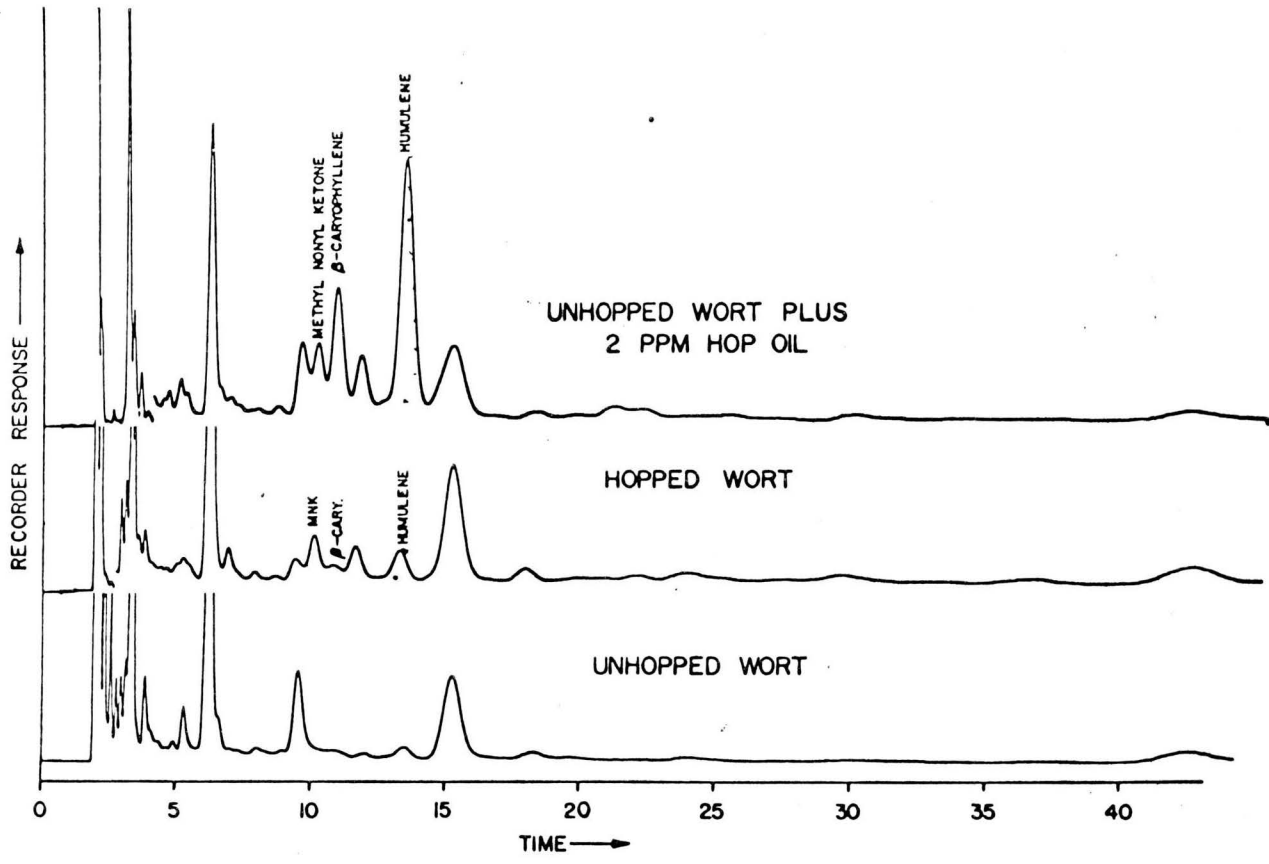

Figure 3. Addition of 2 ppm. hop oil to unhopped wort provides an estimate of the sensitivity of the isolation method and shows the presence of certain hop oil components in hopped wort.

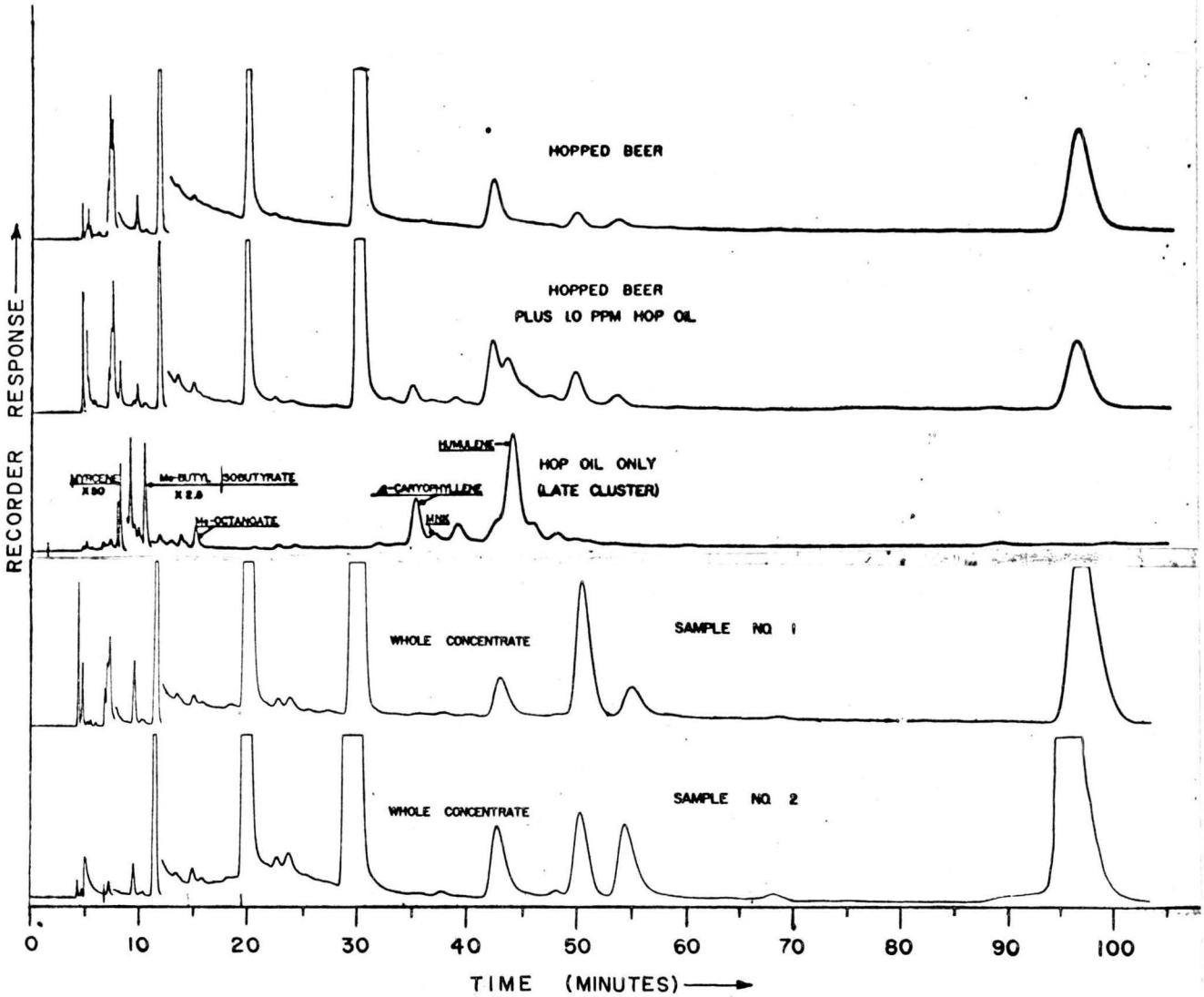

Figure 4. Absence of hop oil constituents in experimental beer (top) is indicated by recovery of hop oil components from "spiked" sample of beer. Samples no. 1 and 2 (bottom) are concentrates prepared from local retail brands, also indicating absence of hop oil components.

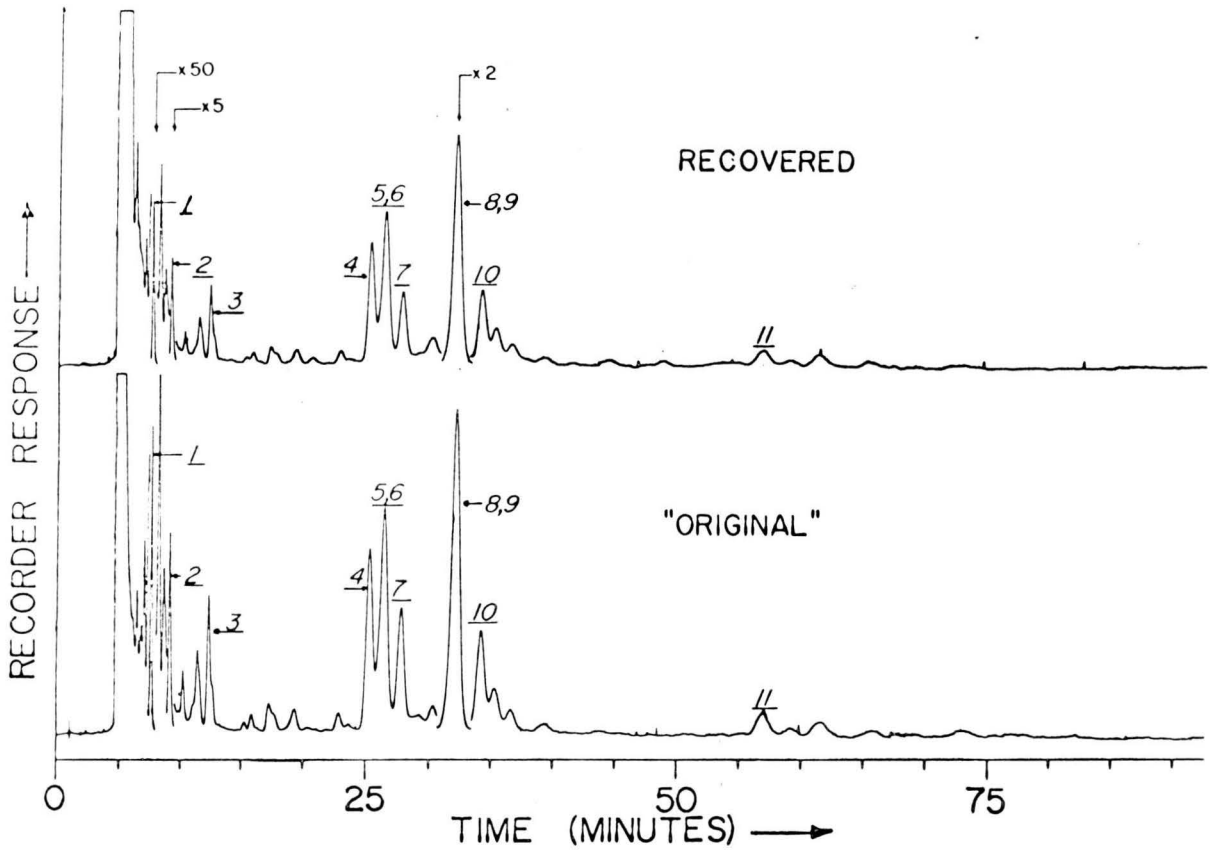

Figure 5. Gas chromatograms of concentrates from unhopped and hopped worts show the increase in components during hopping. Chromatograms of a concentrate from unhopped wort + 0.5 ppm. hop oil indicate the added components arise from hop oil. Chromatogram of hop oil shows which hop oil components are involved. See text for identification of peak numbers.

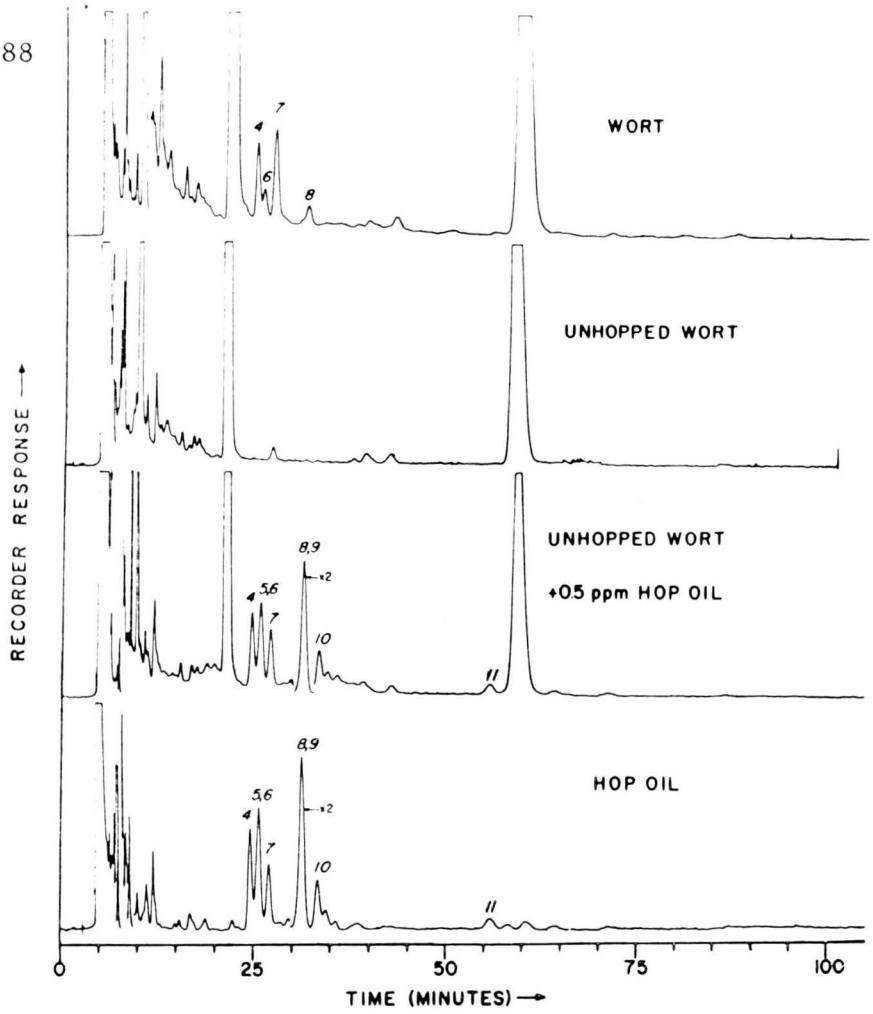

Figure 6. Gas chromatogram of hop oil recovered from a model system containing 0.5 ppm. oil. Comparison with "original" oil indicates uniformity of recovery over the spectrum of components. See text for identification of peak numbers.

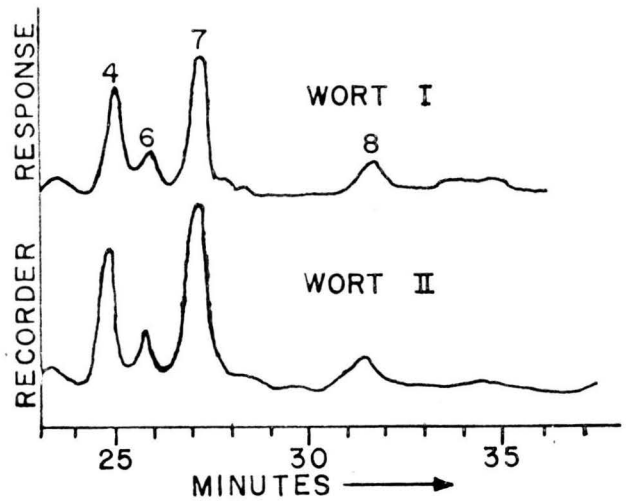

Figure 7. Gas chromatograms of concentrates from fresh (I) and aged hopped (II) worts. The 2 samples represent 2 separate brews. See text for identification of peak numbers.

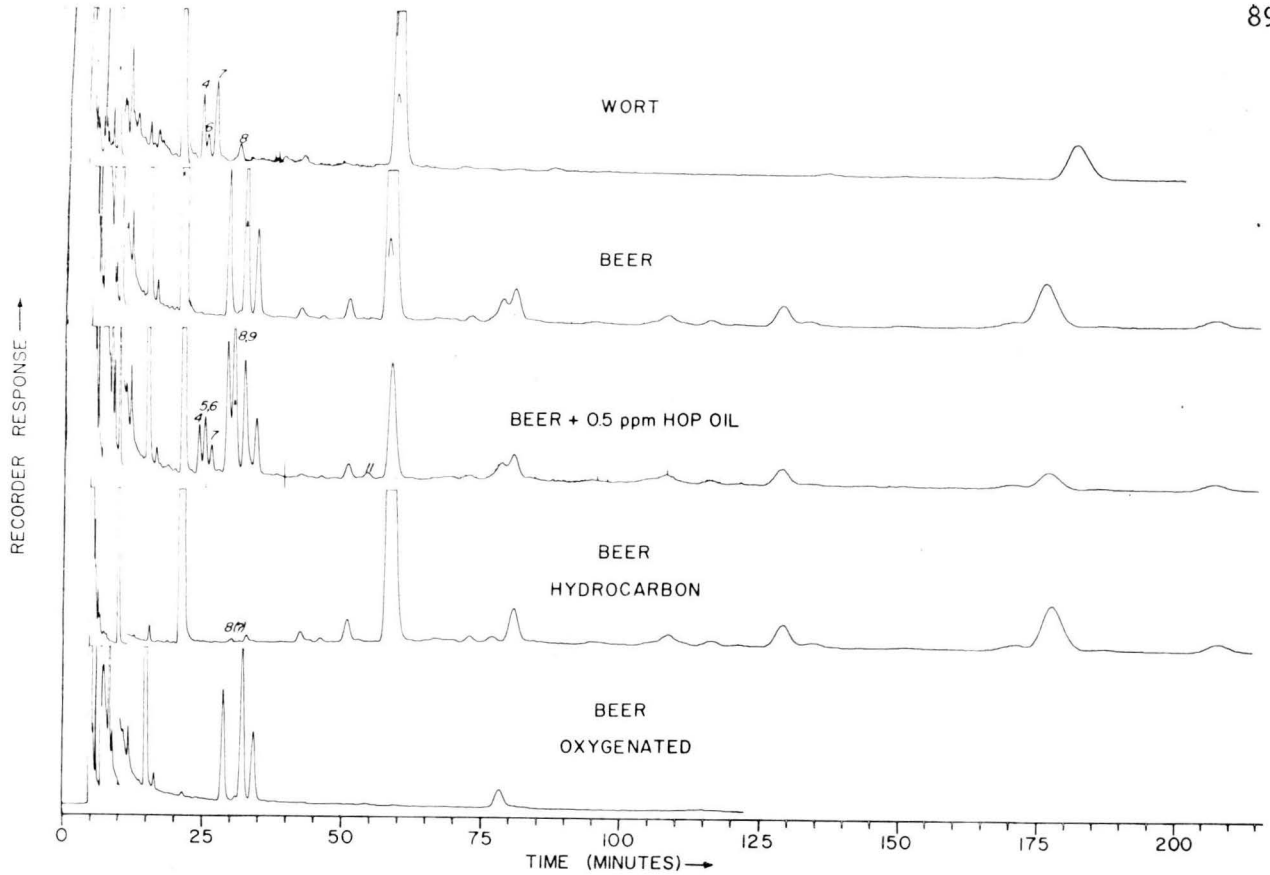

Figure 8. Series of chromatograms indicating the loss of certain hop oil constituents during fermentation (peaks 4, 6, and 7). Peak 8 is obscured in the concentrate from beer, but its possible presence is shown in the hydrocarbon fraction. See text for identification of peak numbers.

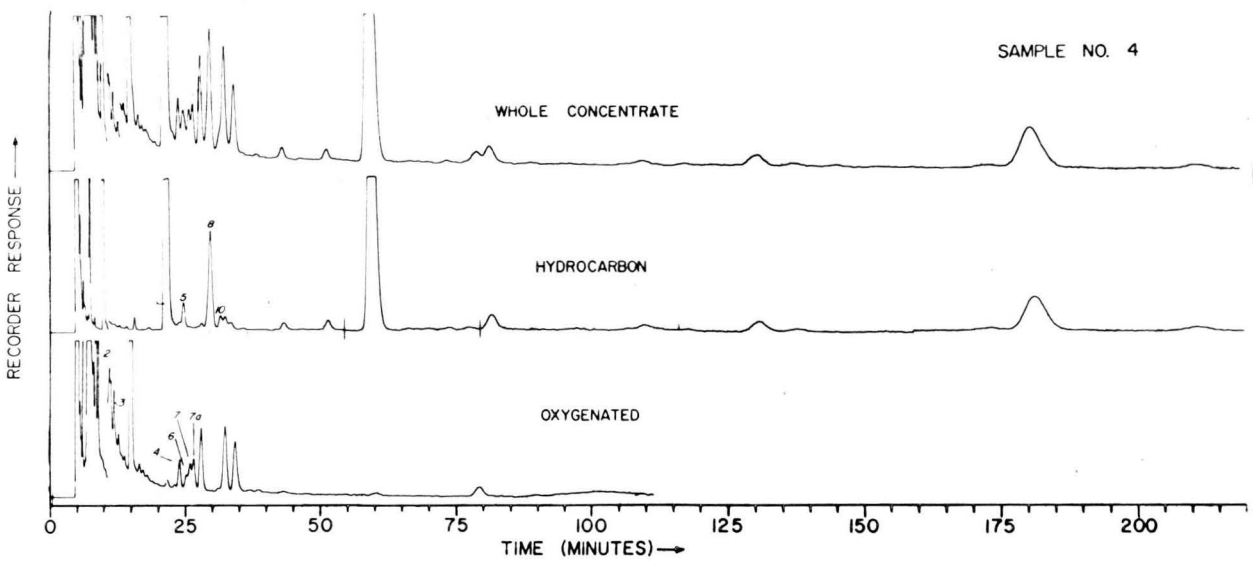

Figure 9. Gas chromatograms of concentrate from retail sample 4 and its hydrocarbon and oxygenated fractions. Peak numbers refer to hop oil constituents. See table 6 for instructions.

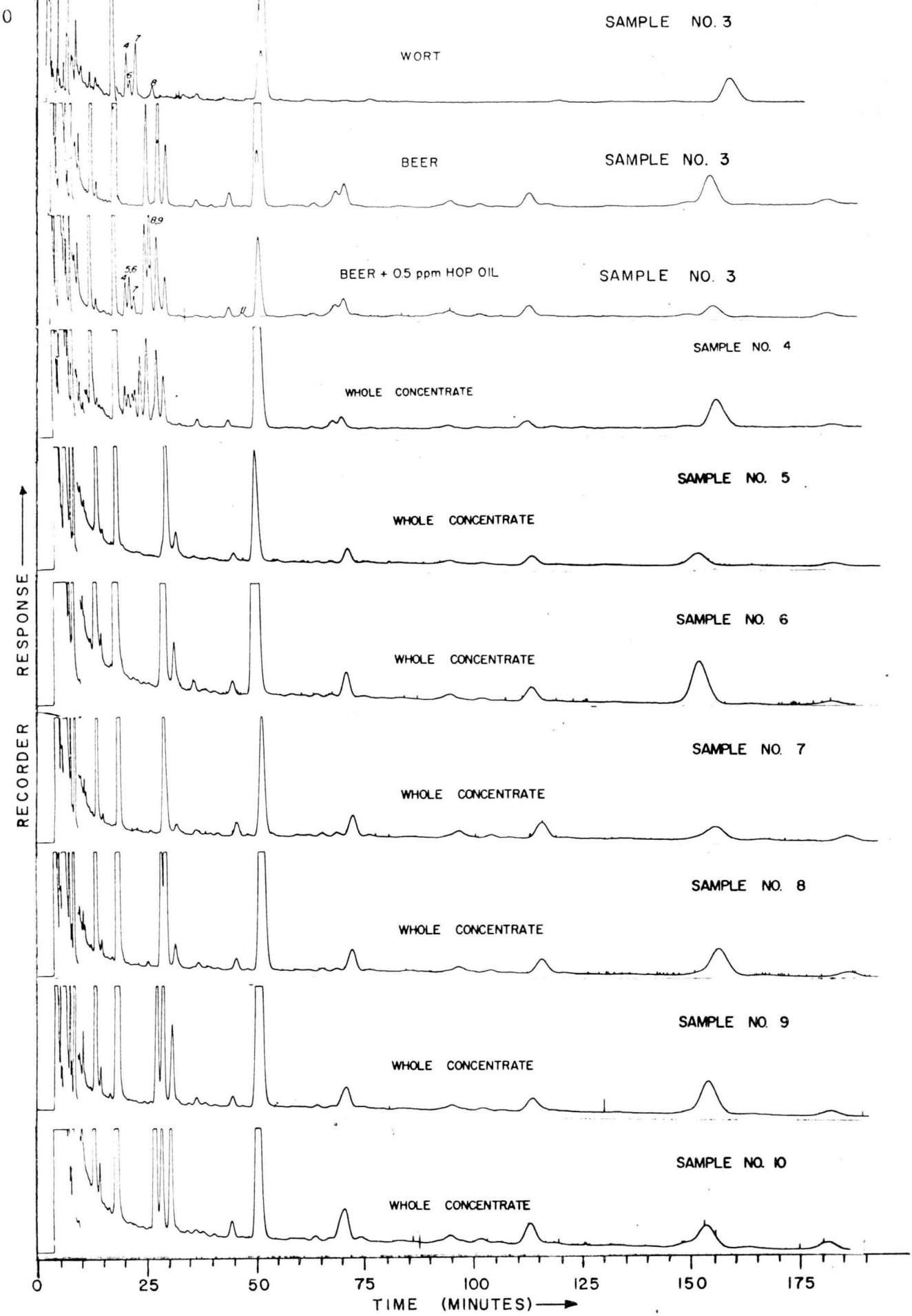

Figure 10. See text.

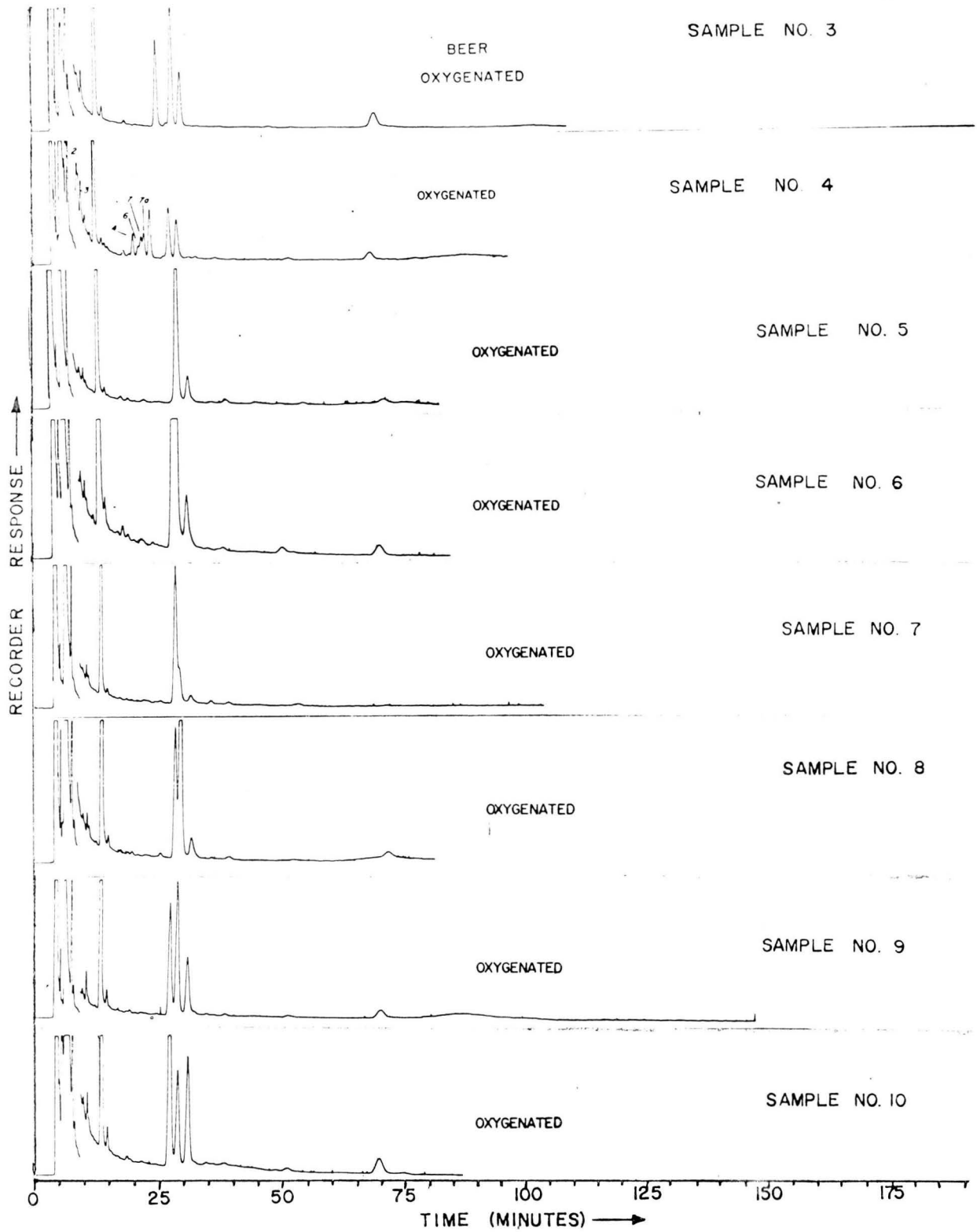

Figure 11. See text.

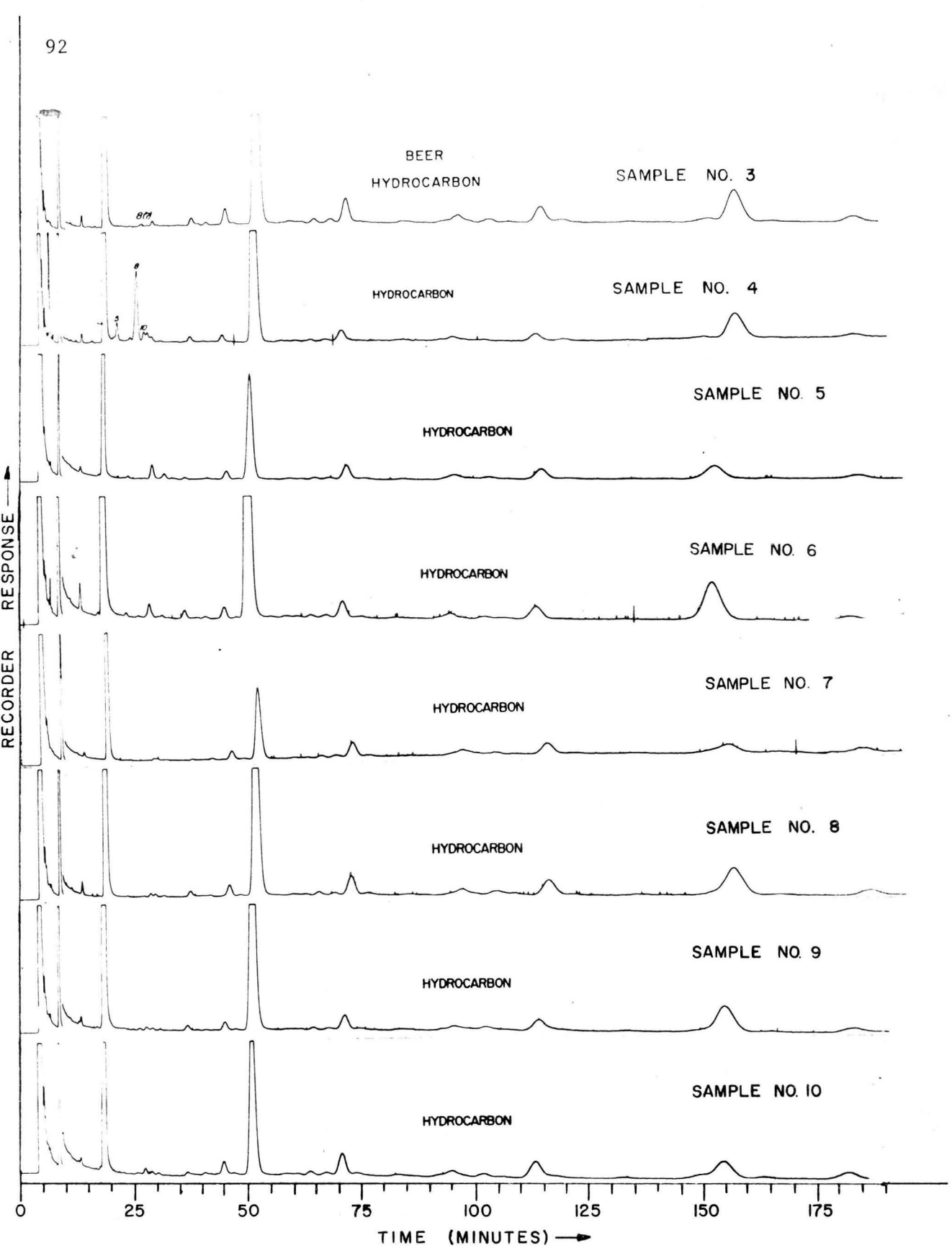

Figure 12. See text.

The analytical results of retail sample number 4 brings several points into focus: First, the method satisfactorily isolated and estimated major hop oil components when they were present. Second, since in excess of 1000 ppb. hydrocarbon and 42 ppb. oxygenated components were present, Howard's conditions for flavor contributions were met. Third, this brew had an unmistakable hop aroma.

It should be borne in mind, however, that the "major hop oil components" referred to in this report (Table 8) is but one of three possible flavor-contributing groups of the essential oil of hops. Remaining to be evaluated are a low-boiling fraction which escapes during isolation by steam distillation, and a fraction which is isolated by steam distillation but which is non-volatile and escapes detection by gas-chromatographic analysis.

Table 8. Effect of pH on recovery of hop oil from model systems when added at the rate of 2 ppm.1/

Peak number	component	Rate added (ppb.)	Percent recovered pH 5.0	pH 5.8	pH 6.6	pH 7.2	pH 7.8
1	myrcene	1268	80	87	87	71	81
2	methyl butyl isobutyrate	72	84	90	90	78	78
3	methyl octanoate	16	75	82	86	77	68
4	methyl dec-4-enoate	54	87	90	92	88	72
5,6	β-caryophyllene + undecanone-2	56	83	95	99	89	95
7	methyl dec-4,8-dienoate	34	76	74	83	81	62
8,9	humulene + oxygenated component	228	96	—	97	91	92
10	hydrocarbon with retention time of farnesene	36	88	97	88	94	94
11	oxygenated sesquiterpene	8	100	86	100	86	86
	Average		85	88	91	84	81

1/ One hr. distillation-extraction.

Table 9. Effect of distillation-extraction time on recovery of 2 ppm hop oil from model system.

Peak number [1]	Percent recovered	
	1 hr.[2]	2 hr.[3]
1	87	73
2	90	74
3	84	77
4	91	87
5,6	97	85
7	78	83
8,9	97	87
10	92	87
11	93	97
Average	90	83

[1] See Table 8 for key to peak numbers and rate added.
[2] Average of 5.8 pH and 6.6 pH from Table 1.
[3] Average of duplicate determinations.

Table 10. Recovery of 0.5 ppm. hop oil from model system.

Peak number [1]	Rate added (ppb.)	Percent recovered
1	317	56
2	18	54
3	4	59
4	14	69
5	11)	70
6	3)	
7	8	62
8	51)	72
9	6)	
10	8	77
11	2	67

[1] See Table 8 for identification of peak numbers.

Table 11. Estimated quantities of hop oil components found in experimental wort and beer.

Component	Peak number	Minimum detectable (ppb.)	Found in wort (ppb.)	Found in beer (ppb.)
myrcene	1	6 (?)	6 (?)	not found
2-methylbutyl isobutyrate and methyl ocanoate.	2,3	not determined	not determined	not determined
methyl dec-4-enoate	4	3	14	not found
β-caryophyllene	5	3	not found	not found
undecanone-2	6	2	3	not found
methyl dec-4,8-dienoate	7	3	13	not found
humulene	8	2	3	1 (?)
oxygenated component with retention time of humulene	9	5	not found	not found
hydrocarbons group represented by farnesene	10	3-5 each	not found	not found
oxygenated group represented by peak number 11	11	2 each	not found	not found

Table 12. Properties of retail beer and ale (including domestic and imported brands) for hop oil content.

Sample number 1/	Hop aroma 2/	I.B.U. 3/	Hop oil components found
1	perceptible	13.0	None
2	doubtful	15.6	"
Control	doubtful	----	"
4	strong	17.3	12 components (Table 6)
5	perceptible	18.5	None
6	perceptible	17.7	"
7	medium	13.7	"
8	doubtful	18.5	1 ppb. peak 7 (?)
Control	doubtful	10.5	None
10	mild	23.0	"

1/ Sample numbers are in the order of analysis date. One sample was re-run to establish no change in the performance of the method during the period of analysis.

2/ Judgement of 3 laboratory personnel

3/ Isohumulones Bitterness Units (1).

Table 13. Detailed analysis of retail sample No. 4.

Peak No.	Component	ppb. found uncorrected	ppb. found corrected 1/
1	myrcene	540	970
2	methylbutyl isobutyrate	present	present
3	methyl ocanoate	5	8
4	methyl dec-4-enoate	8	12
5	β-caryophyllene	19	27
6	undecanone-2	3	4
7	methyl dec-4,8-dienoate	7	10
7a	unidentified oxy. 2/	8	8+
8	humulene	45	63
10+	3 post-humulene hydroc. incl. farnesene	15	19
11	oxy. sesquiterpenes	absent	absent
	Total hydrocarbons found		1079
	Total oxygenated found		>42

1/ Corrected according to recoveries in Table 3.
2/ Origin uncertain but occurs in some varieties of hops.

AC-4 INVESTIGATIONS INTO ANALYTICAL METHODS.

Objectives:

To evaluate, modify, or extend analytical methods as may be necessary to accomplish the overall objectives of CRe5-5.

Reasons, duration, etc:

See AR 1959, p. 113.

Summary:

Unacceptable variation in the spectrophotometric analysis of dried, ground hops for α-acid was traced to inadequate mixing of the sample after grinding, and no improvement was noted with a 5.0 gram sample when compared to the routine 2.5 gram sample.

Sampling hop yards for determination of α-acid was investigated and it was learned that the α-acid content may rise slightly towards evening, but during a period of one day the α-acid is surprisingly constant. Regarding required sample size, it was determined that a single field sample of 1000 grams is reliable; a single subsample for α-acid is reliable; a single titration is reliable; but subsampling for α-acid must be immediate after picking and bracketed by duplicate moisture samples.

After subsamples for moisture and α-acid are taken from a field sample, the α-acid content is stable for a period of 12 hours if kept cool (17-25°C.).

Results:

Laboratory Error in α-acid Analysis.

Review of re-run data from 1962 samples indicated appreciable lab. error was present in α-acid analysis. Examination of the samples indicated poor reproducibility may be associated with high moisture content which tended to result in "pelleted" samples upon grinding, which gave poorly mixed samples.

An experiment was run to test M.C. and uniform mixing. 2.5 g. samples, 100 ml. pet. ether, 1 ml. to 100 ml. alk. MeOH, spectro.

Sample*	Condition	% α-acid 1	2	3	Mean	Range
88-62	Coarse - hi M.C.	6.3	5.6	5.9	5.9	0.7
89-62	"	4.0	4.0	2.9	3.6	1.1
218-62	Uniform, normal M.C.	5.0	5.4	4.8	5.0	0.2
219-62	"	4.9	1.6	4.2	3.6	3.3 ?
196-62	Uniform, re-mixed	6.3	6.4	6.1	6.3	0.2
201-62	"	3.6.	3.6	4.0	3.7	0.4
202-62	"	6.0	5.7	6.2	6.0	0.4
208-62	"	2.0	1.7	1.5	1.7	0.4

This led to the belief that mixing before sampling had been inadequate. As a check, sample 88-62 was thoroughly mixed and 9 analyses run. The average of the 9 was 5.8 with a range of 0.7, which indicated superior results. While improvement was noted, more variation was present than is considered permissible. An experiment was run to determine if a larger sample would improve results.

Sample	Sample size	% α-acid 1	2	3	Mean	Range
79-62	2.5 g.	7.2	6.6	7.4	7.1	0.8
	5.0 g.	7.0	7.9	7.8	7.5	0.9
105-62	2.5 g.	5.3	5.2	5.4	5.3	0.2
	5.0 g.	5.2	5.4	5.2	5.3	0.2

If mixing had still been inadequate, a 5.0 g. sample would have improved reproducibility. Since the larger sample indicated no improvement, it followed that the difficulties were in the part of the determination which followed sampling. Therefore 4 successive aliquots of the same extracts were prepared and the results were:

Aliquot No.	% α-acid	
1	5.2	
2	5.4	range = 0.2
3	5.4	
4	5.2	

It was concluded that better results could be anticipated next year if samples were more thoroughly mixed after grinding and more care given to aliquoting, using double dilution if necessary.

Source of Variation in Field Sampling for Maturity Curves of α-acid.

Maturity curves for following the accumulation of α-acid are notoriously erratic. There have been many speculations regarding the source of the variation, but no reliable data.

The purpose of this experiment was to determine the source of variation and determine the sample sizes or sampling methods necessary to correct the situation.

The method was to collect field samples (FS) in duplicate at 3 times (Ti) during the day. Three subsamples (SS) were taken from each field sample. After extraction, 2 aliquots (Al) were taken from each subsample for α-acid analysis. Statistical analysis was applied to determine which sampling step contributed significantly to the overall variability.

Details of procedure:

3 sections (6 x 100 hills each) of a 100 A. Bullion yard were sampled simultaneously by 2 sample-collectors from the bottom 6 ft. of the vines at 8:30 A.M. on 8/17/63. Collected about 1000 g. for each field sample.

Samples were taken immediately to the lab. in plastic bags. From field sample 1 was taken 110 g. for moisture; 3 subsamples of 100 g. each for α-acid, and a second 100 g. for a duplicate moisture determination. (Note moisture samples taken on each side of α-acid samples.) Moisture samples were toluene distilled for M.C.

Each 100 g. α-acid sample was extracted with 400 ml. toluene 10 min. in Waring blendor, allowed to settle 3-5 min. while cooling (extraction cup in pan of cool, running water). About 60 ml. was decanted into a bottle containing 15 g. Na_2SO_4, stoppered and shaken 2 minutes to remove water.

2 aliquots of 20 ml. each were removed from each extract and titrated conductometrically with 4.38% lead acetate.

Calculation of α-acid was:

$$\frac{\text{end-point}}{\%\ \text{dry matter}} \times 83.0 = \%\ \alpha\text{-acid}$$

After first field sample had been analyzed, moisture, α-acid subsamples, moisture samples were taken from the second field sample. After all samples from the first collection time (8:30 A.M.) had been analyzed, a second pair of field samples were collected (4:00 P.M.) and handled in the same manner. A third pair of field samples were collected at 8:30 P.M. and treated the same as the first two times.

In the analysis of variance, field samples were considered randomized-block because of time of standing while awaiting analysis. The same applies to subsamples and aliquots, so there was a continuous "Ageing" occurring from the first titration (aliquot) within a time through the last titration within a time.

Analysis of variance indicated the major source of variation was in field samples (Tables 14 and 15), and that the second field sample contained less α-acid than the first by about 5% (or 0.4% α-acid). This, in turn suggests that during the time lapse between picking and analysis, α-acid degenerates. This cannot be since such a trend would show up in the subsamples but does not. The only operation in which time-lapse is directly connected with field samples is the moisture determination.

If the idea of α-acid deterioration with time is rejected on the basis of no difference in subsamples, one is led to believe that the moisture determination, in some way, over corrects when calculating to a dry basis.

The conclusions from this experiment are:

1. α-acid content may rise slightly in late afternoon or early evening.

2. Erratic maturity curves must result from day-to-day variation.

3. A single field sample is adequate, but must be analyzed promptly -- especially for moisture (with α-acid subsample weighed out at same time.

4. A single subsample is reliable (C.V.<0.5%).

5. A single titration (aliquot) is reliable. (C.V.<0.5%)

Table 14. Source of variation in Field Sampling for α-acid

Source of variation	D.F.	S.S.	M.S.	F
Main plots:				
Times of sampling	2	1.185	0.5925	20.8 *
Runs (FS).	1	2.778	2.7780	97.5 **
Error a (Ti x FS)	2	0.057	0.0285	
	5	4.020		
Sub plots:				
Subsamples	2	0.102	0.0510	--
Subs x Times	4	0.133	0.0332	--
Subs x Runs (FS)	2	0.410	0.2050	--
Error b (Sub x Time x FS)	4	0.955	0.2388	
	12	1.600		
Sub-sub plots:				
Duplicates	1	0.040	0.0400	1.75 N.S.
Error c	17	0.390	0.0229	
	18	0.430		
Total	35	6.050		

Table 15. Data for Field Sampling Variation Experiment, Aug. 17, 1963.
% α-acid, dry basis.

	9:30 AM		4:00 PM		8:30 PM		
SS	FS 1	FS 2	FS 1	FS 2	FS 1	FS 2	
1 al 1	12.2	11.7	12.2	11.7	13.2	11.7	
2	12.5	12.0	12.4	12.0	13.6	11.9	
T(Ti x FS x SS)	24.7	23.7	24.6	23.7	26.8	23.6	147.1
2 al 1	12.2	11.9	12.4	11.9	12.4	12.2	
2	12.1	11.6	12.3	12.0	12.5	12.2	
T(Ti x FS x SS)	24.3	23.5	24.7	23.9	24.9	24.4	145.7
3 al 1	12.5	11.7	12.4	11.7	12.4	12.3	
2	12.1	11.6	12.4	11.9	12.5	12.3	
T(Ti x FS x SS)	24.6	23.3	24.8	23.6	24.9	24.6	145.8
T(Ti x FS)	73.6	70.5	74.1	71.2	76.6	72.6	
T(Ti)	144.1		145.3		149.2		438.6 GT

Table 16. Field Sample x Sub sample interaction

SS	FS 1	FS 2	T(SSxTi)	T(SS)
1	24.7	23.7	48.4	
	24.6	23.7	48.3	
	26.8	23.6	50.4	
T(FS x SS)	76.1	71.0		147.1
2	24.3	23.5	47.8	
	24.7	23.9	48.6	
	24.9	24.4	49.3	
T(FS x SS)	73.9	71.8		145.7
3	24.6	23.3	47.9	
	24.8	23.6	48.4	
	24.9	24.6	49.5	
T(FS x SS)	74.3	71.5		145.8
T(FS)	224.3	214.3	438.6	438.6
	1	2		
Total aliquots	218.7	219.9		

Demonstration of α-acid Stability in Green Hops.

Results of the previous experiment indicated a certain degree of α-acid stability in green hops between the time of sampling and analysis. It seemed desirable to know the extent of this stability.

The purpose of this experiment was to determine the length of time which was permissible between the time of sampling and the time of analysis, and the temperature requirements, if any.

The procedure was to take a field sample at 7:30 P.M. (8/19/63) subsample for moisture, 6 α-acid samples, and a second moisture, in that order. The samples were held for 2 "ageing" periods at 2 temperatures and analyzed for α-acid by the conductometric method.

Table 17. Effect of "ageing" and temperature on α-acid content (% D.B.) of green (undried Bullion hops).

Time (hr.)	Temperature 17-25°	2°C.
0	11.7	11.4
3	11.3	11.4
12	11.6	11.5

The results indicate that, providing moisture samples are taken immediately, the α-acid content of green (undried) hops is stable for a period of at least 12 hours and that cool room temperature is satisfactory (refrigeration is not required).

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AC-5 SERVICE WORK FOR COOPERATIVE AGRONOMIC AND BREEDING TRIALS.

Objectives:

To detect any changes in hop quality, as assessed by chemical analysis, brought about by agronomic variables, and to make chemical quality evaluations of experimental lines from other research stations.

Reasons, duration, etc.:

See A.R. 1959.

Summary:

OSU, 54 samples from Height of Trellis, 1963.

U of I, 13 samples from 1962 maturity for N-content,
6 samples from N fertility trial for quality and N content,
24 experimental lines for quality,
1 sample for cohumulone and oil composition.

U of W, 17 experimental lines for quality,
4 samples for cohumulone,
1 sample for oil composition.

Results:

Height of Trellis (OSU)

54 samples were collected, dried, and analyzed for moisture, α-acid, β-acid (spectrophotometric) and oil content (Wright-Connery). These are included with the full report under CRe5-4, this report.

Nitrogen Fertility on Late Cluster (U of I)

The maturity data for Idaho Late Cluster from 1962 (1962 AR, pp. 78, 79) were completed with analysis for Kjeldahl nitrogen.

Table 18. Nitrogen content (in % N) of IDAHO Late Cluster maturity study of 1962.

	N Application Rate			
Coll. date	120 N	160 N	200 N	240 N
8/17	2.97	3.12	3.30	3.15
8/22	2.83	2.96	3.00	2.91
8/27	2.93	2.89	3.09	3.08
8/29	3.07	2.83	3.04	3.82
9/3	2.79	2.83	2.91	2.49
9/5	2.60	3.19	2.72	2.78
9/10	2.56	2.84	2.83	2.70
9/12	2.61	2.61	2.63	2.50
9/19	2.42	----	2.57	2.35
9/24	1.99	2.41	2.29	2.11
9/26	1.99	2.56	2.31	2.04
10/1	2.09	2.17	2.08	2.05
10/3	1.76	----	1.99	1.87

Six samples of Late Cluster from R. R. Romanko of the Univ. of Idaho were analyzed for chemical quality and for Kjeldahl-nitrogen with the following results:

Table 19. Chemical data on IDAHO N-fertility trial.

N-rate(#/A)	Plot	M.C.	Ml.oil/ 100 g.	α-acid(%)	β-acid(%)	N (%)
80	B	6.50	0.70	10.03	5.41	2.27
"	D	6.40	0.69	8.52	5.45	2.46
160	A	6.50	0.59	8.97	5.45	2.37
"	F	6.25	0.69	9.29	5.17	2.37
240	C	6.85	0.64	8.44	5.67	2.34
"	E	6.25	0.69	8.40	5.54	2.32

Evaluation of Experimental Lines (U of I)

Ten Early Cluster selections and 4 experimental lines were analyzed for Dr. Romanko of the Univ. of Idaho.

Table 20. Chemical evaluation of IDAHO experimental lines.

Sample	M.C. (%)	Oil (ml/100g)	α-acid (%)	β-acid (%)
EC-1	6.00	0.63	8.45	5.31
EC-2	6.05	0.44	7.66	4.70
EC-3	6.05	0.43	7.89	4.85
EC-4	5.95	0.56	9.02	4.91
EC-5	6.00	0.50	9.07	5.04
EC-6	6.05	0.56	8.65	4.84
EC-7	6.40	0.42	8.26	4.67
EC-8	6.35	0.53	8.38	5.22
EC-9	6.40	0.69	8.07	4.82
EC-10	6.35	0.55	8.21	4.74
O-3	6.85	0.43	7.21	6.23
O-11	7.55	1.14	8.79	4.59
O-11-B	9.05	1.19	9.02	4.74
O-11-A	6.05	1.37	8.69	4.64

Genotype O-11-B was analyzed for cohumulone and oil composition:

cohumulone	48%	Alpha acid
adhumulone	10%	
humulone	42%	
myrcene	63%	Oil
humulene	5%	
β-caryophyllene	3%	
others	29%	

Evaluation of Experimental Lines (U of W):

Dr. C. B. Skotland of Univ. of Washington, sent 17 samples from his selection-evaluation trial for quality evaluation.

Table 21. Evaluation of WASHINGTON experimental lines. 1/

No.	Selection	Harvest Date	M.C. (%)	Oil(ml/100g)	α-acid (%)	β-acid (%)
22	E-1	8/27	7.05	0.87	9.88	4.70
4	E-2	8/27	7.00	0.54	8.10	4.69
31	"	9/4	7.85	0.98	9.18	4.72
26	E-5	9/4	6.80	0.96	10.67	4.89
29	E-9	9/4	7.30	0.97	8.44	4.45
24	E-10	8/27	7.10	0.86	10.78	3.97
20	E-21	8/27	6.85	0.54	7.74	4.20
27	"	9/4	7.65	0.97	9.19	4.65
56	L-1	8/27	7.35	0.86	8.87	4.65
44	"	9/4	7.35	0.81	8.90	4.96
53	L-2	9/9	10.60	1.13	11.83	5.79
42	L-3	9/9	11.70	1.13	9.71	5.62
40	L-4	9/9	10.75	1.01	9.57	5.35
60	L-8	9/9	6.85	0.75	9.70	5.34
37	L-9	9/4	7.20	0.97	10.12	4.60
47	"	9/9	10.40	1.12	11.36	5.39
50	L-16	9/9	9.15	1.10	10.80	5.35

1/ All α- and β-acid analyses are averages of duplicate determinations by the spectrophotometric method.

In addition, those lines scheduled for brewers inspection were analyzed for cohumulone:

	CoH (%)
E-2	49
E-21	45
L-1	47
L-8	48

Oil analysis of L-8 was:

Total	0.75 ml./100 g.
myrcene	49%
humulene	11%
β-caryophyllene	5%
others	35%

AC-6 (USBA 20) INVESTIGATIONS INTO THE CAUSES OF CONE BREAKAGE (SHATTER).

The emphasis of this line of work has shifted to one of plant physiology and the major responsibility has been transferred to C. E. Zimmermann. The detailed report of the 1963 work is entered in this A.R. under CRe5-4.

It is anticipated that Work Plan AC-6 will be given a new title in 1964, probably dealing with hop extracts.

AC-8 INFLUENCE OF HOPS ON FERMENTATION PRODUCTS

Objective:

To determine the extent to which hop extractives modify the products of yeast fermentations.

Duration, reasons, etc:

See A.R. 1962, pp. 84-85.

Summary:

No new work was done under this work plan during 1963. It is proposed to carry the work-plan title for one additional year, however, and continue the work outlined under "procedure" in the 1962 A.R. This is not considered high-priority work and continuance will depend largely upon availability of time.

AC-9 QUALITY CHANGES DURING DRYING AND BALING.

Objective:

To determine factors responsible for quality losses, especially oil content and composition, as they are associated with the production processes of drying and baling.

Duration, reasons, etc.

See AR 1961, p. 67

Summary:

Dry ice was added at the rate of 10 lb. and 20 lb. to 2 bales of Bullion hops and analyses for oil and α-acid were compared with a control bale (1) before baling, (2) 12 hours after baling and 36 hours after baling. No significant changes took place in the quality of any of the treatments up to this time. The bales were shipped by refrigerated rail to P. Ballantine's for sampling and analyses at a later date.

Procedure:

Three consecutive bales of Bullion hops from Ray Kerr's Farm were selected for this study. Each bale was sampled immediately prior to compression. The first bale was used as control.

Dry ice was crushed with a hammer to a maximum chunk size of about 1 inch diameter with the average being 1/4 to 1/2 inch. This was weighed and sprinkled by hand into the press as the hops were added.

After dry ice had been added to the second two bales, thermocouples were inserted to a depth of 9 to 10 inches into the centers of the bales at 2 locations for the check bale, and 3 locations (bottom, middle, and top) of each of the test bales.

Readings of each of the 8 thermocouples were taken each minute with a motorized rotary switch and recorded on a strip chart recorder. After 12 hours, the thermocouples were removed, samples were taken and the bales were moved directly to refrigerated (0°F.) railroad cars. After 24 hours the bales were again sampled. They were then sent to P. Ballantine's where they were transferred to frozen storage.

Results and discussion:

The cooling curves (figure 13) indicate that after about 8 hours, the bale receiving 10 lb. dry ice was beginning to warm, while 20 lb. dry ice held an additional 4 hours or longer. Although calculation indicates 10 lb. of dry ice should reduce the temperature of a bale of hops only about 10°F. the data suggests this quantity may freeze the bale temporarily. Twenty lb. of dry ice apparently freezes the bale and holds it in that condition for some time. (At points where dry ice fragments occurred near the surface, frost formed and was still evident after 12 hours.)

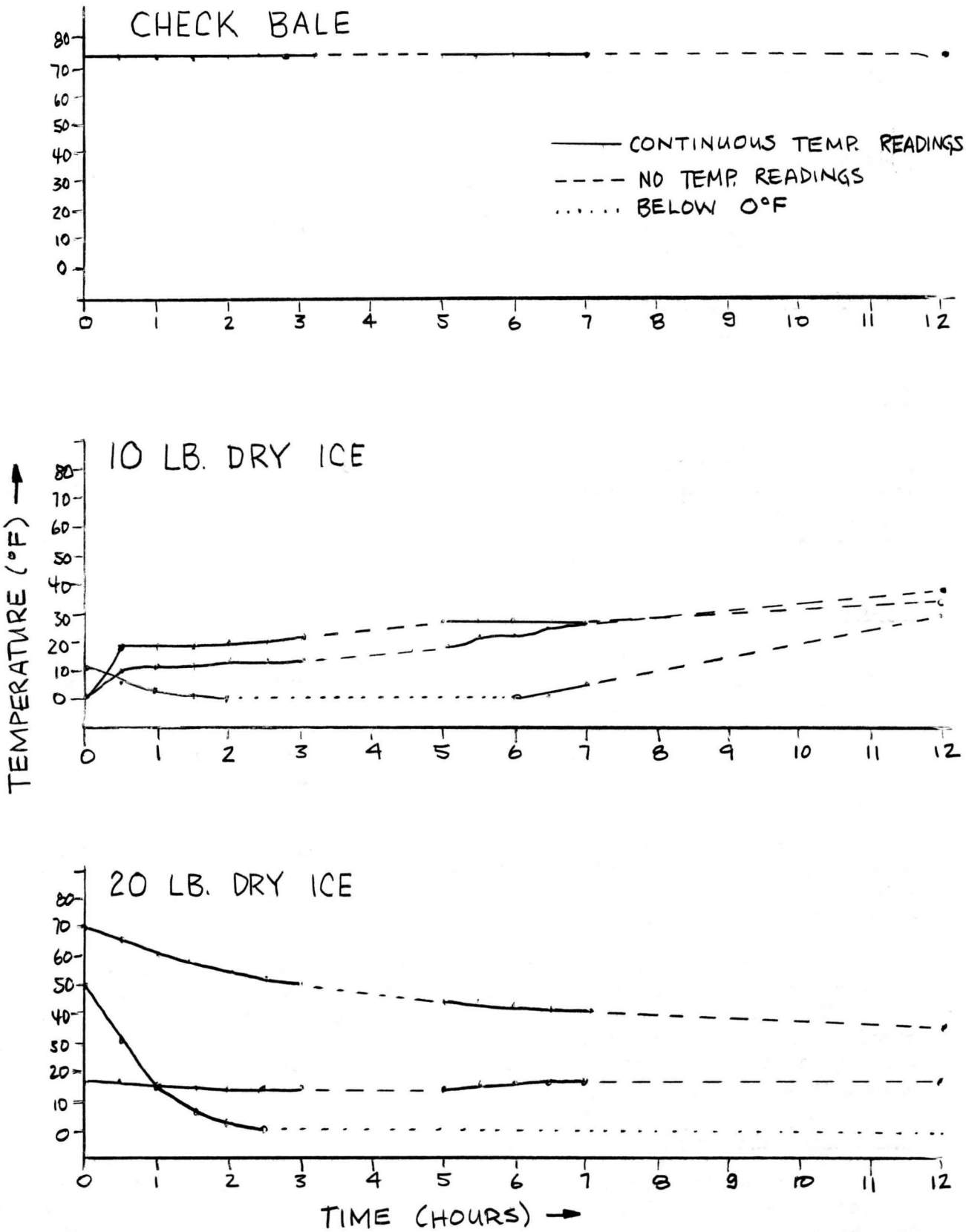

Figure 13. Cooling curves for dry-iced bales.

There are slightly over 10 moles of CO_2 per lb., or 8 cu. ft. per lb. Therefore, 10 lb. dry dry ice should furnish 80 cu. ft. and 20 lb. should furnish 160 cu. ft. of CO_2 with which to displace the air trapped in the bale during compression. A bale of hops is about 13.5 cu. ft., of which about 4.5 is solid and 9.0 is air. Therefore, 10 lb. dry ice furnishes about 10 volumes of CO_2 to the bale and 20 lb. furnishes 20 volumes. Either should be adequate to displace all, or nearly all, the air present in a bale.

Between the immediate effect of lowering the temperature and thus retarding reactions of degradation and the longer lasting effect of displacing the oxygen required for degradation, improved stability was anticipated.

However, analyses of loose, baled (12 hr.) and baled (36 hr.) showed no losses in any of the test bales including the check (Table 22). Samples of the stored bales are to be provided by P. Ballantine.

Table 22. α-acid and oil content of dry-iced bales.

Treatment	Time (hr)	Condition	Oil content (ml./100g.)	α-acid (%)
Control	0	loose	3.94	13.8
	12	bale	3.78	13.4
	36	"	3.84	13.7
10 lb. dry ice	0	loose	3.88	13.0
	12	bale	—	13.8
	36	"	3.86	13.5
20 lb. dry ice	0	loose	3.86	13.7
	12	bale	3.82	13.7
	36	bale	3.92	13.5

MISCELLANEOUS -- PRELIMINARY WORK ON HOP EXTRACTS

1. Separation of β-acid from concentrated hop extract.

Extracted 75 g. 128-I (1963) with 800 ml. pet. ether in omnimixer. Filtered and concentrated to thick syrup.

Took 3 crops of β-acid crystals (-5°F., 24 hr. each) and reduced β-acid/α-acid ratio from 0.318 to 0.01.

Necessary to filter β-acid with vacuum and Gooch crucible with asbestos filter pad. Even this was very slow.

2. Separation of "hop wax" from β-acid-free extract:

Dissolved extract in MeOH and held -5°F. 8 hr. (No additional ppt. after 24 hr. at -5°F) Filtered at -5°.

Residue was not waxy at room temperature, but was a green viscous liquid. It was not bitter, but had a very "grassy" taste.

128-I is seedless and may not have appreciable "hop wax".

After removal of methanol from filtrate, the β-acid-free, "wax"-free extract had a very pleasant, slightly estery aroma and was very bitter.

3. Hop oil in β-acid-free, "wax"-free extract:

The extract (4-6 ml) was diluted to 10 ml. with pet. ether to reduce viscosity. 5 µl were chromatographed on a 27 ft., 2% butanediol succinate column. A fairly typical curve resulted with the exception that the myrcene content was low:

myrcene	22% of the oil
MNK	2% " " "
β-caryophyllene	5% " " "
humulene	24% " " "
oil	4.3% of the extract

4. Removal of hydrocarbons from β-acid-free, "wax"-free extract:

Two ml. of extract in pentane was added to a 1 x 22 cm. column of silicic acid and first eluted with 300 ml. pentane, then with ethyl ether.

After removal of solvent, the hydrocarbon fraction was yellow-orange and had a harsh bitter taste. The oxygenated fraction was green and was very bitter.

Each fraction was examined for oil and the separation was found to be complete, i.e., the hydrocarbon contained β-caryophyllene, myrcene (very little) and humulene, but no oxygenated components, while the oxygenated fraction was hydrocarbon-free.

A P P E N D I X

Cultural Practices

A cool wet spring during 1963 hampered spring field work and delayed plant growth, so that the last hops were trained on June 1st, which is approximately 2 weeks later than noted with an average season.

All plots received a fertilizer application in early spring, at the rate of 135 pounds of nitrogen and 75 pounds each of P_2O_5 and K_2O. Plots were pruned by the last of April.

The month of May had an ideal temperature-moisture condition for downy mildew infection. The 128-I hops, located at the Smith yard, produced primary "spikes" after pruning which were unsuitable for training. A propane flame was used to destroy the sporulating spikes and stimulate new shoot growth. This practice proved quite successful in control of mildew, and permitted crown buds to elongate which were not systemically infected. All hops were sprayed with 1000 ppm. streptomycin at 20 gallons per acre during the month of May when shoots were 8 to 10 inches in length. Hops located in the breeding nursery were not sprayed with streptomycin, nor were they stripped or suckered. Downy mildew was not a problem during the growing season, but favorable conditions in August caused the spread of infection to the hop cones. A dust application of a fungicide with tractor drawn equipment is often difficult due to dense vine growth late in the season. An aircraft was contracted to dust the hops with a zinc fungicide at a cost of less than $4.00 per acre. The application cost was less than if applied by our own personnel.

High populations of cutworm larvae were reported in the State of Oregon and considerable damage was reported in different hop areas. Larvae present in the soil crawled up hop vines during darkness and chewed off leaves and developing hop cones. The experimental hop yard was dusted with Diazinon to control cutworm damage. One application of TEPP during June resulted in a fair control of hop aphids, but less than that obtained with Systox.

The hop yard located on the East Farm received 5 inches of irrigation water in late June, whereas the Smith yard received 2 applications of 5 inches each. The gasoline-driven irrigation pump on the Smith yard was replaced with an electric motor which required the installation of a power line. This electrical system was more efficient and required less man hours to operate than the old system.

All hops were harvested by machine during the period of August 22 to September 17.

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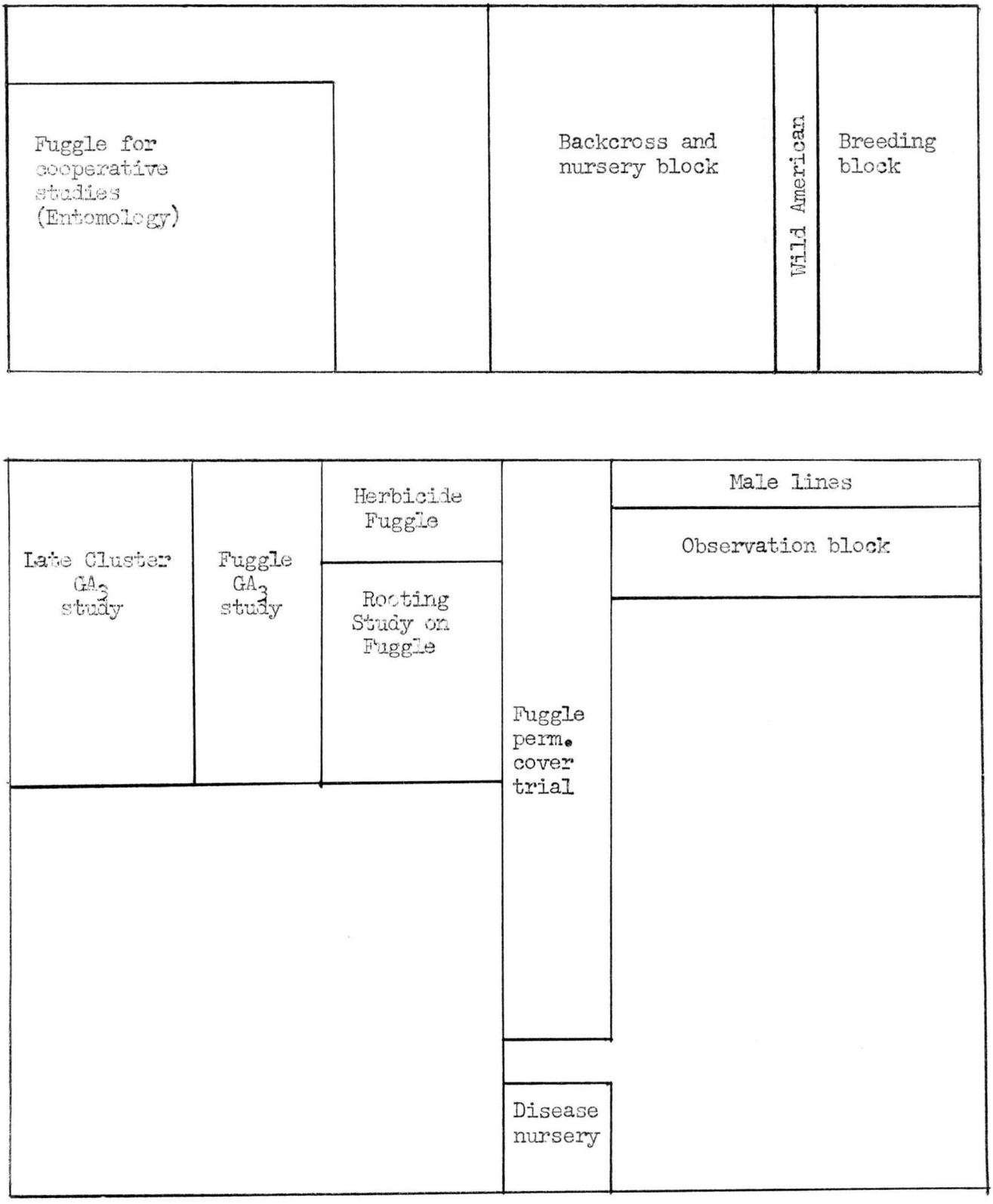
Field Map of Hop Investigations, College East Farm



Field Map of Hop Investigations, Smith Farm

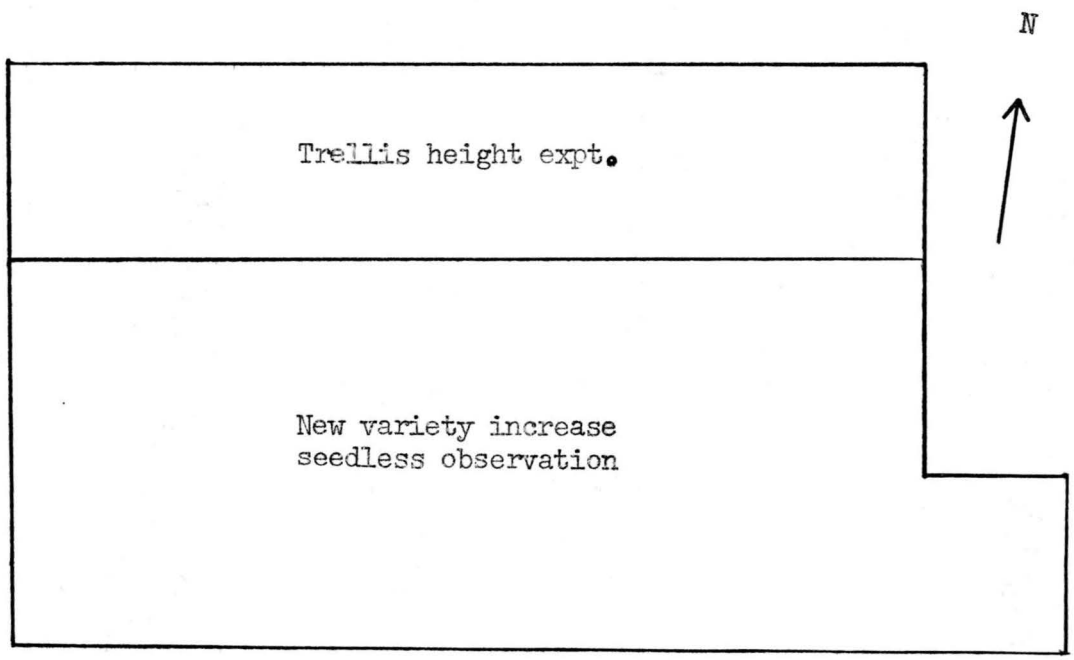


Table Seedlings in 1961 nursery (1960 crosses) at Corvallis to go into 1964 nursery at Prosser, Washington. (Rows 50-53 are BC material and rows 64-69 regular breeding material).

Location	Cross	DM	Location	Cross	DM	Location	Cross	DM
50-4* 1/	69	I	64-2	01	R-	66-28*	34	S
50-6	70	R	64-3	01	R	66-38	34	I
50-9	70	R-	64-4	04	R	66-39	34	R
50-11	70	R-	64-6	06	R	66-40	34	I
50-12	70	R-	64-7	06	R-	66-48	90	R
50-14	70	R	64-10	06	R	66-51*	90	R-
50-15* 2/	70	R	64-11*	07	R-	66-52	90	R
50-16	71	R-	64-19*	21	I	67-4	38	R
50-22	71	R	64-21*	21	R-	67-6	38	I
50-25	72	R	64-22	21	I	67-9	38	R
50-32	74	R-	64-23	21	R-	67-10	38	I
50-44	78	R	64-24	21	I	67-12	39	I
51-4*	46	S	64-25	21	R	67-16	39	I
51-9	51	R	64-26	21	I	67-17	39	I
51-30	87	R-	64-31	23	R-	67-18	39	R-
51-35	88	R	64-34	24	I	67-19	39	R-
51-38	88	R	64-37	24	I	67-20	39	R
52-5	28	R	64-38	24	R	67-29	40	I
52-8	28	R	64-46	25	R	67-30	40	R-
52-9	28	I	64-47	25	R	67-32*	40	S
52-12	28	R-	64-53	89	R	67-37*	42	R-
52-13	28	R-	65-1	26	R	67-39	44	R
52-14	28	R	65-25	30	I	67-40	44	R
52-15	28	R-	65-26	30	I	67-42	44	R
52-17* 3/	28	R	65-30	30	R-	67-43*	47	R-
52-19	28	R-	65-31	30	R-	67-44*	47	I
52-26	28	R-	65-32	30	I	67-48*	48	I
52-28	28	I	65-34	31	R	68-1 *	53	R-
52-30	28	R-	65-37	31	R	68-4	53	R-
52-34	28	R-	65-40	31	R	68-7	54	R
52-37	09	R	65-41*	31	R-	68-8	54	R
53-4	28	R-	65-44*	32	R-	68-9	54	I
53-5	28	R	65-45	32	R	68-13	55	R-
53-7	28	R-	65-47	32	R	68-16	56	R-
53-9	28	R	65-49	32	R	68-23	57	I
53-14	28	R	65-50	32	R	68-24* 5/	58	I
53-15	28	R-	65-51	32	R	68-43	60	R-
53-24	28	R-	66-1* 4/	33	R	68-51	83	R-
53-36	28	R-	66-2	33	R-	69-9	61	R-
53-40	28	R-	66-4	33	R	69-29	64	I
53-41	28	R-	66-8	33	I	69-48	67	R
53-42	28	R-	66-9*	33	I	69-49	67	R
53-48	28	R	66-11*	34	S	OB841 6/	58059	R
53-49	28	R	66-26*	34	S			

* Good vigorous seedlings included regardless of mildew reaction.
1/ C61001 selected in 1963 for continuation at Corvallis.
2/ C61002 selected in 1963 for continuation at Corvallis.
3/ C61003 selected in 1963 for continuation at Corvallis.
4/ C61004 selected in 1963 for continuation at Corvallis.
5/ C61005 selected in 1963 for continuation at Corvallis.
6/ C59006 selected in 1960 for continuation at Corvallis.

1963 Report on New Hop Varieties at the Irrigation Experiment Station, Prosser, Washington

C. E. Nelson

No.	Vigor 0-9*	Cone size 0-9**	(1) Maturity	Aroma 0-9*
1/OB-830	3	3	M	6
1/59-2-42	2	3	ME	7
1/59-3-8	3	5	ME	5
1/59-3-41	3	6	M	4
1/59-4-10	2	2	ME	5
1/59-4-11	4	6	M	6
1/59-4-31	2	5	M	4
1/59-6-1	2	4	ME	5
13-32		missing		
13-36	3	2	E	4
13-29	6	7	M	4
13-28		male		
13-27	2	4	E	5
13-25	7	8	ML	5
13-24		missing		
13-23		missing		
13-19		missing		
13-18	7	9	ML	5
13-17	8	5	M	6
13-39	2	2	E	3
13-42	7	7	E	6
13-43	6	6	E	3
13-44	6	4	M	4
13-45	7	5	ME	6
13-49	3	4	ML	6
13-34	1	Weak - few cones		
13-10	3	2	ML	5
13-9	4	2	ME	2
13-8	3	3	M	2
13-6		missing		
13-3	2	2	E	4
13-1	6	5	ME	6
G20713	6	4	ME	3
12-12	4	3	M	4
12-7	3	2	ME	6

No.	Vigor 0-9*	Cone Size 0-9**	(1) Maturity	Aroma 0-9*
12-4	6	4	M	6
12-3	6	5	ME	6
12-23	2	damaged		
12-28		missing		
12-27	7	5	ME	4
12-22	7	5	ML	4
11-48	4	7	ML	6
128I	6	5	ML	7
524-5 WA		missing		
523-3 WA		missing		
523-4 WA		missing		
OB843		missing		
OB842		missing		
11-46	4	5	M	4
11-42	4	3	ML	3
11-40		missing		
11-32	3	5	ML	6
OB840	5	6	ME	4
11-26	6	8	L	5
11-16	4	8	L	4
525-4WA	7	7	ME	5
10-51		missing		
10-47	8	8	L	6
11-11	3	3	M	5
11-4	6	5	ME	4
11-1	5	7	E	2
10-45	5	7	M	4
10-43		weak		
10-41		weak		
10-40	4	4	ME	2
10-38		missing		
10-37	4	1	L	1
10-33		missing		
10-32		missing		
10-28		missing		

* 0 = poor 9 = good
** 0 = small 9 = large

(1) E = early, M = medium, L = late, ME = medium early, ML = medium late

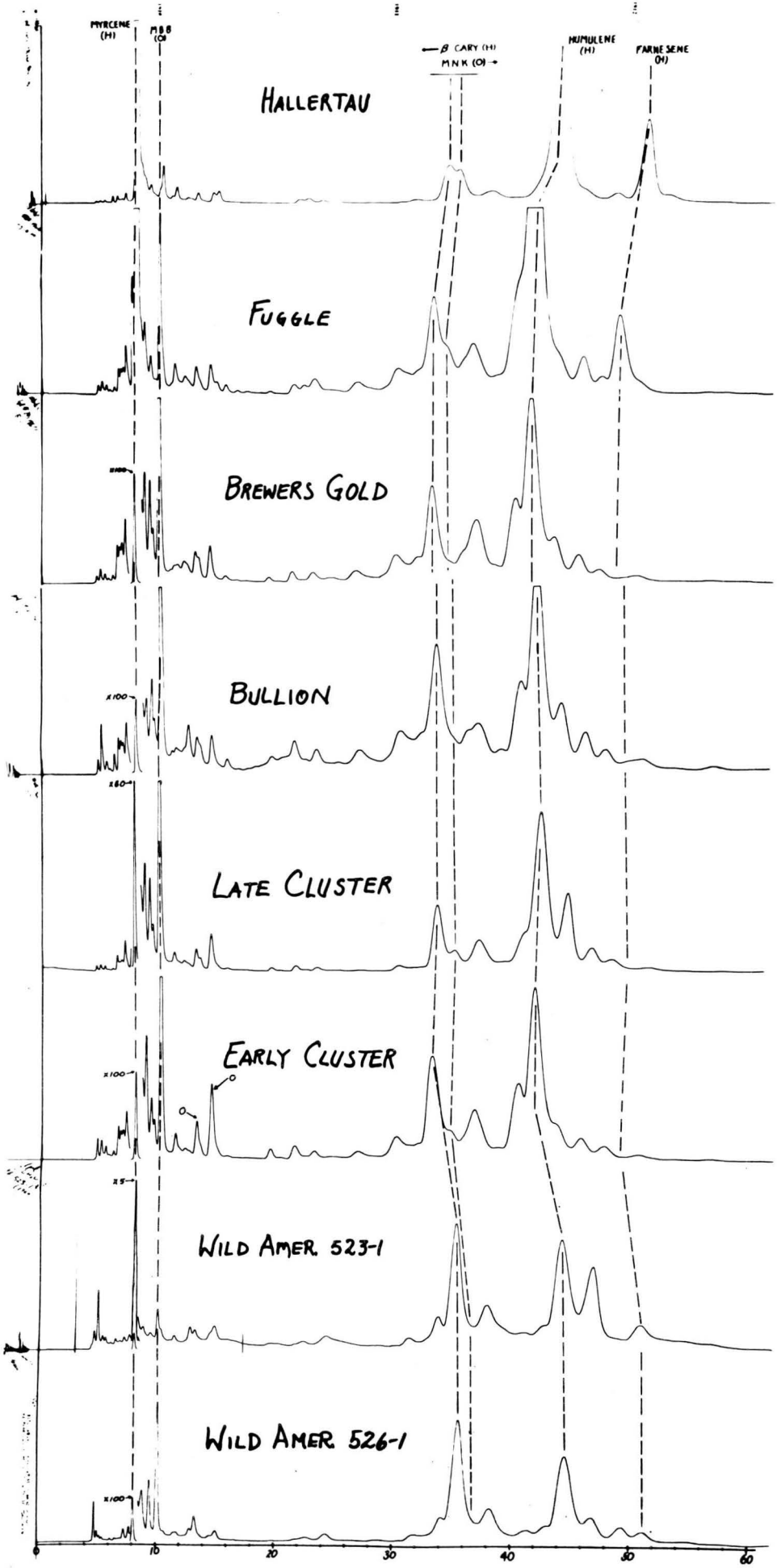
1/ Saved from 1961 planting at Prosser. All the rest were planted in 1962.

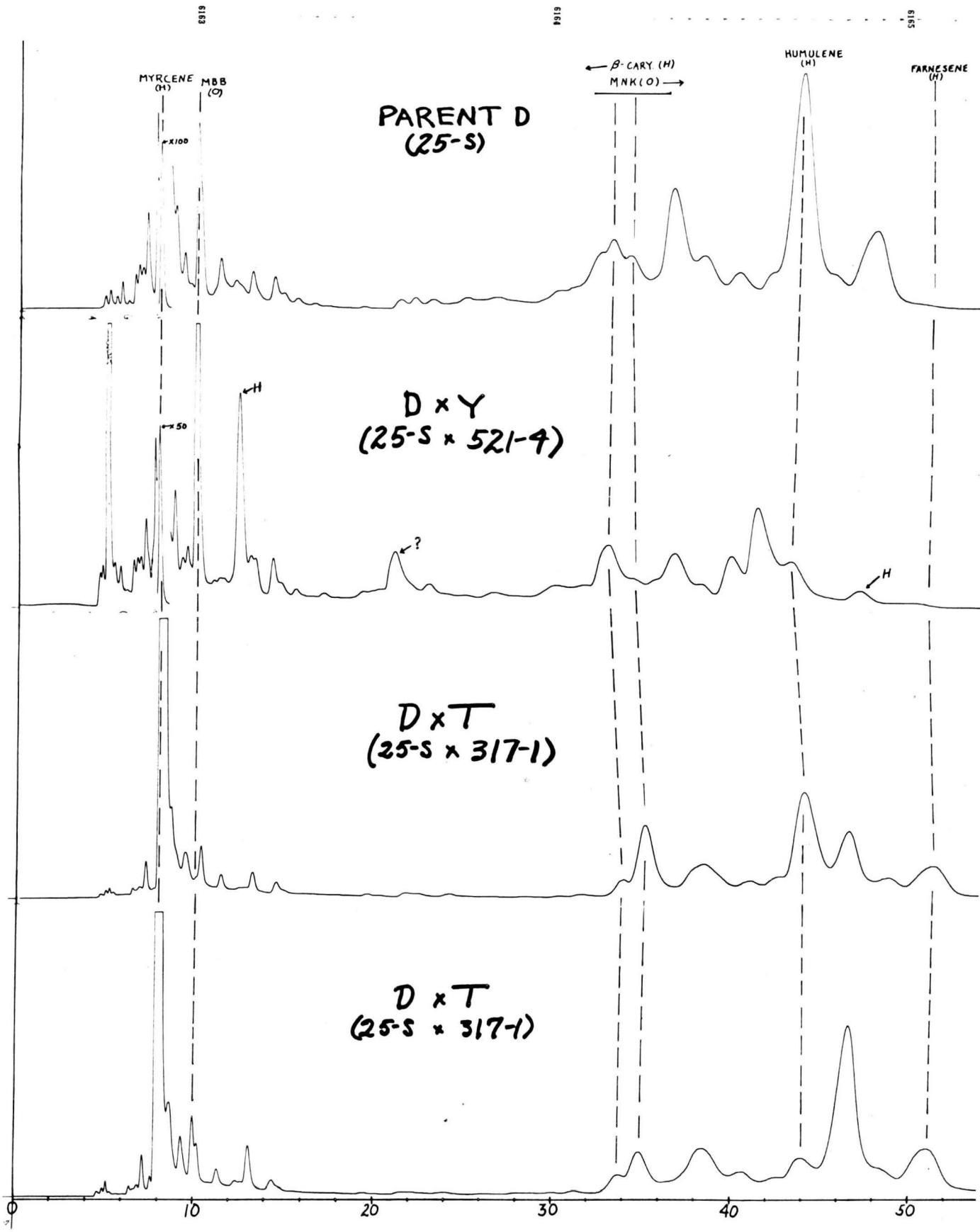
No.	Vigor 0-9*	Cone size 0-9**	(1) Maturity	Aroma 0-9*
10-24		missing		
10-23	6	6	M	7
10-21	4	3	ML	2
10-20	7	7	L	3
10-75	7	5	M	5
10-11	8	5	M	3
10-10	4	6	L	3
10-6	4	7	M	2
10-5	4	2	L	5
10-4	injured - little growth			
8-51	3	4	E	4
8-46		missing		
10-3	4	5	E	2
10-2	4	3	M	2
10-1	5	5	M	3
8-40	4	3	ME	5
8-39	4	3	ME	2
8-38		missing		
8-37	6	4	M	4
8-35		missing		
8-33	4	2	E	2
8-29		missing		
8-26		missing		
8-25	5	3	ME	2
8-21	7	4	ML	3
8-19	4	4	M	2
8-18		missing		
8-17		missing		
8-13	4	1	M	3
8-12	4	1	ME	2
8-6	4	4	E	2
8-8	5	2	ME	2
8-5		missing		
8-4	4	2	E	2
8-2	4	2	E	2

* = 0 = poor 9 = good

** = 0 = small 9 = large

(1) E = early ME = medium early
M = medium ML = medium late
L = late


MYRCENE (H)
MBB (O)
β CARY (H)
MNK (O)
HUMULENE (H)
FARNESENE (H)
HALLERTAU
FUGGLE
BREWERS GOLD
BULLION
LATE CLUSTER
EARLY CLUSTER
WILD AMER. 523-1
WILD AMER. 526-1
x100
x60
x100
x5
x100
0
10
20
30
40
50
60


6163
6164
6165
MYRCENE (H)
MBB (O)
β-CARY. (H)
MNK (O)
HUMULENE (H)
FARNESENE (H)
PARENT D
(25-S)
x100
D x Y
(25-S x 521-4)
x50
H
?
H
D x T
(25-S x 317-1)
D x T
(25-S x 317-1)
0
10
20
30
40
50

Downy Mildew Ratings -- Breeding Block -- 1963

Row and Hill No.	DM Reaction	Row and Hill No.	DM Reaction	Row and Hill No.	DM Reaction
101-2	R	405-3	I	310-2	R
101-3	R	505-1	S	210-5	I
201-3	R	505-2	S	210-4	I
301-1	I	505-3	S	210-3	S
301-2	R	505-5	R	210-2	R
401-1	I	306-2	R	210-1	I
401-2	R	206-5	I	110-2	Virus
401-3	I	206-4	I	110-1	Virus
401-4	R	206-3	R	111-2	R
401-5	I	206-2	S	111-3	R
501-3	R	206-1	S	311-1	R
402-5	R	106-5	R	311-2	R
402-4	R	106-4	R	311-3	I
402-3	R	106-3	R	311-4	R
402-2	R	106-2	R	311-5	R
402-1	I	106-1	R	411-1	I
102-3	R	107-1	R	411-2	R
103-2	I	307-1	R	411-3	I
203-1	R	307-2	R	411-4	S
203-2	R	307-3	S	411-5	S
203-3	R	307-4	I	511-3	R
203-4	R	307-5	R	412-5	R
203-5	R	407-2	I	412-4	R
303-1	R	407-3	VS	412-3	R
403-1	R	507-1	VS	412-2	I
403-2	R	507-2	R	412-1	R
403-3	R	507-3	I	312-5	R
403-4	R	508-3	I	312-4	R
403-5	R	508-2	R	312-3	R
503-1	R	408-3	I	312-2	R
503-3	I	308-1	R	312-1	I
504-3	R	208-3	R	212-5	R
504-2	R	108-5	R	212-4	R
504-1	S	108-4	R	212-3	R
404-5	R	108-3	R	212-2	R
404-4	R	108-2	R	212-1	R
404-3	R	108-1	R	113-2	S
404-2	R	109-1	R	313-5	R
404-1	R	209-1	R	413-3	R
304-3	S	209-2	R	513-2	R
304-2	S	209-3	R	514-2	R
104-2	I	209-4	R	414-5	I
105-1	R	209-5	R	414-4	R
205-1	I	309-3	R	414-3	R
205-2	R	409-2	R	414-2	I
205-3	R	409-3	R	414-1	R
205-4	R	509-1	R	314-5	S
205-5	R	310-3	S	314-4	VS

Downy Mildew Ratings — Breeding Block — 1963 cont.

Row and Hill No.	DM Reaction	Row and Hill No.	DM Reaction	Row and Hill No.	DM Reaction
314-3	S	218-1	R	522-5	
314-2	S	118-5	R	522-4	
314-1	S	118-4	R	522-3	
214-3	I	118-2	I	522-2	R
214-2	R	119-1	R	522-1	
114-3	R	119-2	R	422-5	R
115-1	R	119-4	R	422-4	I
215-2	R	119-5	R	422-3	S
315-1	R	219-1	R	422-2	S
315-2	R	219-2	I	422-1	I
315-3	VS	219-4	VS	322-5	I
415-1	R	219-5	R	322-4	I
416-5	R	319-2	S	322-3	R
416-4	R	319-4	I	322-2	R
416-3	I	319-5	R	322-1	R
416-2	S	419-1	R	222-5	R
416-1	S	419-2	R	222-4	R
316-3	S	419-5	R	222-3	R
316-1	R	519-2	S	222-2	R
216-5	S	519-5	R	222-1	R
216-4	S	520-5	R	122-1	S
216-3	S	520-2	S		
216-2	S	520-1	S		
216-1	S	420-5	I		
116-2	R	420-4	I		
117-3	I	420-2	VS		
217-1	R	320-5	VS		
217-2	R	320-4	VS		
217-4	R	320-2	VS		
217-5	R	320-1	VS		
317-1	S	220-5	I		
317-2	S	220-4	VS		
417-1	I	220-1	VS		
417-2	R	120-5	R		
417-5	R	120-2	VS		
517-1	R	120-1	VS		
517-2	R	121-2	I		
517-5	R	121-5	VS		
518-2	R	221-1	VS		
418-5	R	221-2	S		
418-2	R	321-1	S		
418-1	R	321-4	R		
318-5	I	321-5	R		
318-4	I	421-1	R		
318-2	R	421-2	R		
318-1	R	521-2	R		
218-4	S	521-4	R		
218-2	S	521-5	R		
		522-5			

Downy Mildew Ratings -- Nurseries -- 1963

Row and Hill No.	DM Reaction
50- 1	R
2	--
3	R
4	I
5	I
6	R
7	R
8	I
9	R ?
10	R
11	R
12	R
13	VS
14	R
15	R
16	R
17	R
18	R
19	S
20	R
21	R
22	R
23	R
24	R
25	R
26	R
27	R
28	R
29	--
30	R
31	R
32	R
33	R
34	S
35	R
36	R
37	R
38	R
39	R
40	--
41	--
42	--
43	R
44	R
45	--
46	--
47	--
48	--
50-49	--
50	--
51	--
52	R
53	R
51- 1	R
2	--
3	--
4	S
5	R
6	VS
7	R
8	R
9	?
10	VS
11	--
12	--
13	I
14	VS
15	--
16	R
17	I
18	I
19	--
20	--
21	--
22	--
23	R
24	--
25	R
26	--
27	VS
28	--
29	R
30	R
31	R
32	R
33	R
34	--
35	R
36	R
37	VS
38	R
39	R
40	VS
41	--
51-42	--
43	R
44	--
45	--
46	--
47	--
48	--
49	--
50	R
51	--
52	--
53	--
54	--
52- 1	--
2	S
3	R
4	I
5	R
6	S
7	--
8	R
9	I
10	--
11	--
12	R
13	R
14	R
15	R
16	R
17	R
18	--
19	R
20	--
21	I
22	VS
23	VS
24	S
25	R
26	R
27	--
28	I
29	R
30	R
31	R
32	R
33	VS

Downy Mildew Ratings -- Nurseries -- 1963 Cont.

Row and Hill No.	DM Reaction
52-34	R
35	R
36	S ?
37	R
38	I
39	R
40	R
41	--
42	--
43	--
44	--
45	--
46	--
47	--
48	--
49	--
50	--
51	--
52	R
53	--
54	R
53- 1	--
2	--
3	R
4	R
5	R
6	R
7	R
8	--
9	R
10	--
11	--
12	S
13	I
14	R
15	R
16	I
17	R
18	VS
19	--
20	S
21	R
22	--
23	S
24	R
25	S

Row and Hill No.	DM Reaction
53-26	--
27	--
28	--
29	S
30	--
31	--
32	--
33	VS
34	--
35	--
36	R
37	--
38	--
39	R
40	R
41	R
42	R
43	--
44	--
45	--
46	R
47	--
48	R
49	R
50	--
51	--
52	--
53	--
54- 1	S
2	--
3	S
4	I
5	--
6	S
7	I
8	--
9	VS
10	--
11	VS
12	--
13	S
14	--
15	S
16	--
17	?
18	VS

Row and Hill No.	DM Reaction
54-19	VS
20	R
21	S
22	--
23	VS
24	VS
25	--
26	S
27	--
28	I
29	S
30	S
31	--
32	--
33	I
34	VS
35	VS
36	--
37	VS
38	I
39	R
40	I
41	S
42	--
43	VS
44	VS
45	--
46	S
47	R
48	S
49	R
50	S
51	--
52	--
53	--
55- 1	--
2	--
3	--
4	--
5	S
6	--
7	I
8	VS
9	VS
10	--
11	--

Downy Mildew Ratings — Nurseries — 1963 Cont.

Row and Hill No.	DM Reaction
55-12	VS
13	VS
14	VS
15	VS
16	—
17	—
18	—
19	—
20	S
21	I
22	VS
23	VS
24	—
25	S
26	VS
27	VS
28	—
29	—
30	R
31	VS
32	VS
33	—
34	S
35	R
36	—
37	—
38	—
39	—
40	—
41	—
42	—
43	—
44	—
45	—
46	—
47	—
48	—
49	—
50	—
51	—
52	—
53	—
56- 1	R
2	—
3	—
4	—
56- 5	—
6	I
7	—
8	S
9	—
10	—
11	—
12	R
13	I
14	—
15	—
16	—
17	I
18	—
19	R
20	R
21	—
22	R
23	R
24	—
25	R
26	R
27	—
28	R
29	—
30	R
31	R
32	R
33	R
34	—
35	—
36	R
37	VS
38	I
39	VS
40	R
41	—
42	—
43	VS
44	—
45	—
46	VS
47	—
48	VS
49	—
50	—
51	—
52	R
56-53	—
54	—
57- 1	—
2	R
3	I
4	S
5	VS
6	I
7	—
8	I
9	—
10	—
11	I
12	—
13	—
14	—
15	—
16	R
17	I
18	S
19	—
20	VS
21	—
22	—
23	—
24	S
25	R
26	—
27	—
28	I
29	—
30	—
31	—
32	R
33	—
34	S
35	S
36	R
37	R
38	VS
39	R
40	VS
41	—
42	R
43	S
44	R

Downy Mildew Ratings — Nurseries — 1963 Cont.

Row and Hill No.	DM Reaction
57-45	R
46	I
47	VS
48	R
49	R
50	R
51	—
52	—
58- 1	R
2	R
3	VS
4	—
5	S
6	I
7	I
8	I
9	VS
10	I
11	S
12	—
13	R
14	I
15	—
16	I
17	I
18	S
19	R
20	R
21	—
22	—
23	—
24	I
25	—
26	VS
27	VS
28	VS
29	VS
30	—
31	S
64- 1	R
2	R
3	R
4	R
5	R
6	R
7	R
64- 8	R
9	R
10	R
11	R
12	—
13	R
14	VS
15	R
16	S
17	—
18	—
19	I
20	I
21	R
22	I
23	R
24	I
25	R
26	I
27	VS
28	VS
29	—
30	I
31	R
32	—
33	VS
34	I
35	I
36	S
37	I
38	R
39	R
40	I
41	I
42	—
43	—
44	—
45	R
46	R
47	R
48	—
49	—
50	—
51	R
52	—
53	R
65- 1	R
1	R
2	—
3	I
4	R
5	I
6	VS
7	S
8	S
9	—
10	R
11	R
12	R
13	VS
14	—
15	VS
16	VS
17	I
18	S
19	—
20	S
21	VS
22	I
23	—
24	I
25	I
26	I
27	R
28	I
29	R
30	R
31	R
32	I
33	—
34	R
35	I
36	I
37	R
38	R
39	R
40	R
41	R
42	—
43	R
44	R
45	R
46	R
47	R
48	I

Downy Mildew Ratings -- Nurseries -- 1963 Cont.

Row and Hill No.	DM Reaction
65-49	R
50	R
51	R
52	--
66- 1	R
2	R
3	R
4	R
5	S
6	S
7	--
8	I
9	I
10	--
11	S
12	--
13	VS
14	VS
15	VS
16	S
17	VS(good for
18	-- picture)
19	--
20	VS
21	--
22	--
23	VS
24	VS
25	--
26	VS
27	--
28	VS
29	S
30	I
31	I
32	--
33	--
34	I
35	S
36	--
37	S
38	I
39	R
40	I
41	I
42	--
43	I

Row and Hill No.	DM Reaction
66-44	I
45	VS
46	VS
47	R
48	R
49	I
50	I
51	R
52	R
67 - 1	R
2	R
3	R
4	R
5	I
6	?
7	?
8	R
9	R
10	I
11	S
12	?
13	S
14	VS
15	R
16	I
17	I
18	R
19	R
20	?
21	VS
22	I
23	R
24	I
25	--
26	VS
27	I
28	S
29	I
30	R
31	S
32	S
33	VS
34	I
35	VS
36	S
37	R
38	R

Row and Hill No.	DM Reaction
67-39	R
40	R
41	I
42	R
43	R
44	I
45	I
46	S
47	I
48	--
49	VS
50	--
51	--
52	--
68 -1	R
2	S
3	I
4	R
5	R
6	I
7	R
8	R
9	I
10	--
11	?
12	R
13	R
14	I
15	R
16	I
17	R
18	--
19	R
20	--
21	--
22	I
23	I
24	VS
25	S
26	--
27	--
28	S
29	--
30	I
31	VS
32	--
33	--

Downy Mildew Ratings — Nurseries — 1963 Cont.

Row and Hill No.	DM Reaction
68-34	VS
35	VS
36	VS
37	VS
38	--
39	S
40	VS
41	VS
42	R
43	VS
44	--
45	VS
46	VS
47	VS
48	VS
49	--
50	S
51	R
69-1	S
2	S
3	--
4	VS

Row and Hill No.	DM Reaction
69- 5	--
6	VS
7	VS
8	VS
9	R
10	--
11	S
12	S
13	--
14	VS
15	--
16	S
17	VS
18	S
19	--
20	?
21	--
22	--
23	--
24	--
25	--
26	S
27	--
28	S

Row and Hill No.	DM Reaction
69-29	I
30	--
31	S
32	VS
33	VS
34	S
35	--
36	VS
37	--
38	--
39	--
40	--
41	VS
42	VS
43	--
44	--
45	I
46	VS
47	VS
48	R
49	R
50	S
51	--
52	--

Downy Mildew Ratings -- Observation Block -- 1963

Line No.	DM rating	Line No.	DM rating	Line No.	DM rating
OB831-1	S	OB843-3	R	OB850-4	R
2	R	OB844-1	R	5	R
3	I	2	R	OB851-1	R
4	R	3	R	2	R
5	R	4	R	3	R
OB833-1	R	5	R	4	R
2	I	OB845-1	I	5	R
3	R	2	R	OB852-1	R
OB835-1	R	3	R	2	R
2	R	4	R	3	R
3	I	5	R	4	R
4	R	OB846-1	R	5	R
OB839-1	S	2	R	OB854-1	R
2	S	3	--	2	R
3	S	4	R	3	R
4	I	OB847-4	R	4	R
5	R	5	R	OB855-1	R
OB840-1	I	OB848-1	R	2	R
2	I	2	R	4	R
3	R	3	R	OB856-1	R
4	R	4	R	2	I
OB841-1	I	OB849-1	R	3	R
OB842-1	R	OB849-5	R	4	R
2	R	OB850-1	R	OB826-1	R
3	R	2	R	2	R
4	R	3	R	5	R

No readings were taken on the rest due to lack of foliage.

Downy Mildew Ratings -- Selections -- 1963

Selection No.	DM rating	Selection No.	DM rating	Selection No.	DM rating
25-S	R	42-S	I	94-S	R
24-S	VS	44-S	I	95-S	R
23-S	I	46-S	VS	96-S	S
22-S	R	47-S	R	Males-124-S	R
18-S	VS	49-S	I	123-S	R
16-S	S	50-S	R	119-S	R
15-S	--	73-S	R	117-S	R
14-S	R	72-S	R	116-S	R
13-S	R	70-S	S	113-S	R
10-S	R	68-S	R	112-S	R
8-S	R	67-S	R	110-S	S
7-S	R	64-S	S	108-S	R
6-S	I	62-S	I	106-S	R
32-S	R	61-S	I	131-S	R
33-S	R	59-S	I	134-S	R
34-S	R	58-S	R	136-S	R
35-S	R	56-S	R	142-S	R
36-S	R	84-S	S	144-S	R
39-S	S	85-S	R	145-S	R
40-S	S	88-S	R	148-S	R
41-S	S	92-S	R	150-S	I

Downy Mildew Rating — Male Lines — 1963

Plot and Line No.	DM rating	Plot and Line No.	DM rating	Plot and Line No.	DM rating
101 ML	R	301 ML	R	501 ML	I
2	R	2	S	2	S
3	R	3	R	3	R
4	S	4	S	4	R
5	—	5	R	5	S
6	—	6	R	6	I
7	R	7	I	7	I
8	—	8	R	8	I
9	S	9	R	9	R
110	R	310	—	510	R
11	S	11	I	11	R
12	R	12	R	12	I
13	R	13	R	13	S
14	S	14	I	14	I
15	I	15	R	15	S
16	R	16	S	16	R
17	S	17	I	17	I
18	I	18	R	18	I
19	I	19	R	19	R
120 ML	R	320 ML	S	520 ML	R
201	R	401	I		
2	I	2	R		
3	S	3	R		
4	R	4	R		
5	R	5	I		
6	R	6	R		
7	S	7	R		
8	I	8	I		
9	R	9	S		
210	I	410	S		
11	R	11	R		
12	R	12	S		
13	I	13	R		
14	R	14	R		
15	S	15	—		
16	I	16	S		
17	I	17	—		
18	S	18	I		
19	S	19	R		
220 ML	R	420 ML	I		

Downy Mildew Rating -- Wild American -- 1962

Row and Hill No.	DM rating	Row and Hill No.	DM rating	Row and Hill No.	DM rating
523-1	R	73-23	VS	72-3	--
2	R	24	I	2	S
4	--	25	R	72-1	R
523-5	--	26	R	71-1	R
524-4	--	27	S	2	R
2	--	73-28	VS	3	R
524-1	--	72-28	S	4	R
525-1	R	27	S	5	S
3	R	26	I	6	S
4	R	25	S	7	S
525-5	R	24	I	8	VS
526-5	--	23	VS	9	VS
526-3	R	22	VS	10	VS
		21	I	11	I
73-3	I	20	VS	12	I
5	VS	19	VS	13	R
6	I	18	R	14	VS
7	VS	17	R	15	S
8	I	16	VS	16	I
9	I	15	VS	18	S
11	--	14	VS	20	R
12	I	13	VS	21	VS
13		12	VS	22	VS
15	S	11	VS	23	VS
16	VS	10	R	24	--
17	VS	9	--	25	I
18	R	7	R	71-26	R
20		6	VS		
21		5	--		
22	VS	4	--		

Observations during machine picking of 6 varieties in Height of Trellis Trial, 1963.

C. E. Zimmermann

Fuggle HT

Machine picked Sept. 4. Picked with light shatter, some clusters and some light cones going over re-cleaner. Few hop cones left on picked vine.

44-I HT

Machine picked Sept. 4. Hop picked with little if any shatter, without petioles or leaves and with very light cones which required reduced air on re-cleaner. Excellent picking hop. Terminal flowering branches had feathered cones also double and triple cone sets and this accounted for some high gram-force readings.

135-I HT

Machine picked Sept. 9. Hop picked with very light cone shatter, many sidearms broken off from brushy vine, many clusters in hops, and some lost through rear of machine. Vine picked clean of cones and nearly all leaves were detached during the operation.

Late Cluster HT

Machine picked on Sept. 13. Hop picked with light cone shatter, many clusters and leaf petioles mixed with harvested cones. Picked vine had an average number of cones still attached. There was an excess of 10% loss in cones due to sidearm breakage and large clusters, an additional 5% loss in light cones which had dried up on the vine. This variety when grown at this location produces a large number of secondary lateral branches bearing sterile male flowers. More seed was found in cones of other varieties at this location in 1963, the origin of the pollen is not known, but some of the L.C. male flowers could be shedding pollen. The anther and filament extended outward in a manner similar to fertile male flowers. It was difficult to observe a noticeable difference in pickability of varieties grown on 16, 18 or 20 ft. trellis heights, but an obvious difference was noted with Late Cluster. The large amount of vine growth at the trellis is a characteristic pattern of Late Cluster, but the density in top growth was reduced when grown on a 20 ft. trellis and these vines had less cone loss during picking than those grown at 16 ft.

128-I HT

Machine picked Sept. 17. Hop picked with very little cone shatter, a good clean pick except for the large number of leaf petioles with the picked cones. The picked vine had very few hops remaining and vine leaves were removed. A characteristic of 128-I picked vines is the cone petiole which has two base "stipular bracts" from the cone attached to its terminal end. The cone is actually detached by breaking the strig and not the cone petiole. About 1% of the cones were severely infected with downy mildew late in the season and the cones were too heavy to remove with the re-cleaner.

Brewers Gold HT

Harvested on Sept. 17. Hop picked with light shatter and clean hop cones except for a few clusters. Cones were light (open) and required less air on re-cleaner, approximately 1 to 2% "white" cones were lost over re-cleaner. Average amount left on vine, with all vine leaves still attached, but a few sidearm leaves were stripped.

Overall Pickability of Height of Trellis Trial (Seedless)

	VG	G	G	F	
	128-I	144-I	Fuggle	135-I	
Best	B.G.			L.C.	Worst

Observations on pickability obtained during machine harvest of experimental lines, 1963.

C. E. Zimmermann

OB 841 (Fair)

Machine picked Sept. 9. Hop picked with moderate shatter, cones being light and fluffy with some going over re-cleaner. There was only one hill of this variety but it had a heavy set and most of the cones were shaded. These shortcomings could possibly be eliminated if grown seedless. Pickability force 646 g.

OB 839 (Fair to poor)

Machine picked Sept. 9. Hop picked with moderate to heavy shatter, large cones and more than 50% of the cone set having two cones with one cone petiole. Many bare strigs on the picked vine. Pickability force 889 g. with 13 out of 20 over 1000 g. Double cones contributed to high pickability force requirement.

OB 845 (Very poor)

Machine picked Sept. 9. Hop picked with heavy cone shatter, very many clusters, and with bare strigs on the picked clusters. The picked vine had few whole cones, but had many bare strigs with every lateral terminal having a bare strig attached. The pickability of this variety was the most difficult ever experienced. Sterile male flowers were noted on all laterals along with cones. Pickability force 693 g.

OB 830 (Fair to poor)

Machine harvest Sept. 9. Hop picked with moderate to heavy shatter, picked cones being fluffy, most cones missing petals and some clusters, but less than OB 845. Many bare strigs were left on picked vine. Pickability 944 g. with 14 out of 20 over 1000 g.

OB 844 (Fair to poor)

Machine picked Sept. 4. Hop has a characteristic light green cone. During picking there was light shatter (re-cleaner), cones detached with long petioles and also as clusters. Average number of cones (1-2%) left on the picked vine. Hop vine was brushy which resulted in a heavy load of leaves on re-cleaner, with some leaves not removed. Pickability force was 486 g.

OB 831 (Very good)

Machine picked Sept. 4. Hop was rated as a very good picker. There was very little shatter (comparable to good seedless), having a good break on the cone petiole and with no clusters. Hop vine had a few male flowers near the trellis. Less than average number of cones left on vine. Pickability force 444 g.

OB 801 (Poor)

Machine picked Sept. 4. Vines were thin with a light cone set. There was a moderate shatter, detached cones had long petioles and with clusters. Whole sidearms broke from the vine during picking and there was above average cone loss on picked vine. If vine had a heavier set it probably would rate as a poor picker with heavy shatter. Pickability force 669 g.

OB 829 (Poor)

Machine picked Sept. 13. Hop was a poor picker with moderate to heavy shatter, long petioles on picked cones, also with some clusters. Large numbers of broken cones were left on the vine along with bare strigs. Pickability force was 891 g. but 10 of the 20 cones required more than 1000 g. Readings in excess of 1000 g could not be determined.

OB 826 (Good)

Machine picked Sept. 13. Hop was low yielding, but a good picker with light shatter and a good pick on the vine. Picked cones had a long petiole. Pickability force 846 g. with 6 out of 20 cones above 1000 g. Indication being that due to a tight cone the additional picking force did not break up the cone.

OB 822 (Poor)

Machine picked Sept. 13. Hop was a poor picker with heavy shatter, long petiole with extended fiber on picked cones, with some clusters. Large number of broken cones and bare strigs left on vine. Pickability force 992 g. with 19 of the 20 cones above 1000 g.

OB 833 (Fair)

Machine picked Sept. 17. Hop picked with light to moderate shatter, long cone petioles and some clusters. Most of the vine leaves were off the picked vine, even though very few cones were left on the vine it also had many bare strigs. Pickability force 602 with 4 out of 20 above 1000 g.

OB 843 (?)

Only one vine available so it was hand picked Sept. 17. Vine was low in yield and had pickability of 578 g.

OB 840 (Very poor)

Machine picked Sept. 17. Hop picked with very heavy shatter, cones were light and partly broken and this caused some cones to be discarded over bottom re-cleaner even though the air was reduced to a minimum. The vine picked clean, but it had some bare strigs and additional bare strigs were found in the picked cones. Pickability force 552 g.

OB 835 (Very good)

Machine picked Sept. 17. Hop picked with light shatter and with a long break on cone petiole in excellent condition. Vine was picked clean with both vine and lateral leaves intact. Very few hops display this property. Most hops lose their lateral leaves during mechanical harvest and they are easily removed by the recleaner. Some hops also lose their vine leaves resulting in broken leaf petioles mixed with the picked cones. Usually if the vine leaf is detached, the petiole is so brittle that it also breaks at the base of the leaf, leaving the stem-like petiole.

Pickability of OB 835 is similar to the Brewer's Gold seedless hop (Smith) in that these two varieties do not lose many leaves when picked by a portable machine. OB 835 probably would rate as the best agronomic variety in 1963 with also having a 4-hill plot yield of 62 pounds. Pickability force 578 g.

OB 842 (Poor)

Machine picked Sept. 23. Hop picked with moderate shatter, many large clusters lost through rear of machine, most of picked cones were in clusters and with many leaves and petioles etc. (dirty). This hop set cones in clusters (3-5 cones) with very short cone petioles which were protected from the force of picking fingers, so that the breaking point was the secondary branch of the lateral, resulting in clusters. The vine of this hop was very brittle and subsequently broke when clamped in the grasper bar. The brittleness was also noticed in the leaves, since all the leaves were removed from the picked vine.

Supplement to OB pickability:

Selection 15-S was picked by hand, yielding 200 g of dried hops. This sample was kept for quality evaluation.

Selection OB 812, 813 and 827 were machine picked August 30th without getting detailed notes on pickability or dynamometer readings.

Selection OB 812 and 827 were rated as poor pickers having many clusters in with the cones. Selection OB 813 was rated as a good picker with clean hops. This selection had sterile male flowers.

Pluckability Data — Minor Elements Study on Fuggle Hops, 1963.

		I			II			III			
		1	2	3	1	2	3	1	2	3	Total
Con-	(1)	2350	2290	1580	1320	2470	1760	2000	1520	1960	17250
trol	(2)	1740	1740	3280	1780	1950	2050	2480	1910	2030	18960
	(3)	2330	2440	1380	2600	1590	1530	1710	2220	2160	17960
	Sub.	6420	6470	6240	5700	6010	5340	6190	5650	6150	
	RT			19130			17050			17990	54170
Mg.	(1)	1840	1450	2590	1810	1090	1170	1970	1800	1430	15150
	(2)	1920	1860	1230	1920	1100	2500	1350	1960	2050	15890
	(3)	2410	1650	2440	1530	1660	2080	1600	2170	1770	17310
	Sub.	6170	4960	6260	5260	3850	5750	4920	5930	5250	
	RT			17390			14860			16100	48350
Fe	(1)	2260	2590	1320	1870	1620	1900	1980	1620	2800	17960
	(2)	1560	1400	1830	2290	1810	1930	1150	2130	2200	16300
	(3)	2030	1630	1660	2110	2400	2030	1940	1770	2300	17870
	Sub.	5850	5620	4810	6270	5830	5860	5070	5520	7300	
	RT			16280			17960			17890	52130
Mn	(1)	2070	1440	1520	1810	1780	1450	1910	1860	1340	15180
	(2)	1820	1610	1400	1850	1730	1490	2100	1600	1740	15340
	(3)	1670	1790	1500	1850	1330	1030	1970	1700	1590	14430
	Sub.	5560	4840	4420	5510	4840	3970	5980	5160	4670	
	RT			14820			14320			15810	44950
	Grand			67620			64190			67790	199600

Sy^2 = 385,697,400
Sy^2R^2 = 13,288,304,600
Sy^2T^2 = 10,010,150,800
Sy^2Sa = 1,120,712,400
Sy^2Sb = 1,125,213,000
Sy^2RT = 3,345,044,200

Analysis of Variance

Source	DF	SS	MS	F
Treatments	3	1,855,955	618,652	*
Replications	2	229,202	114,601	N.S.
Error	6	696,051	116,008	
Plot total	11	2,781,208		
Plants within plots	24	1,899,222	79,134	
Plant total	35	4,680,430		
Clusters within plants	72	12,126,600	168,425	
Sample total	107	16,807,030		

Treatments	Pluckability 1/	Shatter (% whole)
Untreated	401 a	10.1
MgEDTA (2 lbs/Ac)	358 b	5.9
FeEDDNA "	386 a	8.6
MnEDTA "	333 c	5.8

1/ Avg. gram-force required to detach cones.

Hops treated with FeEDDA were not significantly different from untreated, whereas Mg & Mn produced hops with significantly lower pluckability than untreated.

Determination of sample size with pluckability data (gram-force) obtained from seeded Fuggle treated with 5 ppm Gibrelate at 5-foot stage, 1963.

Plant	Cluster	Readings per cluster	Total	Plant	Cluster	Readings per cluster	Total
Sampling method using 10 plants, 4 sec. laterals/plant & 5 readings/lateral							
	1	240 250 300 250 390	1430		1	270 250 230 200 300	1280
1	2	270 270 370 320 370	1600	2	2	210 230 260 260 400	1360
	3	430 270 200 320 330	1550		3	240 250 330 290 380	1490
	4	260 250 220 370 330	1430		4	270 260 320 350 340	1540
	1	160 210 220 159 240	980		1	190 250 240 360 270	1310
3	2	300 260 320 300 310	1490	4	2	230 230 220 280 320	1280
	3	190 190 230 230 290	1130		3	230 260 220 270 320	1300
	4	260 300 250 260 250	1320		4	320 270 360 340 340	1630
	1	320 280 250 350 340	1540		1	260 240 180 160 270	1110
5	2	180 240 250 370 420	1460	6	2	260 310 270 250 370	1460
	3	180 240 250 240 320	1230		3	270 230 250 280 320	1350
	4	250 190 280 250 370	1340		4	310 280 220 290 320	1420
	1	320 260 280 270 300	1430		1	230 310 300 260 320	1420
7	2	170 250 310 230 320	1280	8	2	230 200 250 400 320	1400
	3	160 280 210 240 340	1230		3	250 330 160 190 250	1180
	4	250 250 240 180 300	1220		4	240 210 240 230 220	1140
	1	290 230 240 290 320	1370		1	180 220 250 220 240	1110
9	2	230 260 220 250 390	1350	10	2	250 120 220 210 270	1070
	3	180 140 250 230 330	1130		3	220 220 260 180 260	1140
	4	220 310 230 280 320	1360		4	230 300 220 240 280	1270
Sampling method using 20 plants, 1 sec. lateral/pl. & 5 cones/lateral.							
1		200 310 340 330 340	1520	11		370 330 370 380 480	1930
2		290 260 250 320 340	1460	12		260 260 320 330 310	1480
3		240 320 340 340 380	1670	13		360 370 430 400 440	2000
4		270 290 330 280 400	1570	14		280 260 320 320 380	1560
5		260 250 250 290 250	1300	15		200 350 260 370 520	1700
6		280 260 320 340 360	1560	16		310 260 360 230 380	1540
7		340 290 350 360 450	1790	17		300 280 310 430 330	1650
8		330 360 300 430 420	1840	18		330 340 270 270 440	1650
9		350 280 460 410 560	2060	19		200 260 250 240 320	1270
10		250 230 320 270 380	1450	20		270 290 270 280 350	1460

Determination of sample size with pluckability data (gram-force) obtained from seeded Fuggle treated with 5 ppm Gibrelate at 5-foot stage, 1963.

Sampling method using 20 plants, 2 sec. lateral/plant, & 5 readings/lateral. Laterals sampled from 2 different heights.

Plant	7 foot height Readings per cluster	Total	11 foot height Readings per Cluster	Total
1	190 200 220 320 280	1210	380 400 480 340 510	2110
2	200 220 320 180 320	1240	340 320 360 270 370	1660
3	280 270 260 280 340	1430	330 330 320 270 320	1570
4	280 260 330 400 350	1620	280 330 320 300 360	1590
5	160 210 240 310 370	1290	290 240 370 350 360	1610
6	230 270 200 250 240	1190	260 310 370 280 380	1600
7	250 280 280 320 340	1470	260 370 250 310 290	1450
8	310 330 370 370 380	1760	420 430 330 390 670	2240
9	230 210 280 280 360	1360	280 230 290 330 470	1600
10	250 250 220 240 330	1290	280 270 220 310 400	1480
11	270 270 320 280 310	1450	430 280 320 260 390	1680
12	190 230 230 270 340	1260	270 290 320 280 330	1490
13	200 190 290 230 330	1240	310 370 240 330 460	1710
14	280 270 200 330 350	1430	380 430 450 460 620	2340
15	220 230 220 210 300	1180	360 380 380 420 360	1900
16	220 210 270 230 290	1220	360 340 430 360 490	1980
17	320 270 270 320 400	1580	210 250 280 600 320	1660
18	250 250 250 210 290	1250	180 320 190 200 430	1320
19	240 270 280 260 330	1380	190 230 350 350 470	1590
20	250 280 260 230 320	1340	270 230 280 320 330	1430
Totals	4820 5310 6570 4970 5520	27190	6080 6550 8300 6350 6730	34040

Infiltration rates of soil samples obtained from Permanent Cover Trial on Fuggle. Samples obtained from 3 depths within each of 3 core locations per plot, 1963.

Replication	Core location	Mls. of H_2O infiltrated after 5,10 & 20 minutes								
		Depth 1			Depth 2			Depth 3		
		5	10	20	5	10	20	5	10	20
	Grass treatment									
	X1	62	178	415	2	5	8	+	+	+
I	X2	--	--	--	200	602	1101	6	14	22
	X3	17	82	+	1	1	2	3	4	4
	X1	--	--	--	3	4	4	0	0	0
II	X2	5	11	20	23	66	144	+	+	+
	X3	12	22	36	12	30	90	4	4	4
	X1	50	168	410	0	4	4	0	0	1
III	X2	--	--	--	110	286	616	25	97	156
	X3	24	69	153	62	188	416	0	0	0
	X1	6	10	9	22	43	77	0	0	0
IV	X2	4	0	5	29	57	135	0	0	0
	X3	+	+	+	72	212	446	12	56	140
	X1	--	--	--	51	161	300	0	0	0
V	X2	--	--	--	0	0	0	0	6	10
	X3	0	0	0	0	0	0	0	0	0
	X1	12	32	40	0	0	0	0	0	0
VI	X2	0	0	0	4	5	5	7	13	22
	X3	33	76	155	22	81	170	+	+	+
	Cultivated treatment									
	X1	9	23	48	0	0	0	0	0	0
I	X2	4	4	4	19	51	75	28	73	119
	X3	0	6	11	10	19	24	5	8	8
	X1	32	94	+	+	+	+	0	0	0
II	X2	2	2	2	+	+	+	+	+	+
	X3	--	--	--	+	+	+	8	15	22
	X1	5	7	8	2	2	4	4	4	4
III	X2	4	4	8	1	9	19	28	56	109
	X3	22	51	95	32	53	95	14	45	98
	X1	10	18	25	0	1	1	0	0	0
IV	X2	+	+	+	90	145	302	200	444	772
	X3	26	86	196	78	228	476	1	1	1
	X1	5	9	20	0	0	3	0	0	4
V	X2	0	0	3	0	0	0	0	0	0
	X3	24	71	158	80	180	308	+	+	+

Infiltration rates of soil samples obtained from Permanent Cover Trial on Fuggle. Samples obtained from 3 depths within each of 3 core locations per plot, 1963. -- cont.

Replication	Core location	Mls. of H_2O infiltrated after 5,10 & 20 minutes								
		Depth 1			Depth 2			Depth 3		
		5	10	20	5	10	20	5	10	20
	Cultivated treatment									
	X1	0	0	1	50	149	338	14	40	78
VI	X2	0	0	0	+	+	+	+	+	+
	X3	0	0	0	22	68	123	+	+	+

+ Excessive water percolation caused by holes from roots and earth worms.
-- Missing data

Bulk density determination from Permanent Cover Trial on Fuggle, 1963.

Replication	Core location	Grass Depth 1	2	3	Total	Fallow Depth 1	2	3	Total	Total
I	X1	1.57	1.66	1.59	4.82	1.55	1.32	1.36	4.23	
	X2	1.59	1.65	1.57	4.81	1.56	1.35	1.37	4.28	
	X3	1.67	1.65	1.62	4.94	1.58	1.37	1.34	4.29	
	Sub.	4.83	4.96	4.78	14.57	4.69	4.04	4.07	12.80	27.37
	Avg.	1.61	1.65	1.59		1.56	1.35	1.36		
II	X1	1.57	1.54	1.34	4.45	1.56	1.60	1.48	4.64	
	X2	1.59	1.39	1.37	4.35	1.58	1.63	1.60	4.81	
	X3	1.57	1.33	1.29	4.19	1.66	1.70	1.62	4.98	
	Sub.	4.73	4.26	4.00	12.99	4.80	4.93	4.70	14.43	27.42
	Avg.	1.58	1.42	1.33		1.60	1.64	1.57		
III	X1	1.57	1.35	1.36	4.28	1.57	1.42	1.43	4.42	
	X2	1.57	1.42	1.40	4.39	1.57	1.40	1.39	4.36	
	X3	1.64	1.38	1.35	4.37	1.64	1.42	1.40	4.46	
	Sub.	4.78	4.15	4.11	13.04	4.78	4.24	4.22	13.24	26.28
	Avg.	1.59	1.38	1.37		1.59	1.41	1.41		
IV	X1	1.59	1.40	1.39	4.38	1.47	1.39	1.35	4.21	
	X2	1.58	1.40	1.37	4.35	1.53	1.38	1.34	4.25	
	X3	1.61	1.44	1.37	4.42	1.57	1.41	1.37	4.35	
	Sub.	4.78	4.24	4.13	13.15	4.57	4.18	4.06	12.81	25.96
	Avg.	1.59	1.41	1.38		1.52	1.39	1.35		
V	X1	1.59	1.63	1.38	4.60	1.58	1.37	1.39	4.34	
	X2	1.59	1.54	1.40	4.53	1.55	1.41	1.40	4.36	
	X3	1.60	1.55	1.42	4.57	1.63	1.46	1.36	4.45	
	Sub.	4.78	4.72	4.20	13.70	4.76	4.24	4.15	13.15	26.85
	Avg.	1.59	1.57	1.40		1.59	1.41	1.38		
VI	X1	1.54	1.41	1.36	4.31	1.61	1.66	1.66	4.93	
	X2	1.55	1.36	1.38	4.29	1.58	1.64	1.55	4.77	
	X3	1.43	1.50	1.41	4.34	1.73	1.69	1.59	5.01	
	Sub.	4.52	4.27	4.15	12.94	4.92	4.99	4.80	14.71	27.65
	Avg.	1.51	1.42	1.38		1.64	1.66	1.60		
	Grand	28.42	26.60	25.37		28.52	26.62	26.00		161.53

Plot Harvest Weights (adj. for moisture), Trellis Height Trial, 1963.

Rep.		Fuggle	BG	LC	128I	144I	135I	Total
	16'	24.9	39.6	23.8	34.6	35.7	17.8	176.4
I	18'	14.4	42.7	26.9	40.5	41.8	20.0	186.3
	20'	(29.9)	44.9	40.6	51.3	46.1	29.9	242.7
	Sub.	(69.2)	127.2	91.3	126.4	123.6	67.7	605.4
	16'	24.2	42.8	21.5	39.3	23.0	22.9	173.7
II	18'	26.5	33.9	17.3	29.0	35.5	28.7	170.9
	20'	23.6	37.0	18.2	29.2	33.0	23.9	164.9
	Sub.	74.3	113.7	57.0	97.5	91.5	75.5	509.5
	16'	23.6	40.5	19.3	38.7	42.0	19.3	183.4
III	18'	22.5	46.1	20.9	42.1	40.0	24.4	196.0
	20'	20.3	32.6	17.6	46.7	31.3	27.1	175.6
	Sub.	66.4	119.2	57.8	127.5	113.3	70.8	555.0
								1669.9

				Fug.	B.G.	L.C.	128I	144I	135I	Total
Sy^2	=	56,537.03	16'	72.7	122.9	64.6	112.6	100.7	60.0	533.5
Sy^2V^2	=	493,331.75	18'	63.4	122.7	65.1	111.6	117.3	73.1	553.2
Sy^2R^2	=	934,124.41	20'	73.8	114.5	76.4	127.2	110.4	80.9	583.2
Sy^2H^2	=	930,774.73								
Sy^2Sub a	=	314,185.37								
Sy^2VH	=	165,158.89	Total	209.9	360.1	206.1	351.4	328.4	214.0	1669.9

Analysis of Variance

Source	DF	SS	MS	F	
Height	2	69.60	34.80	N.S.	
Replication	2	255.69	127.84	2.56	N.S.
Error a	4	398.83	49.85		
Sub a	8	724.12			
Varieties	5	3174.53	634.91	22.19	**
V x H	10	168.72	16.87	N.S.	
Error b	(29)	829.55	28.61		
Sub b	44	4172.80			
Grand	52	4896.92			

Height of Trellis Experiment - 1963

% ∝-acid (dwb)

Rep.	Height	Variety: Fug.	L.C.	B.G.	128-I	135-I	144-I	Sum
I	16'	7.21	8.81	13.83	14.52	4.13	5.70	54.20
	18'	7.22	9.13	13.90	13.11	3.89	5.23	52.48
	20'	(7.25)	8.35	13.90	15.04	3.50	5.53	53.57
		(21.68)	26.29	41.63	42.67	11.52	16.46	(160.25)
II	16'	7.69	9.14	13.77	14.95	3.88	5.41	54.84
	18'	7.76	7.08	13.25	14.14	3.92	5.63	51.78
	20'	7.73	6.59	13.90	15.07	3.99	5.63	52.91
		23.18	22.81	40.92	44.16	11.79	16.67	159.53
III	16'	7.22	7.31	12.97	12.90	3.81	5.59	49.80
	18'	7.79	7.23	13.43	14.45	3.87	5.67	52.44
	20'	7.67	6.71	13.85	13.98	4.28	5.70	52.19
		22.68	21.25	40.25	41.33	11.96	16.96	154.43

Variety x Height Interaction

	16'	22.12	25.26	40.57	42.37	11.82	16.70	158.84
	18'	22.77	23.44	40.58	41.70	11.68	16.53	156.70
	20'	(22.65)	21.65	41.65	44.09	11.77	16.86	(158.67)
	Sum	(67.54)	70.35	122.80	128.16	35.27	50.09	(474.21)

Sy^2 = 4,990.0963
Sy^2V^2 = 44,768.5807
Sy^2R^2 = 74,978.5083
Sy^2H^2 = 74,961.2045
Sy^2sub a = 25,003.3871
Sy^2VH = 14,942.5273

Analysis of Variance

Source	DF	SS	MS	F	
Height	2	0.1572	0.0786	0.196	NS
Replication	2	1.1185	0.55925	1.397	NS
Error a	4	1.6013	0.400325		
Subtotal a	8	2.8770			
Variety	5	809.9326	161.98652	718.94	**
V x H	10	6.3985	0.63985	2.840	*
Error b	29	6.5341	0.22531379		
Subtotal b	43	822.8652			
Grand	52	825.7422			

% CV = 7.23

Height of Trellis Experiment - 1963

% β-acid (dwb)

Rep.	Height	Variety						
		Fug.	L.C.	B.G.	128-I	135-I	144-I	Sum
I	16'	3.08	5.16	4.67	4.74	6.16	4.59	28.40
	18'	2.98	4.52	4.66	4.53	6.30	4.85	27.84
	20'	(3.02)	5.72	4.32	4.23	6.11	4.67	(28.07)
		(9.08)	15.40	13.65	13.50	18.57	14.11	(84.31)
II	16'	3.17	4.85	4.99	4.81	5.97	4.87	28.66
	18'	3.25	2.62	4.53	4.40	5.87	4.58	25.25
	20'	3.06	3.04	5.00	4.18	6.23	4.47	25.98
		9.48	10.51	14.52	13.39	18.07	13.92	79.89
III	16'	3.15	3.02	4.65	4.23	5.88	4.44	25.37
	18'	3.04	2.77	5.04	4.69	6.03	4.55	26.12
	20'	3.19	2.77	4.93	3.80	5.95	4.27	24.91
		9.38	8.56	14.62	12.72	17.86	13.26	76.40

Variety x Height Interaction

	16'	9.40	13.03	14.31	13.78	18.01	13.90	82.43
	18'	9.27	9.91	14.23	13.62	18.20	13.98	79.21
	20'	(9.27)	11.53	14.25	12.21	18.29	13.41	78.96
		(27.94)	34.47	42.79	39.61	54.50	41.29	(240.60)

Sy^2 = 1,129.7262
Sy^2V^2 = 10,043.8748
Sy^2R^2 = 19,327.5482
Sy^2H^2 = 19,303.6106
Sy^2sub a = 6,449.8684
Sy^2VH = 3,374.4682

Analysis of Variance

Source	DF	SS	MS	F	
Height	2	0.4162	0.2081	1.029	NS
Replication	2	1.7460	0.8730	4.315	NS
Error a	4	0.8092	0.2023		
Subtotal a	8	2.9714			
Variety	5	43.9794	8.79588	108.62	**
V x H	10	8.4205	0.84205	10.400	**
Error b	29	2.3483	0.080976		
Subtotal b	44	54.7482			
Grand	52	57.7196			

% CV = 10.1

Moisture dry-down percentages, Trellis Height Trial, 1963

Rep.		Fuggle	BG	LC	128I	144I	135I
I	16'	26.0	26.2	21.4	30.2	24.3	24.5
	18'	26.1	27.8	22.6	28.9	22.5	24.3
	20'	--	28.5	23.4	28.2	23.7	25.0
II	16'	24.7	25.7	22.7	28.9	22.0	24.1
	18'	21.5	26.1	22.8	29.9	21.9	23.2
	20'	25.0	28.5	23.3	29.9	23.9	23.9
III	16'	24.5	27.4	21.3	26.9	22.0	24.3
	18'	24.1	29.0	22.4	29.0	23.5	23.5
	20'	25.9	27.9	22.9	28.4	23.0	24.8
Average		(24.7)	27.4	22.5	28.9	23.0	24.2

Pluckability -- Height of Trellis Experiment - 1963.
(Each value represents an average of 20 readings (5 from each of 4 plants)

Rep.& Height		Fuggle	L.C.	B.G.	128-I	135-I	144-I	Total
	16'	411	417	466	490	374	336	2494
I	18'	427	637	443	457	414	350	2728
	20'	(417)	475	455	478	424	351	(2600)
		(1255)	1529	1364	1425	1212	1037	(7822)
	16'	513	685	455	415	369	334	2771
II	18'	450	678	457	501	378	429	2893
	20'	538	641	467	481	423	356	2906
		1501	2004	1379	1397	1170	1119	8570
	16'	497	586	449	387	370	326	2615
III	18'	377	657	481	441	407	396	2759
	20'	445	569	458	480	309	434	2695
		1319	1812	1388	1308	1086	1156	8069
				Variety x Height				
	16'	1421	1688	1370	1292	1113	996	7880
	18'	1254	1972	1381	1399	1199	1175	8380
	20'	(1400)	1685	1380	1439	1156	1141	(8201)
		(4075)	5345	4131	4130	3468	3312	24461
		453	594	459	459	385	368	453

Sy^2 = 11,494,513
Sy_2V^2 = 102,293,079
Sy_2R^2 = 199,737,345
Sy_2H^2 = 199,575,201
Sy_2Sub a = 66,628,077
Sy^2VH = 34,267,873

Analysis of Variance

Source	DF	SS	MS	F
Height	2	7,131.	3,565.5	13.86 *
Replication	2	16,139	8,069.5	31.37 **
Error a	4	1,029	257.2	
Subtotal a	8	24,299		
Varieties	5	285,515	57,103.0	30.26 **
V x H	10	49,598	4,959.8	2.63 *
Error b	29(30)	54,721	1,887.0	
Subtotal b	43	389,834		
Grand	52	414,133		

Pluckability --- Height of Trellis Experiment - 1963.
(Statistical analysis based on 5 readings from each plant in the experiment)

Sy^2 = 244,335,080
Sy^2H^2 = 79,833,360,900
Sy^2R^2 = 79,898,465,100
Sy^2HR = 26,652,389,700
Sy^2V^2 = 40,917,186,700
Sy^2HV = 13,680,811,700
Sy^2RVH = 4,597,707,700

Analysis of Variance

Source	DF	SS	MS	F
Heights	2	142,676	71,338	*
Replications	2	323,521	161,760	**
Error a	4	20,391	5,098	
Sub Plot	8	486,588		
Varieties	5	5,701,044	1,140,209	**
Heights x Varieties	10	553,148	55,315	N.S.
Error b	29(30)	1,527,945	52,688	
Plot total	52(53)	8,268,725		
Plants within plots	162	5,018,815	30,980	
Plant total	215	13,287,540		
Cones within pl.	864	8,944,292	10,352	
Sample total	1078(1079)	22,231,832		

Interaction tables

Height	Variety						
	Fuggle	L.C.	B.G.	144-I	135-I	128-I	Total
16'	28,400	33,750	27,400	19,920	22,270	25,860	157,600
18'	25,070	39,440	27,610	23,500	23,990	27,990	167,600
20'	28,000	33,690	27,600	22,820	23,130	28,790	164,030
Total	81,470	106,880	82,610	66,240	69,390	82,640	489,230

Rep.	Fuggle	L.C.	B.G.	128-I	135-I	144-I	Total
I	25,090	30,580	27,260	28,510	24,250	20,740	156,430
II	30,010	40,060	27,590	27,970	23,400	22,380	171,410
III	26,370	36,240	27,760	26,160	21,740	23,120	161,390

Rep.	16'	18'	20'
I	49,870	54,560	52,000
II	55,430	57,870	58,110
III	52,300	55,170	53,920

Notes on hop rooting experiment Feb. 6, 1964

After the hop cuttings were dug they were evaluated for number of roots and also the length of the roots. Photographs were taken on each treatment. The following notes will include observations on visual characteristics of the hop cuttings.

Treatment 1 has normal looking cuttings which are firm comparable to that of the check. The buds look very good on all of the soaking times. This treatment also displays an increased amount of root initiation at the base.

Treatment 2. All soaking times showed an excellent root development with considerable branching in the new roots which were initiated. The cuttings had a warty-calloused appearance with the base being enlarged as well as all nodes. The 48 hour soak showed a brown discoloration at the nodes which penetrated into the cortex. All cuttings from this treatment had a brown rough outer surface.

Treatment 3 was characteristic of having cuttings which were soft to the touch in that the cortex was pulpy, indicating a depletion of food reserves. Other than this feature the cuttings were normal in outward appearance.

Treatment 5 had cuttings with similar outward appearance to that of the check, but there was an apparent increase in number of roots initiated. No other differences were noted.

Treatment 6 has quite abnormal looking cuttings, having warty appearance in all soaking times, probably more so with a 6 hour soak. This soak also has a firmer cutting than that of the 20 and 48 hour soak. The cuttings are larger in diameter than those of the 6 to the 48, with the 48 hour soak having a tremendous increase in size, approximately double that of when the cutting was planted. The 48 hour soak also has an increased degree of rot as compared with that of the 20 and 6 hour soak. The cuttings are also soft and spongy with an increased amount of water present in the tissue.

Treatment 7 has a normal looking cutting in texture, but all of the cuttings are soft and corky to the touch. It appears that most of the buds on the cuttings have been stimulated more so with the 20 and 48 hour soak. As many as 5 buds have been stimulated at each node, which appears to be quite abnormal on most cuttings. The stimulated buds are very spindly, having the appearance of roots rather than shoots.

Treatment 8 has normal looking cuttings which are firm under the cortex, the six hour soak shows a large number of small rootlets.

Treatment 9 has firm normal looking cuttings with vigorous shoots and buds at each node.

Treatment 10 has the characteristic warty appearance on all cuttings with convolutions which are characteristic of the synthetic auxin treatment. The cutting is firm which is contrary to that observed earlier with gibberellin treated cuttings. Under the cortex there appears to be a great number of rootlets initiated from cuttings common to all soaking times. The shoots from the 6 hour soak appear to be quite normal whereas that of the 48 hour appeared to be

different in that they have a weak bud which is abnormal in some way. The root set appears to be satisfactory, but the treatment might be restricted to the 6 hour soak.

Treatment 11 has normal cuttings, with the 6-hour soak showing some wartiness, but not having an abnormal color whereas cuttings from the 20 and 48 hour soak show a brown discoloration on the outer surface with a rot present at all of the nodes. The nodes are also enlarged with the 20 and 48 hour treatments. A good set of roots is evident on the 6 hour and 20 hour soak. This may be a promising treatment.

Treatment 12 has normal cuttings with the 6 hour soak having a good root system with some roots appearing at the base as well. The 20 and 48 hour soak display a warty surface with an enlargement of all of the nodes and a marked increase in callous tissue at the base. The nodes and bases of all of these cuttings also show a progressive rot.

Treatment 13 has normal cuttings which are soft and corky probably being typical of all gibberellin treated hop cuttings. There does not appear to be the stimulation at the lower nodes that was evident with other gibberellin cuttings.

Treatment 14 was a normal looking cutting with a soft corky feel similar to that of treatment 3. Removal of the cortex displayed a large number of rootlets had been initiated from the pericycle, but had not extended past the epidermal tissue. This might be a good characteristic of this treatment.

Treatment 15 has normal cuttings with a light brown surface being very firm similar to that of the check. There is no enlargement of the nodes or basal portions of the cuttings from any of the soaking times. Buds at the nodes are also quite normal in appearance.

Treatment 16, being the check, has a normal cutting which is firm which shows a moderate root set, but interesting to note, a large number of rootlets under the cortex, especially with the 6 hour soak.

Treatment 17 was a complete dust of the hop rhizome with "Rootone" prior to the planting. Observations on this date indicate that considerable damage was done to the buds and the cells proliferated causing an outward warty and corky characteristic on the epidermis. The roots were very short, mainly extended from the base of the root, whereas very small rootlets appeared throughout the cutting. This indicated that there was a root inhibition and/or the concentration was too high. This treatment would be unfavorable for commercial practice.

Treatment 18 showed very little if any root development on the cutting itself and the only roots which appeared were those at the base of the cutting. The surface of the cutting was a light brown surface with a normal smooth texture.

Notes on greenhouse rooting experiment Feb. 25, 1964

Treatment 1 -- Normal foliage, 20 hour soak best for rooting, good apical buds on all.

Treatment 2 -- Normal foliage on 6 hour soak, abnormal on rest. Excellent rooting on 6 hour, with progressively less on longer soaking times, corresponding with a progressive rot with the longer soaks. Roots on longer soaking times appear to have been inhibited and/or died due to the rot of cuttings. Suggest a shorter soak than six hours or a lower concentration.

Treatment 3 -- Rooting average in all soaking times, foliage abnormal. Foliage above the 18" level has unifoliate leaves which are crinkled and appear to be withered.

Treatment 4 -- Normal foliage, with an apparent increase in rooting with longer soaking times. Average number of roots. The 6 hour soak has a greater number of rootlets at the base than the other soaking times.

Treatment 5 -- Normal foliage with a possible increase in vigor. All vines appear to be strong in all soaking times. Six hour soak displays more roots primarily due to an increased number at the base of the cutting as compared with the other soaking times.

Treatment 6 -- Cuttings are similar in looks to those of treatment 2. The longer soaking times display cuttings increased in size due to increased water uptake or increase in callus tissue. This treatment has the largest number of living roots, though the longer soaking times display a rot in all cuttings with a progressive rot in the six hour soak. Suggestion similar to that with treatment 2.

Treatment 7 -- Average root set, vigorous growth with unifoliate leaves above the 18" level, being chlorotic yellow and wilted.

Treatment 8 -- Normal foliage, less than average root set, cuttings soft and undergoing rot. The 48 hour soak having an increased root set at cut base of the cuttings.

Treatment 9 -- Average root set, average foliage on 6 and 20 hour soak. The 48 hour soak having unifoliate leaves on upper portions of the vine.

Treatment 10 -- Foliage present only on 6 hour soak, being average except for unifoliate leaves, having a good root set, except at the 20 and 48 hour soak. The cuttings at the 6 hour soak appear sound, whereas the 20 hour soak has the start of a rot and the 48 hour soak has a progressive rot with an enlargement of all the nodes and cuttings.

Feb. 26, 1964

Treatment 11 -- Good foliage, short on 6 hour soak, with good roots, 20 hour had stunted shoots with very good roots, 48 hour had no foliage, cuttings rotted with some new roots at base.

Treatment 12 -- Six hour soak had uneven shoot growth with up to 12 roots, 3 in. long, from base pericycle, fair number of roots. 20 hour had good roots, with no shoots. Same for 48 hour plus node enlargement.

Treatment 13 -- Shoots with unifoliate leaves, poor roots.

Treatment 14 -- Shoots with simple leaves, poor roots.

Treatment 15 -- Fair shoots, least number at 48 hours, same for roots.

Treatment 16 -- Good shoots, best at 6 hours, worst at 48 hours, fair to good roots.

Treatment 17 -- Cuttings rotted, many short roots (1-2 mm), root initiated at apical cut.

Treatment 18 -- Fair foliage, but uneven. Simple leaves, less than average root set.

Special apparatus and details of methods for isolation of hop volatile from brewing products.

A special distillation unit was constructed which would allow simultaneous condensation of a steam distillate and an immiscible extracting solvent (figure 1). The distillate-return arms were at different levels so that the low-density layer returned through arm A and the high-density layer returned through arm B.

Use of a 15 ml. conical centrifuge tube as the solvent distillation flask allowed concentration of the extract without transfer. Loss of extracting solvent as vapor was compensated for by addition of fresh pentane through the vent in the condenser (figure 1).

This design offered several advantages. First, a large interface was available at the condenser surface for extraction into the solvent phase. Second, fresh solvent was continually supplied for the extraction so that accumulation of solutes was possible. Third, solutes occurring in parts per billion quantities were concentrated 32,000 times in a single operation with minimum exposure time.

Materials and methods:

A freshly distilled seedless 'Late Cluster' hop oil sample was divided into 50 µl. aliquots and each sealed in a glass ampoule. These were stored at -5°F. and a fresh ampoule was opened for each test requiring hop oil. The analysis of the lot was:

Peak No.			
	1.	Myrcene	63.4%
	2.	2-methylbutyl isobutyrate	3.6%
	3.	Methyl octanoate	0.8%
	4.	Methyl dec-4-enoate (2)	2.7%
	5.	β-caryophyllene	2.2%
	6.	Undecanone-2	0.6%
	7.	Methyl dec-4,8-dienoate (2)	1.7%
	8.	Humulene	10.3%
	9.	Oxygenated component with retention time identical with humulene	1.1%
	10.	Hydrocarbon with retention time corresponding to farnesene	1.7%
	11.	Oxygenated sesquiterpene	0.4%
	--	Unidentified components	11.5%
		Total	100.0%

All extractions were made into pentane which had been pruified by stirring with concentrated H_2SO_4 for two days after which it was washed twice with water, twice with 5% $NaH\,CO_3$, twice with water, then redistilled (B.P. 36-38°C.) and stored over Na_2SO_4.

Separations of hydrocarbon from oxygenated fractions were carried out using 80/100 mesh silicic acid (13% moisture). Columns of 7 mm. diameter were prepared with 5 cm. of Na_2SO_4 followed by 10 cm. silicic acid

which was added as a slurry with pentane. The columns were loaded with 50 µl. samples and the hydrocarbons eluted with 8 ml. pentane at a rate of 0.5 ml. per min. Oxygenated components were eluted with 10 ml. reagent grade, anhydrous ethyl ether.

Distillation-extraction of model systems were carried out as follows: Nine liters of 3.5% ethanol in distilled water (v/v) were acidified with 2 ml. glacial acetic acid, then neutralized to the desired pH with 2 M NaOH. The system was then buffered with KH_2PO_4 and NaOH according to standard practice. The system was purged for at least 30 min. with N_2 and the hop oil added as an ethanol solution. Return arm B of the distillation-extraction apparatus was prepared with 70% ethanol and a layer of pentane added to arm A. Five ml. pentane and a boiling chip were added to the pentane reservoir. The pentane distillation rate was adjusted to about 1 ml. per min. before distillation of the sample began. The distillation rate of the model system was adjusted so that condensation occurred on the top 3 to 5 cm. of the condenser. Except where noted, distillation time was 2 hr.

Wort and beer samples were obtained from a local brewery in plastic containers and held at 35°F. until use. The wort was hopped with 0.21 lb. seedless 'Late Cluster' per bll. containing about 0.6% oil. Approximately 5 ppm. hop oil was available to the wort. Unhopped wort was taken from the kettle and hopped wort was taken after cooling, aeration and filtration. Beer samples were taken from storage immediately prior to packaging.

Wort samples (8 l.) were prepared for distillation-extraction by first adjusting the pH to 6.0 with 2M NaOH, then buffering with 54.3 g. KH_2PO_4 and 13.4 ml. 2M NaOH. The distillation-extraction apparatus was prepared by adding distilled water and pentane. The pentane reservoir was prepared as for the model systems. Distillation rates were as for the model systems, and distillation time was 2 hr.

Beer samples were handled in the same manner as the wort samples, except that the distillation-extraction apparatus was prepared with 70% ethanol instead of distilled water. The beer contained about 10 ppm. iso-humulene units (1).

Immediately after distillation all pentane extracts were concentrated to about 0.2 ml. in the distillation tubes under a gentle stream of N_2 at room temperature. They were then transferred to calibrated vials made from 3mm. glass tubing and the volume adjusted to 0.25 ml. with pentane. The vials were capped and held at -5°F. until use.

Gas chromatographic separations were carried out on a 1/8 in. by 27 ft. column packed with 2% butanediol succinate on 60/80 mesh Chromosorb-P. The first 2 ft. section of the column was detachable and was replaced weekly to compensate for column variation due to elution of the stationary phase. The column was operated at 144°C. under a 2 atm. pressure drop which gave a flow rate of 9 ml. nitrogen per min. The splitting ratio was 2:1. Detection was by means of flame ionization. Under these conditions, the column produced resolution equivalent to about 10,000 theoretical plates when calculated according to the formula; total theoretical plates = 16 (retention time ÷ peak width at the base)^2.

When recovery of hop oil was of interest, identical amounts of oil were: (1) added to the system, and (2) diluted to 0.25 ml. with pentane. After distillation-extraction the volume of recovered concentrate was also adjusted to 0.25 ml. Five μl. of each were chromatographed and recoveries of individual components were calculated by:

$$\frac{\text{P.H. rec.} \times \text{R.T. rec.}}{\text{P.H. ref.} \times \text{R.T. ref.}} \times 100 = \% \text{ recovery},$$

where P.H. is the peak height of the component (mm.), R.T. is its retention time (min.), rec. is the recovered concentrate, and ref. is the reference concentrate.

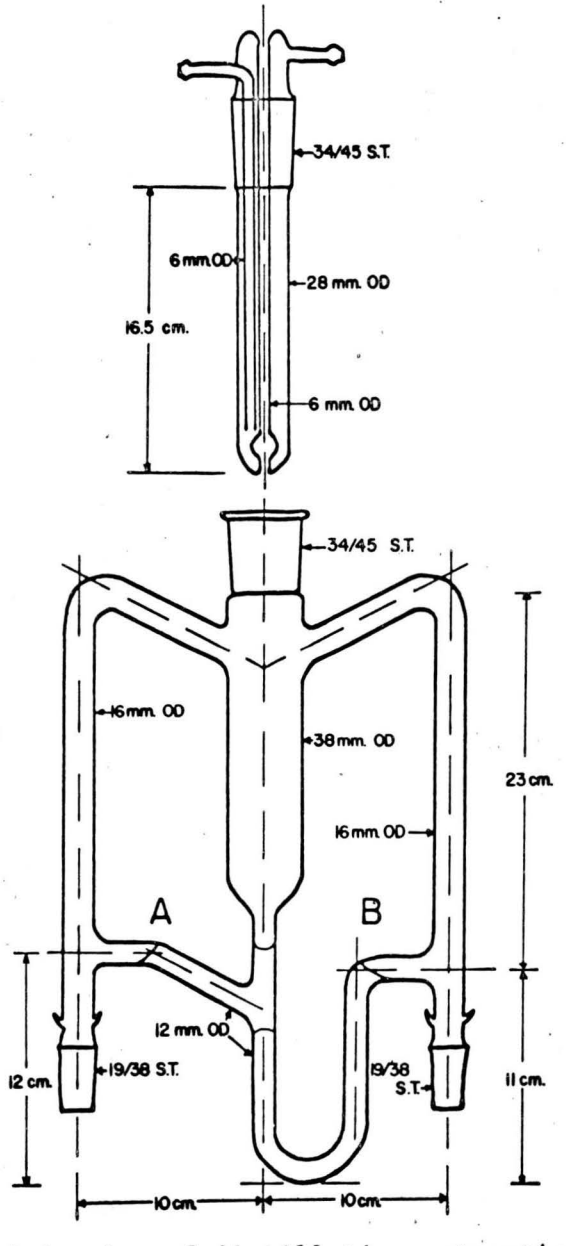


Figure 1. Scaled drawing of distillation-extraction apparatus.