1962

ANNUAL REPORT

OF

HOP INVESTIGATIONS
(CRe5, OAES 36)

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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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S. T. Likens

A P P E N D I X

INTRODUCTION

S. N. Brooks

This 1962 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, 1962 to February 28, 1963. 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 1962 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 Chemist, USDA,
Mr. C. E. Zimmermann, Research Agronomist, USDA,
Mr. H. L. Dooley, Asst. in Plant Pathology (part time), OSU,
Mrs. J. M. Barnes, Secretary, USDA,
Mr. Bernes Frey, Agric. Aid, USDA,
Mrs. Hulda Bauer, Agric. Aide, OSU,
Miss Gail Nickerson, Research Lab. Tech., OSU,
Mr. Richard Avery, Farm Laborer (part-time), OSU,
Mr. Iver Deudahl, Student Help (part-time), OSU,
Miss Judy Maurer, Lab. Assistant (part-time), OSU.

Following a period of 6 years during which there were few publications, there has been a marked increase during the past 3 years. Following is a list of publications (including abstracts of talks presented at scientific meetings) authored or co-authored by project personnel since 1960:

Technical

Brooks, S. N., and K. R. Keller. Effect of time of applying nitrogen fertilizer on yield of hops. Agron. J. 52: 516-518. 1960.

Likens, S. T. Sampling hop yards and chemical determination of hop maturity. Crops Research, ARS 34-17. July, 1960.

Likens, S. T., and S. N. Brooks. A method of estimating α- and β-acids in flowers of male hops. Mod. Brewery Age 63(3): 50-53. 1961.

Brooks, S. N. Effectiveness of selection within Fuggle hops (Humulus lupulus L.). Crop Sci. 2: 5-10. 1962.

Bullis, D. E., and S. T. Likens. Hop oil — past and present. Brewers Digest 37: 54-59, April, 1962.

Brooks, S. N., and S. T. Likens, Variability of morphological and chemical quality characters in flowers of male hops. Crop Sci. 2: 189-192. 1962.

Brooks, S. N. Association of quality characters in flowers of male hops. Crop Sci. 2: 192-196. 1962.

Likens, S. T. Development and fate of hop oils. Proc. Master Brewers Assoc. Amer. p. 10-16. October, 1962.

Likens, S. T., and G. B. Nickerson. Influence of compression on α-acid, β-acid and essential oil in hops. Amer. Brewer 96(1): 50-52, 1963.

Abstracts

Brooks, S. N. Breeding hops for resistance to downy mildew. WSCS Crop Science Abstracts, p. 14. July 1960. (mimeo.)

Puri, Y. P., and S. N. Brooks. Pollen germination and longevity in Humulus lupulus. WSCS Crop Science Abstracts, p. 19. July 1960. (mimeo.)

Brooks, S. N. Path coefficient analysis of quality characters in male hops. WSCS Crop Science Abstracts, p. 6. June, 1961. (mimeo.)

Brooks, S. N. Variability of morphological and chemical quality characteristics in flowers of male hops, Humulus lupulus L. Diss. Abs. 22(4): 978. Oct. 1961.

Brooks, S. N. Natural conditions influencing pollen shedding in hops. WSCS Crop Science Abstracts, p. 13. Aug. 1962. (mimeo.)

Zimmermann, C. E. Longevity of hop pollen in storage. WSCS Crop Science Abstracts, p. 12-13. Aug. 1962. (mimeo.)

Non-technical or popular

Brooks, S. N., C. E. Horner, and S. T. Likens. Hop Production. Agric. Info. Bull. 240, ARS, USDA. Nov. 1961. 46 pp.

Horner, C. E. Hop Diseases. Oregon Plant Disease Control Handbook, p. H-4. 1960.

Brooks, S. N. Hop. Encyclopaedia Britannica, vol. 11, p. 733-735. 1960.

Brooks, S. N. Hop. McGraw-Hill Encyclopedia of Science and Technology, vol. 6, p. 478-479. 1960.

Technical manuscripts completed and awaiting publication

Horner, C. E. Chemotherapeutic effects of streptomycin on establishment and progression of systemic downy mildew infection in hops. (accepted for publication in Phytopathology, Vol. 53, 1963.)

Likens, S. T., and G. B. Nickerson. Two-point conductometric titration of hop α-acids. (accepted for publication in Wallerstein Lab. Comm. April, Vol. 26, 1963.)

Brooks, S. N. Relation of training date to pollen shedding in male hops, Humulus lupulus L. (accepted for publication in Crop Science, Vol. 3, 1963.)

Brooks, S. N., and Y. P. Puri. Atmospheric conditions influencing pollen shedding in hops. (submitted to Crop Science, February, 1963.)

Skoe, D. E. Resistance in hops to systemic root stock and crown infection by downy mildew. (M.S. thesis, Oregon State University, May, 1960.)

Zimmermann, C. E. Factors affecting pollen germination and longevity in hops, Humulus lupulus L. (M.S. thesis, Oregon State University, June, 1962.)

Production of hops in 1962-63 amounted to about 165,710,000 pounds in the northern hemisphere and about 5,148,000 pounds in the southern hemisphere for a world total of about 160,858,000 pounds. This amount is up about 9,118,000 pounds over last year and is 16,500,000 below the 1960-61 crop. This increase is largely a reflection of significant increased production in the U.S., West Germany, East Germany, and the United Kingdom. Despite increased world production, carryover remains moderate, and hop prices continue to rise. Beer production continues upward in all countries where statistics are available. Exports of U.S. hops are expected to remain steady.

1962 hop production in the U.S. amounted to 44,231,000 pounds which was 7% below average but up 25% from last year. Hop acreage increased

from 22,900 in 1961 to 29,300 in 1962 and is a reflection of acreage increases in all 4 states. Yields per acre were above average in Oregon and California, but the lowest in 40 years in Washington. Yields in Idaho were about average, but considerably above last year's. Production and marketing data from SRS reports (Dec. 20, 1962) are given in Tables 1 and 2.

Table 1. Hop acreage and yield, 1962, 1961, and 1951-60.

State	Acreage harvested			Yield per acre		
	Average 1951-60	1961	1962	Average 1951-60	1961	1962
	- Acres -			- Pounds -		
Idaho	2,220	3,200	3,400	1,938	1,710	1,940
Washington	15,310	12,800	18,000	1,647	1,570	1,410
Oregon	6,720	3,000	3,800	1,221	1,430	1,380
California	6,400	3,900	4,100	1,507	1,435	1,710
United States	30,650	22,900	29,300	1,545	1,548	1,510

Table 2. Hop production, prices received, and farm value, 1962, 1961, and 1951-60.

State	Production			Price per pound		Value	
	Average 1951-60	1961	1962	1961	1962	1961	1962
	- Thousand pounds -			- Cents -		-Thousand dollars-	
Idaho	4,213	5,472	6,596	45.0	49.0	2,462	3,232
Washington	25,153	20,096	25,380	41.0	43.0	8,239	10,913
Oregon	8,274	4,290	5,244	46.0	46.0	1,973	2,412
California	9,726	5,596	7,011	53.0	59.0	2,966	4,136
United States	47,366	35,454	44,231	44.1	46.8.	15,640	20,693

Cool, damp weather experienced in the spring prolonged the period of training vines in Washington, and resulted in heavy downy mildew infection. Some yards were near failure and a few were abandoned. Poor conditions in reactivated yards contributed to the low average yield in Washington. Conditions were favorable for downy mildew in Oregon, but control measures were effective, and yields were good. Conditions were favorable for hops in Idaho with Late Cluster yielding particularly well. Some hops were blown down in California, but losses were minor, and conditions were conducive to an excellent crop. Climatic data for Corvallis, Oregon are given in Table 3.

Table 3. Climatological data taken at Hyslop Agronomy Farm, near Corvallis, Oregon, in 1962 and during previous years.

Month 1961	Avg. Max. Temp. (°F) 1962	Avg. Max. Temp. (°F) 27 yr. avg.	Avg. Min. Temp. (°F) 1962	Avg. Min. Temp. (°F) 27 yr. avg.	Avg. Mean Temp. (°F) 1962	Avg. Mean Temp. (°F) 27 yr. avg.	Precipitation (inches) 1962	Precipitation (inches) 27 yr. avg.
Oct.	63.61	64.67	40.58	43.28	52.10	54.17	3.73	3.50
Nov.	49.83	53.12	35.33	37.42	41.68	45.19	6.79	5.68
Dec.	47.26	47.94	34.80	35.48	41.03	41.56	6.21	6.08
1962								
Jan.	43.81	45.46	29.93	32.56	36.87	39.04	1.21	6.17
Feb.	50.56	50.62	33.79	35.17	42.18	42.86	3.82	5.24
Mar.	51.42	55.12	35.19	36.96	43.31	46.05	6.37	4.27
Apr.	62.50	62.20	40.60	40.48	51.60	51.35	2.90	2.73
May	59.48	68.26	42.39	44.85	50.93	56.54	2.31	1.87
June	73.33	73.58	45.5	49.20	59.	61.33	.39	1.22
July	80.48	81.30	48.68	51.72	64.58	66.57	0.	.32
Aug.	78.22	81.00	50.03	51.42	64.13	66.25	.57	.39
Sept.	76.06	76.57	48.57	48.70	62.32	62.64	1.60	1.31
Yearly total							35.90	38.78
Yearly mean	61.38	63.32	40.45	42.27	50.81	52.80		

Month 1962	Rel. humid. @8AM (%) 12 1962	Rel. humid. @8AM (%) 12 yr. avg.	Evaporation (in.) 22-25 1962	Evaporation (in.) 22-25 yr. avg.	No. clear 1962	No. clear 27 yr. avg.	No. ptly. cloudy 1962	No. ptly. cloudy 27 yr. avg.	No. cloudy 1962	No. cloudy 27 yr. avg.	No. rainy 1962	No. rainy 27 yr. avg.	Avg. wind velocity (MPH) 9' 1962	Avg. wind velocity (MPH) 9' yr. avg.
Apr.	81.92	79.17	3.240	2.552	5	9	16	12	9	9	17	14	2.05	2.15
May	87.13	76.61	3.262	4.053	1	10	14	12	16	9	24	13	1.66	1.56
June	79.23	76.12	6.871	4.642	13	10	12	11	5	9	3	9	2.07	1.85
July	76.37	70.5	8.334	4.347	15	18	15	10	1	3	0	3	2.19	1.98
Aug.	82.40	75.4	6.740	6.002	7	17	20	9	4	5	10	3	2.27	1.69
Sept.	87.03	80.7	5.014	3.936	10	15	16	11	4	5	6	6	1.90	1.85
Total					51	79	93	65	39	40	60	48		
Mean	82.35	76.21	5.544	4.255	8½	13	15½	11	6½	7	10	8	1.72	1.85

27 year averages are for 1936 through 1962.

CR e5-1 (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

As part of the continuing program of exchange of germ plasm with foreign countries, planting stocks of Density, Defender, and Janus (P.I. 284731, 284730, and 284732, respectively) were received from East Malling, England in November and have been planted into 4-hill observation plots at Corvallis. Seeds of Late Cluster were sent to a research station in Stuttgart, Germany. Cuttings of Early Cluster, Late Cluster, Fuggle, and Brewers Gold were sent to Czechoslovakia. Cuttings of Early Cluster, Late Cluster, Fuggle, Brewers Gold, Bullion, and 135-I were sent to Poland. Cuttings of Late Cluster and Early Cluster were sent to Wye College, England. Cuttings of 524-2 and 525-2 (wild American) were sent to Belgium.

Following is a tabulation of the foreign introductions received in the last 2 years and the plots into which they were planted for observation.

Table 1. Observation block of foreign introductions (planted Dec. 17, 1962)[1/]

Plot No.	P.I. number	Name	Source
OB201	274519	CZ/C6	Agric. Inst., Pulawy, Poland
202	274520	CZ/K23	" " " "
203	274521	D(or P)	" " " "
204	274522	P/K1	" " " "
205	274523	28/30	" " " "
206	274524	43/7	" " " "
207	274525	45/36	" " " "
208	274567	7	" " " "
OB209	274568	N/16	Inst. Plant Ind., Leningrad, U.S.S.R.
210	250809	Golding	Dr.H.Gentry(USA), Ljubljana, Yugoslavia
211	274569	N 18	Inst. Plant Ind., Leningrad, U.S.S.R.
212	274570	N 34	" " " " "
213	255973	Savinja-Golding	Inst. za Hmeljarstvo, Yugoslavia
214	284730	Defender (D3)	East Malling Res. Sta., England
215	284731	Density (D1)	" " " " "
216	284732	Janus (J2)	" " " " "

1/ Received under Post entry Permit No. 37-2858 except for PI 250809 and PI 255973 which were grown under quarantine at Glenn Dale, Maryland 1959-1961.

1962 Selections

Selection was made in the 1960 nursery at Corvallis and in the Genetic Block. C60001 through C60007 were mildew-disease-free plants in the 1960 nursery. C60008 is a sister-selection of OB841, now in preliminary testing, which is an apparently mildew-resistant Late Cluster seedling. C60009 through C60011 are clones which have had little mildew in a genetic study over a three-year period. Disposition of these selections is indicated in Table 2.

Material sent to Prosser in 1961 was inspected in mid August. It was too early to make selection, and it was decided that Mr. Nelson would make a more critical evaluation when the plants had matured. Results of this evaluation are given in the appendix.

Table 2. Selections moved into Observation Block in 1962 (planted Nov. 1962)

Plot		Selection and source
OB846	C60001	106 x 321-1 (59005)
847	C60002	106 x 317-1,2 (59004)
848	C60003	106 x 421-1,2 (59006)
849	C60004	212 x 317-1,2 (59019)
850	C60005	212 x 317-1,2 (59019)
851	C60006	25-S x 317-1,2 (59068)
852	C60007	25-S x 317-1,2 (59068)
853	C60008	LC x Unknown (58059)
854	C60009	106 x 221-2 (57002)
855	C60010	106 x 421-1,2 (57005)
856	C60011	25-S x 521-4,5 (57040)

Nurseries Established in 1962

Approximately 100 seedlings were sent to C. E. Nelson at Prosser, Washington last spring. They were planted in his nursery area and will be evaluated in 1963. This material included plants from the 1960 nursery at Corvallis, cuttings of material going into preliminary testing at Corvallis, and several wild American clones. Table 3 lists the material sent to Washington in 1962.

Table 3. Material sent to Prosser, Washington in 1962 for evaluation in single-hill plots.

No. of plants	Introduction or Cross source	Remarks
22	59037	Hallertau x C19040M (mostly Fuggle)
32	59004	C19032 (some Red Vine) x C19041M (some Early Green)
5	59005	C19032 (some Red Vine) x C19049M (some East Kent Golding and Bavarian)
4	59006	C19032 (some Red Vine) x C19040 (mostly Fuggle)
5	59019	C19028 (some Early Green and Early Cluster) x C19041M (some Early Green)
4	59031	C19076 (mostly Fuggle) x C19049M (some Early Kent Golding and Bavarian
2	59042	C19067 (some Bullion and Kent Golding) x C19041M (some Early Green)
18	59068	I19120 (mostly Sunshine) x C19041M (some Early Green)
1	57003 (G2071-3)	C19032(some Red Vine) x C19041M (some early Green)
1	58059 (OB841)	Late Cluster x Late Cluster (?)
1	I60001 (OB840)	Shinshuwase
1	58018 (OB843)	C50019 (some Elsässer and Fuggle) x O.P.
1	58006 (OB842)	C19032 (some Red Vine) x C19041M (some Early Green)
1	BB526-5	Wild American
1	BB523-1	Wild American
1	BB523-4	Wild American
1	BB524-5	Wild American
101		

A seedling nursery of 277 individuals from 64 crosses made in 1961 was planted under low trellis at a 4' x 8' spacing. A plan of the nursery is given in Table 4.

Table 4. Planting plan of 1962 seedling nursery (rows numbered east from Smith Lane).

Row	Cross number and number of plants in progeny.
49	61074-9; 61084-8; 61085-19; 61086-4; 61087-2; 61088-1; 61091-2; 61099-5; 61102-1; 61104-1.
59(10)	61025-2; 61027-8; 61035-6; 61046-2; 61052-3; 61101-2.
60(11)	61001-1; 61002-9; 61003-2; 61005-1; 61006-5; 61009-3; 61011-5; 61014-1; 61015-1; 61018-1; 61019-1; 61023-6; 61024-3; 61028-3; 61029-5.
61(12)	61030-9; 61033-10; 61034-12; 61036-21.
62(13)	61032-3; 61037-4; 61039-1; 61042-1; 61043-1; 61045-2; 61040-1; 61048-1; 61049-6; 61053-3; 61054-8; 61055-7; 61056-3; 61058-2; 61059-1; 61060-2; 61061-1; 61063-4.
63(14)	61068-2; 61069-4; 61070-2; 61071-2; 61072-3; 61073-5; 61075-9; 61076-14; 61077-4; 61078-3; 61083-4.

Seedling Reaction of 1961 Crosses to Downy Mildew.

(C. E. Horner)

Direct crown inoculation was used to evaluate for resistance to systemic downy mildew infection about 7000 seedlings representing progenies from 103 crosses and open pollinated sources.

Procedure:

Surface disinfested, pre-germinated seeds from each cross were individually space planted in greenhouse flats by the plant breeder in February, 1962. When seedlings were 16-18 weeks of age (June 20-28) aerial stems were clipped off and the soil pushed away from one side of the crown and upper tap root. Crowns were mostly $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter. Very small or weak seedlings were removed at this time, except for certain backcross progenies of particular interest for other tests.

Inoculum was obtained by washing downy mildew sporangia from naturally infected leaf and stem material collected from the field. Inoculum was derived from a wide range of lines and varieties to include possible races of the pathogen. Spore suspensions were filtered to remove dirt and debris, then placed at 20°C. to germinate. When sporangia had released abundant zoospores, inoculation was accomplished by injecting 0.05 ml. into the phloem tissue of the crown of each seedling. Greenhouse temperature controls were set at 70°F. and plants watered and cared for in the usual way.

Because of the time required to individually inoculate several thousand seedlings, a comparison test was made to determine if simply pouring a zoospore suspension over the exposed crown and tap root would result in as good systemic infection as direct crown inoculation with hypodermic syringe. Two flats containing 48 seedling each of cross 75 were used; one flat was inoculated by each method. Seven weeks after inoculation seedling asaay showed 46 of 48 plants infected by spore drench method and 20 of 48 infected by direct crown injection.

Immediately after the above results were obtained all remaining seedlings were reinoculated by pouring a suspension containing 192,000 zoospores per ml. over the exposed crown and upper tap root.

Six to eight weeks after the second inoculation all plants were dug, washed and evaluated for systemic crown infection.

Results:

A. Seedlings from Domestic x Domestic.

Fifty-one crosses yielded 2962 seedlings, of which 401 showed resistance to crown infection. Percentages of resistant seedling varied greatly among crosses. For example, 5% of the 60 seedlings in cross 46 were resistant; whereas 38% of the 79 in cross 34 were resistant. One hundred eight resistant seedlings were selected for further observation.

B. Seedlings from Domestic x Wild American

Forty-four crosses yielded 3488 seedlings, of which 661 showed resistance to downy mildew. Certain crosses (27, 85 and 86) produced large numbers of resistant seedlings, but great variability among crosses was again evident. We saved 161 resistant plants for further observation.

C. Wild American x Wild American

Eight crosses yielded 433 plants for testing, of which 60 showed high resistance to downy mildew crown infection. Eighteen seedlings were saved for observation.

Discussion and Conclusions:

Since many crosses yielded 90-95% susceptible seedlings, the inoculation procedures were adequate to detect, with fairly good accuracy, most of the seedlings having a high level of resistance. The new inoculation procedure used is the most efficient yet devised and will allow us to evaluate large numbers of seedlings with ease.

Table 5. Downy mildew reaction of 1962 hop seedlings.

Resistance to Downy Mildew in Seedlings from Wild American x Wild American Hops, 1962 Assay.

Cross No.	Seedlings tested	Seedlings infected	Seedlings resistant	Percent resistant	Seedlings saved
57	49	43	6	12.2	0
61	134	120	14	10.4	1
65	none				
69	56	48	8	14.3	4
70	17	15	2	11.8	2
71	13	9	4	30.8	2
74	21	9	12	57.1	9
81	14	14	0	0.0	0
82	129	115	14	10.8	0
Totals	433 tested		60 resistant		18 saved

Table 5. (cont.)

Resistance to Downy Mildew in Seedlings from Domestic x Domestic Hops -- 1962 Assay.

Cross No.	Seedlings tested	Seedlings susceptible	Seedlings resistant	Percent resistant	Seedlings saved
1	93	78	15	16.1	6
2	207	148	59	28.5	9
3	90	79	11	12.2	2
4	10	8	2	20.0	1
7	111	108	3	2.7	0
9	17	12	5	29.4	3
10	43	42	1	2.3	0
11	243	221	22	9.0	5
12	36	36	0	0.0	0
13	39	35	4	10.2	0
14	21	18	3	14.3	1
16	2	2	0	0.0	0
17	19	19	0	0.0	0
18	82	66	16	19.5	1
19	43	38	5	11.6	1
20	5	2	3	60.0	0
21	2	0	2	100.0	0
24	119	113	6	5.0	3
25 BC	10	6	4	40.0	2
26 BC	13	10	3	23.1	0
28	115	91	24	20.9	4
29	66	43	23	34.8	5
32	159	135	24	15.1	3
33	26	16	10	38.5	10
34	79	49	30	38.0	12
35 BC	25	16	9	36.0	6
36	180	139	41	22.8	21
37	235	213	22	9.4	5
38	27	27	0	0.0	0
40	169	165	4	2.4	1
41	166	164	2	1.2	0
42	178	175	3	1.7	1
43	49	45	4	8.2	1
46	60	57	3	5.0	2
47	25	24	1	4.0	0
48	2	1	1	50.0	1
50	9	9	0	0.0	0
51	38	33	5	13.1	0
88	4	3	1	25.0	1
89	7	7	0	0.0	0
90	13	13	0	0.0	0
92	10	10	0	0.0	0
93	9	9	0	0.0	0
94	1	1	0	0.0	0
96	7	7	0	0.0	0
100	2	1	1	50.0	0
103	37	36	1	2.7	0
104	42	41	1	2.4	1
106	1	1	0	0.0	0
107	2	2	0	0.0	0
108	14	14	0	0.0	0
Totals	2962 tested		401 resistant		108 saved

Table 5. (cont.)

Resistance to Downy Mildew in Seedlings from Wild American x Domestic Hops, 1962 Assay

Cross No.	Seedlings tested	Seedlings susceptible	Seedlings resistant	Percent resistant	Seedlings saved
5	5	2	3	60.0	1
6	122	90	32	26.2	5
15	21	15	6	28.6	1
22	16	12	4	25.0	0
23	56	41	15	26.8	6
27 BC	72	36	36	50.0	8
30	156	128	28	17.9	9
31	10	8	2	20.0	0
39	126	119	7	5.5	1
44	35	28	7	20.0	0
45	161	144	17	10.5	2
49	162	139	23	14.2	6
52 BC	34	29	5	14.7	3
53	155	133	22	14.1	3
54	195	166	29	14.9	9
55	201	161	40	19.9	7
56	21	11	10	47.6	3
58	100	96	4	4.0	2
59	64	59	5	7.8	1
60	28	24	4	14.3	2
62	68	66	2	2.9	0
63	37	29	8	26.0	4
64)					
66)	no seedlings				
67)					
68	54	44	10	18.5	2
72	166	142	24	14.4	3
73	102	90	12	11.8	5
75	200	156	44	22.0	8
76	158	110	48	30.4	14
77	18	11	7	38.9	4
78	302	268	34	11.2	4
79	62	51	11	17.7	0
80	65	63	2	3.1	0
83	23	18	5	21.7	4
84	158	123	35	22.1	9
85	105	41	64	60.9	19
86	14	6	8	57.1	4
87	35	31	4	11.4	2
91	70	66	4	5.7	2
97	none				
99	59	34	25	42.3	5
101 BC	32	22	10	31.2	2
102	20	15	5	25.0	1
105	none				
Totals	3488 tested		661 resistant		161 saved

Total seedlings tested 6883

Crosses Made in 1962

Seeds from 45 crosses were harvested in 1962. Crosses were made in 5 groups, consisting of (1) backcrosses involving Late Cluster, Early Cluster, Brewers Gold, Hallertau, and Backa, with vigorous, mildew resistant males, (2) crosses between Fuggle and wild American males from 4 states, (3) crosses among wild American males and females, (4) crosses of 107-I and 135-I, mildew resistant lines, with 2 high alpha-acid males, and (5) an attempt to reconstruct 128-I. Since the male parent of 128-I has long been gone from the breeding block, 3 males were crossed on Bullion to provide the chance of isolating lines similar to 128-I.

On February 6, seeds from each cross were treated and placed in a dark, temperature controlled room at 3°C. for 6 weeks. This treatment is the same as last year (1961 AR, p. 12) except no pre-germination will be given on March 20 when the seeds are planted.

The soil mixture used for growing the seedlings has been the same the past 2 years, and consists of:

8 parts by vol., fine sandy loam
2 parts by vol., peat moss
1 part by vol., leaf mulch
25 grams/90 lbs. mix, 13-13-13 fertilizer (about 1000 lb./A.)
60 grams/90 lbs. mix, hydrated lime (about 1.5 T/A.

Planting consists of placing seeds individually in shallow indentations on the soil surface and covering about 1/4 inch deep.

A list of the crosses made in 1962 is given in Table 6.

Table 6. Crosses for 1962.

62001 BC	122 - I 19208 x 421-1, 2 (225) - C 19040 M
62002	122 - I 19208 x 524-4 - I 58015 M
62003 BC	122 - I 19208 x 123-S - C 19182 M
62004 BC	311 - I 19001 x 421-1, 2 (225) - C 19040 M
62005 BC	311 - I 19001 x 526-4 - I 58015 M
62006	311 - I 19001 x 5-29-4 I 19001 x C 19062 M
62007 BC	311 - I 19001 x 123-S C 19182 M
62008 BC	322 - I 56001 x 121-2 (525) C 19062 M
62009 BC	322 - I 56001 x 526-4 I 58015 M
62010 BC	322 - I 56001 x 123-S C 19182 M
62011 BC	422 - I 56002 x 121-2 (525) C 19062 M
62012 BC	422 - I 56002 x 421-1, 2 (225) C 19040 M
62013 BC	422 - I 56002 x 526-4 I 58015 M
62014	422 - I 56002 x 123-S C 19182 M
62015	522 - I 59001 x 421-1, 2 (225) C 19040 M
62016	522 - I 59001 x 121-2 (525) C 19062 M
62017	523-1 I 58001 x 29-1 Ariz. 1-1
62018	523-1 I 58001 x 30-11 Colo. 2-1
62019	Fuggle I 19209 x 29-23 N. Mex. 2-3
62020	Fuggle I 19209 x 30-10 Colo. 2-1
62021	Fuggle I 19209 x 30-15 Colo. 2-3
62022	Fuggle I 19209 x 30-21 Colo. 3-2
62023	Fuggle I 19209 x 30-24 Colo. 4-1
62024	Fuggle I 19209 x 526-4 I 58015 M
62025	Fuggle I 19209 x 525-2 I 58010 M
62026	29-6 Ariz. 1-3 x 29-23 N. Mex. 2-3
62027	29-6 Ariz. 1-3 x 30-11 Colo. 2-1
62028	29-9 Ariz. 1-4 x 29-1 Ariz. 1-1

62029 29-10 Ariz. 1-4 x 525-2 I 58010 M

62030 29-18 N. Mex. 2-2 x 525-2 I 58010 M

62031 29-21 N. Mex. 2-2 x 29-23 N. Mex 2-3

62032 29-21 N. Mex. 2-2 x 30-10 Colo. 2-1

62033 30-13 Colo. 2-2 x 30-10 Colo. 2-1

62034 30-12 Colo. 2-2 x 525-2 I 58010 M

62035 1023 D N I 55081 x 118-4, 5 (518) I 19005 M

62036 1023 D N I 55081 x 119-1, 2 (521) C 19058 M

62037 1023 D N I 55081 x 120-1, 2 (523) C 19060 M

62038 1102 D N (107 I) C 19213 x 120-1, 2 (523) C 19060 M

62039 1123 D N (135 I) C 19151 x 120-1, 2 (523) C 19060 M

62040 401 - C 19012 x 123-S C 19182 M (S)

62041 401 - C 19012 x 119-1, 2 (521) C 19058 M (S)

62042 401 - C 19012 x 317-1 C 19041 M (S)

62043 412 - C 19017 x 221-2 (425-1) C 57101 M (S)

62044 312 - C 19021 x 120-5 (522-1) C 19059 M (S)

62045 206 - C 19024 x 119-1, 2 (521) C 19058 M (S)

(S) Pollen stored in cotton-stoppered vials under 40% RH at 3°C.
Pollen from 123-S and 119-1, 2 was stored for 24 months.

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.

Preliminary Quality Evaluation

Ten samples from Corvallis, eight from Idaho (R. R. Romanko), and four from Washington (C. B. Skotland) were prepared for USBA brewer evaluation. It was originally intended to submit 24 Oregon samples, but plots of OB 822, OB 826, OB 827, OB 829, OB 830, and OB 835 unfortunately were accidentally destroyed before harvest. Samples of OB 812 and G 2071-3 were harvested but were considered unsuitable for evaluation due to foreign material. Samples of OB 802, OB 808 and OB 837 were eliminated because of low resin content. OB 818 was eliminated because it shows little promise as a variety because of average to poor physical quality. A list of the samples for evaluation in 1962 with analytical data supplied by S. T. Likens is given in Table 7. Results of USBA evaluation are given in Tables 8 and 9. Overall evaluation in given in Table 10.

Table 7. Selections for brewer evaluation in 1962.

	Dry wt. basis				
	% α acid	% β acid	mls. oil per 100g	Date harvested	Remarks
Oregon					
OB 801	9.3	6.1	1.12	9/7	Promising 1960, 19th 1961
OB 813	8.6	7.0	2.24	9/7	15th 1961
OB 831	6.2	5.0	1.68	9/11	Promising 1960, 6th 1961
OB 833	6.6	3.8	1.17	9/21	7th 1961
OB 839	6.4	7.6	0.89	9/7	1st 1961
OB 840	6.0	5.2	1.16	9/11	11th 1961
OB 841	5.5	4.1	1.10	9/4	No previous eval.
15-S	6.0	6.4	0.28	8/29	Promising 1960, 5th 1961
50-S	9.3	3.1	1.71	9/4	Average 1960, 3rd 1961
128-I	10.9	5.4	2.12	9/21	Promising
Idaho 1/					
108-I	5.0	4.7	0.90	<9/14	
128-I	6.5	4.3	1.48	9/1	
0-1	7.4	2.1	1.31	9/2	
0-3	7.8	4.8	1.04	9/2	
0-11 (Batt)	10.5	4.6	1.71	<9/14	
0-11 (Obendorf)	10.1	3.9	1.23	<9/14	
0-17	5.3	4.1	0.81	9/21	
0-20	7.0	4.8	1.48	9/21	
Washington					
L-1	6.0	4.1	0.48	9/4	
E-2	7.8	5.0	0.59	9/11	
L-8	9.5	5.8	0.69	9/13	
E-21	7.3	4.7	0.60	9/4	

1/ 0-11 and 108-I taken from bale samples. Other Idaho samples machine picked from small plots subject to wind-whip.

Table 8. Hand evaluation of 1962 hop samples by members of the USBA Fixed Hop Committee, Dec. 11, 1962.

Sample	MWB	FLR	AJS	JBB	RGW	RH	RAS	KBG	Avg.	Rank
Oregon										
OB 801	41.5*	32	38	37	33	38	41	33	36.7	4
OB 802 1/	26*	20	28	(31)	(11)	(14)	(21)	(27)	22.2	23
OB 808 1/	35.5*	(31)	35	(37)	25	35	30	36	33.1	12
OB 813	41.5*	43	38	45	40	39	38	42	40.8	2
OB 818 1/	29*	24	31	(38)	20	20	24	30	27.0	19
OB 831	36*	37	39	(33)	(10)	41	33	43	34.0	10
OB 833	27*	31	33	(35)	28	34	36	40	33.0	13
OB 837 1/	33.5*	35	24*	43	21	31	28	47	32.8	14
OB 839	33*	42	29*	(39)	22	38	35	43	35.1	5
OB 840	28*	42	26*	(37)	(10)	39	33	32	30.9	17
OB 841	26*	37	(23)	(41)	50	(28)	25	48	34.8	9
128-I	42	42	48	(43)	45	(35)	28	53	42.0	1
Washington										
E-21	-	37	40	(35)	25	33	35	38.8	34.8	7
E-2	-	35	42	40	29	41	19	37.3	34.8	8
L-8	-	32	39	37	31	39	(22.5)	43.5	34.8	6
L-1	-	29	40	43	25	41	17	37.5	33.2	11
Idaho										
01	29	24	45	(33)	(7)	23	(10)	19.8	23.8	20
03	-	25	55	39	(12)	30	18	41	31.4	16
05	20.5	20	20	(34)	(2)	10	(12)	17.3	17.0	27
06	20.5	18	42	(29)	(0)	(2)	(12)	15	17.3	26
011-B	36.5	22	53	46	36	51	(27.5)	30	37.8	3
011-0	-	28	32	42	20	32	(22)	16.7	27.5	18
017	29.5	20	26	(32)	(2)	19	16	(17)	20.2	24
020	-	12	25	(31)	18	(7)	(12)	17	17.4	25
107-I	23.5	14	35	(27)	(4)	21	33.5	(21)	22.4	22
108-I	-	18	33	(31)	27	24	(14)	11.8	22.7	21
128-I	41	27	43	(21)	21	23	32	45	31.6	15

1/ To be discarded because of poor quality evaluation for 2-3 years.

* Graded down in overall desirability because of seed content.

( ) Off aroma, zero desirability, not commercial, or "would not buy" discriminatory remarks made. Remarks regarding sulphuring, moisture, wind-whip, etc. were not considered.

Table 9. Hand evaluation of 1962 samples for each criterion by USBA

Criterion	Max. score possible	OB 801	OB 802	OB 808	OB 813	OB 818	OB 831	OB 833	OB 837	OB 839
Appearance	5	2.9	2	2.6	3	2.2	2.4	2.3	1.6	3.4
Cone size	5	3.4	2.5	2.9	3.6	2.3	2.6	2.9	2.8	3.1
Lupulin	15	11.2	6.5	8.75	11.25	6.75	8.75	9.4	9.75	9.25
Aroma	20	12.1	7.75	11.1	13.25	9.25	12.	11.1	11.6	11.1
Overall desirability	15	7.5	3.75	7.5	9.75	6.5	8.	7.4	7.	8.25
Total	60	36.7	22.2	33.1	40.8	27.	34.	33.	32.8	35.1

		OB 840	OB 841	128-I	Wash.E2	Wash.E21	Wash.L1	Wash.L8	Idaho 01	Idaho 03
Appearance	5	2.9	3.1	4.	4.	3.8	2.9	3.1	1.9	2.7
Cone size	5	3.	3.5	4.	3.2	3.3	2.6	3.1	1.8	2.9
Lupulin	15	7.4	11.	11.75	8.6	8.7	9.4	10.1	6.1	8.0
Aroma	20	10.	10.3	12.9	10.7	10.1	10.3	10.85	8.5	11.0
Overall desirability	15	7.6	7.	9.5	9.4	8.85	8.	7.6	5.5	7.1
Total	60	30.9	34.8	42.	34.8	34.8	33.2	34.8	23.8	31.4

		Idaho 05	Idaho 06	Idaho 011-0	Idaho 011-B	Idaho 017	Idaho 020	Idaho 107-I	Idaho 108-I	Idaho 128-I
Appearance	5	1.85	1.7	2.2	3.4	1.7	.8	2.8	1.9	3.1
Cone size	5	1.4	1.5	1.7	2.7	1.75	1.1	2.6	1.4	3.4
Lupulin	15	3.75	4.1	8.4	10.25	5.75	6.1	5.6	6.7	7.75
Aroma	20	6.25	6.4	10.3	12.0	6.6	6.3	6.5	8.1	10.1
Overall desirability	15	3.75	3.6	4.9	9.4	4.4	3.1	4.9	4.6	7.25
Total	60	17.0	17.3	27.6	37.8	20.2	17.4	22.4	22.7	31.6

Table 10. Overall evaluation of 1962 hop samples.

Sample 1/	USBA score	% α-acid X 5	Mls oil/100g X 2	Overall score	Remarks
Oregon					
OB 801	36.7	46.5	2.2	85.4	Good
OB 813	40.8	43.0	4.5	88.3	Good
OB 831	34.0	31.0	3.4	68.4	Average
OB 833	33.0	33.0	2.3	68.3	Average
OB 839	35.1	32.0	1.8	68.9	Average
OB 840	30.9	30.0	2.3	63.2	Average
OB 841	34.8	27.5	2.2	64.5	Average
15-S		30.0	0.6	--	(5th in 1961)
50-S		46.5	3.4	--	(3rd in 1961)
128-I	42.0	54.5	4.2	100.7	Outstanding
Idaho					
108-I	22.7	45.0	1.8	69.5	Average
128-I	31.6	32.5	3.0	67.1	Average
0-1	23.8	37.0	2.6	63.4	Average
0-3	31.4	39.0	2.1	72.5	Average
0-11(B)	37.8	52.5	3.4	93.7	Good
0-11(O)	27.6	50.5	2.5	80.6	Average
0-17	20.2	26.5	1.6	48.3	Poor
0-20	17.4	35.0	3.0	55.4	Poor
Washington					
L-1	33.2	30.0	1.0	64.2	Average
E-2	34.8	39.0	1.2	75.0	Average
L-8	34.8	47.5	1.4	83.7	Good
E-21	34.8	36.5	1.2	72.5	Average

1/ Samples of OB 802, OB 808, OB 818, OB 837 from Oregon; 0-5, 0-6, and 107-I from Idaho omitted from this summary because of poor quality of variety or poor sample.

2/ Arbitrary rating:
Below 60 = Poor
60-79.9 = Average
80-94.9 = Good
95 or above = Outstanding

Preliminary Field Evaluation

A new preliminary yield trial of 11 selections, two commercial varieties, and 128-I was established in the fall of 1962. Eight of these selections have been rated as definitely promising in USBA evaluation in 1960 or 1961. G2071-3 and OB 822 have not been rated thusly but have exhibited extremely good vigor. OB 841 was not evaluated before 1962. It is a sister selection of Idaho O-11 which has exhibited a high degree of downy mildew resistance at Corvallis. Additional data on most of these lines are given under CRe5-5. A planting plan of the trial is given in Table 11.

Table 11. Planting Plan 1963 Preliminary Yield Trial

Entry		Plot number in replication				
		I	II	III	IV	V
1	OB 826	111	207	308	404	506
2	50-S	112	212	304	402	509
3	15-S	102	201	307	412	511
4	OB 831	106	206	312	413	501
5	OB 801	105	209	309	405	504
6	OB 830	114	202	303	411	503
7	OB 839	110	203	302	408	514
8	G 2071-3	107	204	314	414	508
9	OB 822	113	214	305	403	513
10	OB 835	109	211	306	401	510
11	OB 841	104	210	311	406	502
12	Fuggle (HL)	101	213	313	409	507
13	128-I	108	208	301	407	512
14	Brewers Gold	103	205	310	410	505

Advanced Field and Quality Evaluation

Off-station yield trials of advanced selections were discontinued after the 1961 season.

An inspection was made of the off-station plantings of 144-I and 128-I in Washington. Neither planting looked good. It would appear that neither variety is too well adapted to the Yakima Valley. However, 128-I may provide some usefulness on a limited acreage that can be given better care than is commonly given to hops in the Yakima Valley.

The three-acre planting at Carl Weathers' in Oregon was layered for rhizome increase and received little cultivation early in the season as a result of it. Downy mildew infection became severe in June, and this, coupled with a weed problem caused the plot to yield less than the potential of the variety. Following mildew control and clean up in mid-season the planting improved and yielded about seven bales per acre. The last word from the grower indicated that considerable care would be given the planting next year.

One 100-hill plot of HL Fuggle was grown at the Stauffer ranch at Hubbard, Oregon. Since this planting has not reached maximum production following establishment it will not furnish a fair comparison with mature Fuggle until 1963., the third year of production. The planting stock furnished Herman Goschie was lost during the year his hop lands laid idle.

BREEDING BEHAVIOR, GENETICS, AND BOTANY

Effect of Delayed Training on Flowering Dates of Male Hop Clones

Summary:

An additional year's study of the effects of delayed training on pollen shedding of male hop lines confirmed results obtained in 1961, i.e. anthesis of early male lines can be delayed to coincide with flowering of late female lines.

Objectives:

To determine the effect of different dates of training on initial flowering of male hop clones.

Procedure:

See 1961 Annual Report p. 27 for general procedure. In 1962 only 2 dates were used (May 16 or later and June 11 or later), and 2 vines were trained on each string.

Results:

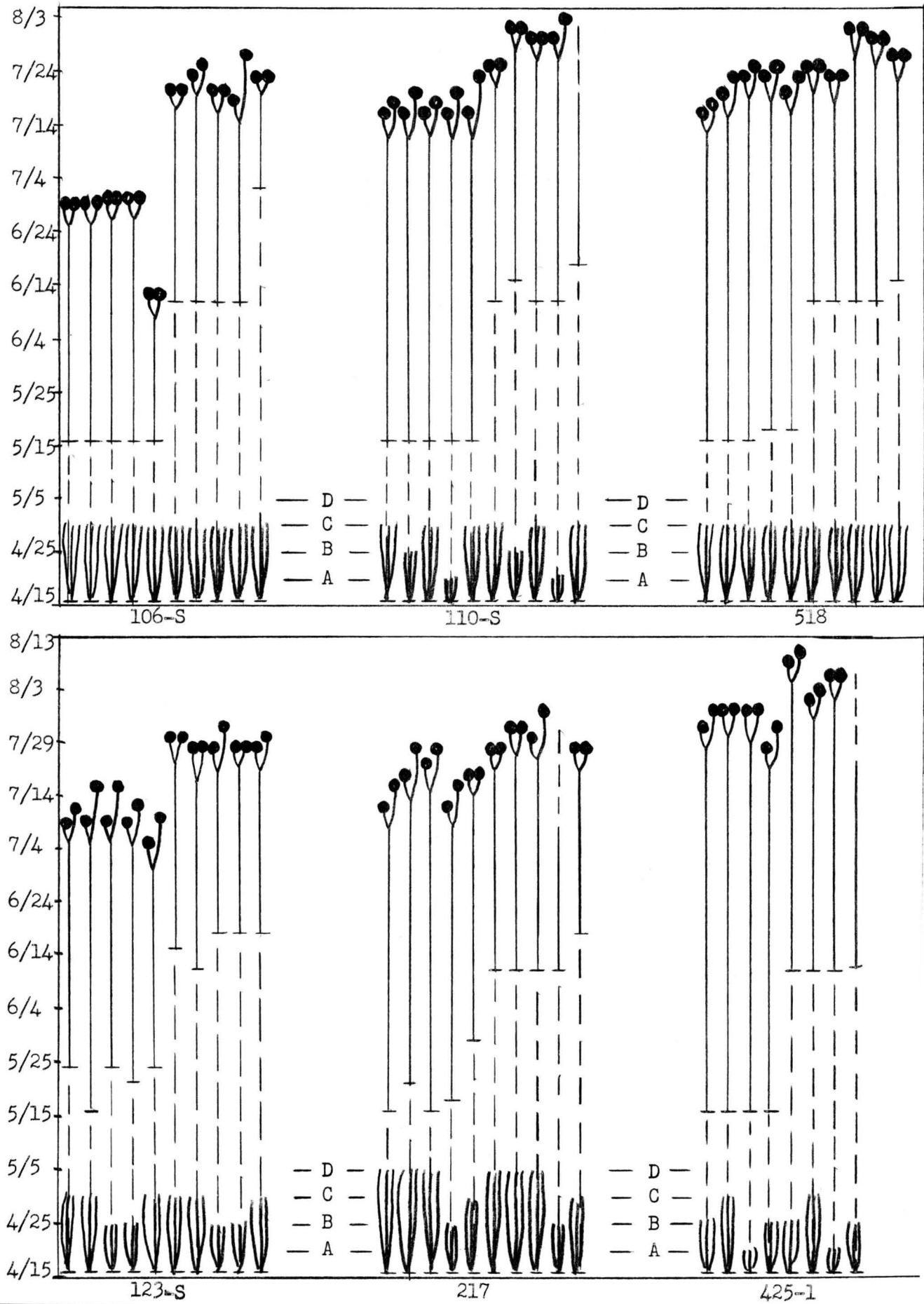
Data from 6 of the clones studied last year are illustrated in Figure 1. Results from all clones studied are given in the appendix.

Results are similar to those of last year for the clones studied in detail. Clone 106-S, the earliest one, exhibited a delay of about 21 days in initial pollen shedding following a 26 day delay in training. This effect was somewhat less pronounced than in 1961. The effect was only slightly less pronounced for 110-S and 217 than it was last year, but about the same for 123-S, 518, and 425-1. Thus, the conclusions reached last year appear to be reasonably well confirmed by this year's data. The earlier the male, the more its pollen shedding period can be delayed by late training.

Legend for Figure I

Date flowered	Amount of growth April 16
Date trained	A 6 inches or less
Date pruned	B 6-18 inches
Did not flower	C 18-30 inches
	D 30 inches or more

Figure 1. Flowering in Male Hop Lines, 1962.



Description of Hop Varieties Grown in the United States

Summary and Conclusions:

Color photographs were taken of growing plants and plant material of Late Cluster, Early Cluster, Fuggle, Bullion, Brewers Gold, and 128-I. Photographs of fresh cones and laterals were made of seedless and seeded samples from Yakima Valley and Willamette Valley yards. Photographs of leaves were taken of samples collected in the main growing area of each variety. Leaf collections from each variety for morphological examination were taken from several yards in Washington and Oregon. About 20 dried cone samples from several varieties and several areas were collected and more are being received periodically.

Although the series of color photographs is incomplete, it shows differences between varieties which would be difficult to describe. Originally it was planned to take only color photographs, but black and white photographs depict these differences as well. Therefore, to reduce expense in printing black and white photographs will be substituted in many instances. Additional photographs will be obtained in 1963 to complete the series.

Nothing has yet been done with the collection of leaves and cones. Morphological examination will be made of these as time permits. Examination of this type will be needed for identification purposes and to supplement the photographs, which are essentially descriptive.

Once data and photographs are completed for Late and Early Cluster, Bullion, Brewers Gold, Fuggle, and 128-I the project will be re-evaluated. Consideration will be given to obtaining similar information on Hallertau, Backa, or any other varieties being grown on limited acreages.

Objectives:

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

Justification:

Detailed descriptions of the currently grown varieties of hops have long been needed. Development of a classification key to varieties would be of benefit to all who are a part of the hop industry -- those who service it or who are served by it as well. Firstly, hop growers, brewers and agronomists need to be able to recognize a variety from its appearance and the degree of uniformity of that variety when grown in the field. Secondly, it is essential to have descriptions of dried cone samples which will indicate the origin and potential brewing value of the particular lot of hops from which the sample was drawn. Thirdly, detailed descriptions of the peculiarities of hop varieties will enable the hop breeding program to progress on a more objective plane.

Procedure:

The end result of this project will be a detailed illustrated booklet describing the hop varieties grown in the United States. The booklet probably will be made up in three sections. (1) A botanical section will treat hops in general with regard to taxonomy and nomenclature, general morphology, and plant characteristics. Various botanical characteristics will be defined. (2) There will be an individual treatment of each hop variety grown in this country. This treatment will include history, importance, distribution, and production performance of that variety. There will be a detailed description of the morphological and growing characteristics of the plant with respect to vines, leaves, and cones, and over-all plant type. Color and striping pattern and climbing hair characteristics of the vines will be described. Dentation, pubescence type and lobing of the leaves will also be described. Condensation, angularity, and bract scar type as well as bract type will be described. All of this will be supported by color photographs illustrating the variety with respect to these characteristics. Photographs will include whole plant, cones, bracts, strigs, leaves, and possibly other details of seeded and seedless hops. The treatment of each hop variety will include chromatographs of the essential oils contained in the cones, brewing quality characteristics in so far as they are known, and analytical data on cohumulon, alpha and beta acids, and perhaps other characteristics wherever they are available. (3) The third section of this booklet will be a classification key by which identification of varieties can be made on the basis of plant characteristics and on the basis of morphological and other characteristics of the dried cone samples. With the present knowledge it is doubtful that a classification key can be constructed because of the variation found within varieties and because of lack of knowledge of definite characteristics which lend themselves to classification. However, a sincere attempt will be made to construct such a classification key from data already available and from data which will arise during the course of the study. If the construction of a classification key proves to be impossible, the booklet will contain the illustrated and detailed treatment of each hop variety and botanical description of the hop plant itself.

The references to be used as guides in this study are:

Davis, E. L., Morphological Complexes in Hops (Humulus lupulus L) With Special Reference to the American Race. Ann. Missouri Bot. Gardens 44(4): 271-294, Nov. 1957.

Davis, E. L., Typing Hop Samples by Microscopic Techniques. First Technical Session MBAA 69th Anniversary Convention.

Schmidt, Käthe, Die deutschen Hopfensorten. Hopfen Rundschau 11, 12, 13, 14, 16 and 19. June 1 to Oct. 1, 1948.

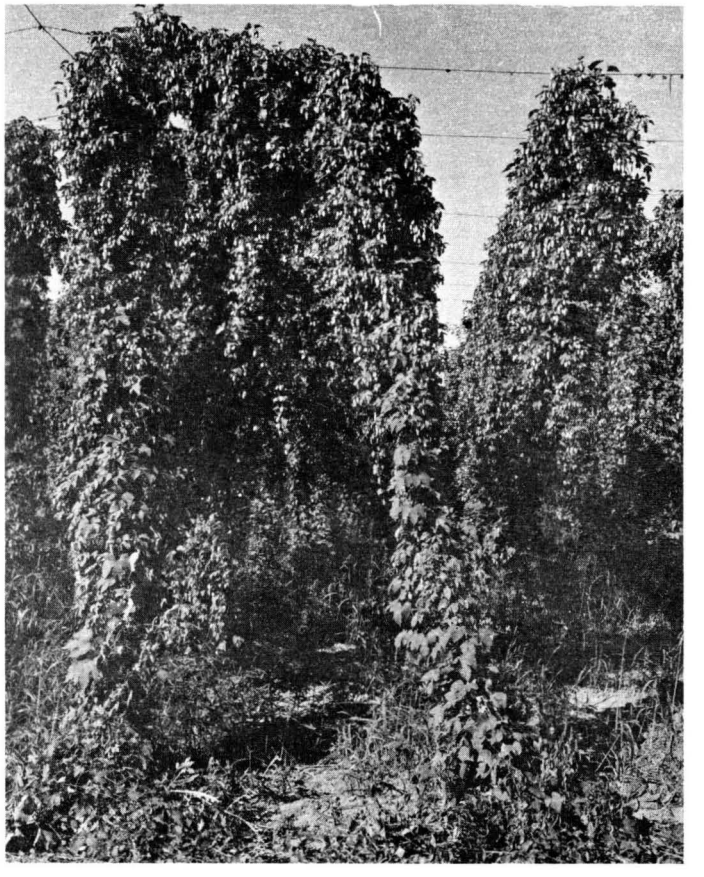
Wiebe, G. A., and D. A. Reid, Classification of Barley Varieties Grown in the United States and Canada in 1958. USDA Tech. Bul. 1224, Feb. 1961.

Growers, brewers, dealers and research scientists will be called upon for assistance.

Results:

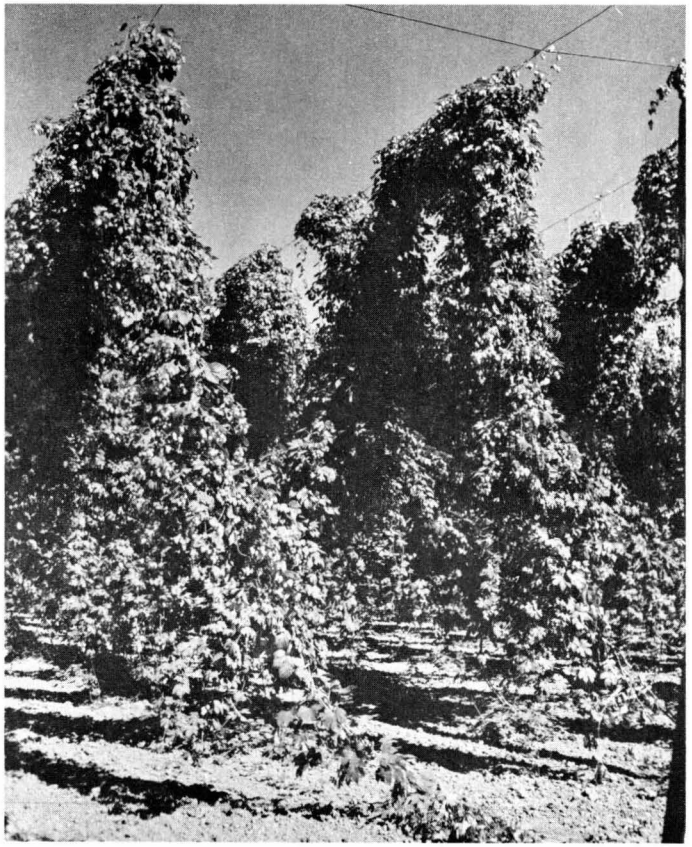
Most effort expended in 1962 was in collecting leaf specimens and obtaining a photographic series. Photographs of leaves of LC, EC, Bu, BG, Fu, and 128-I were obtained. Photographs of fresh whole cones of EC (seedless), LC (seeded and seedless), Bu (seeded and seedless, BG (seeded and seedless), Fu (seeded and seedless), and 128-I (seedless) were obtained. Photographs of growing plants of all varieties except BG were obtained. Photographs of laterals or lateral sections were obtained for most varieties. Photographs taken to date are included in the following several plates. Color transparencies are available for most of the photographs shown.

Early Cluster (Yakima Valley)

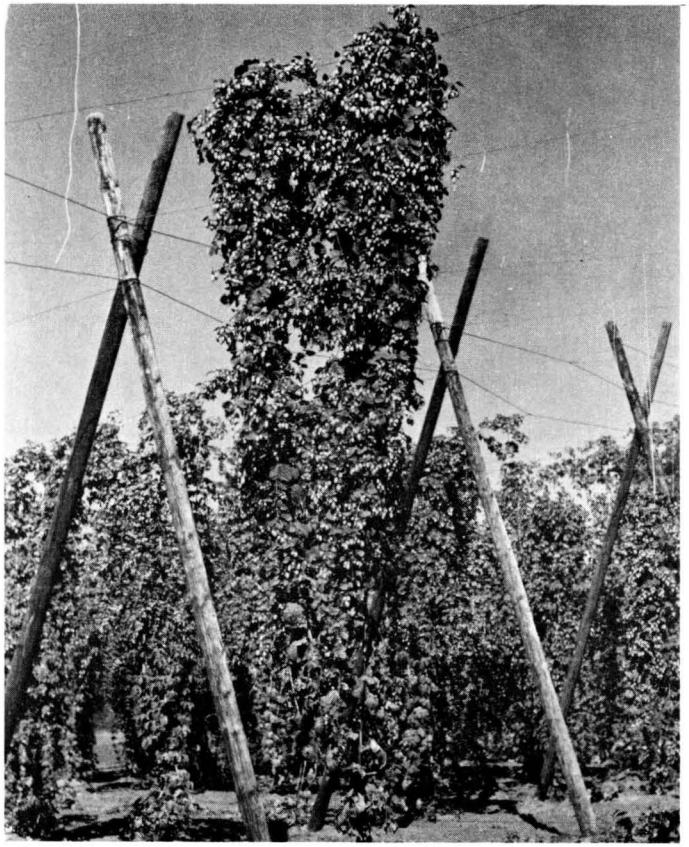


Late Cluster (Yakima Valley)

PLATE I



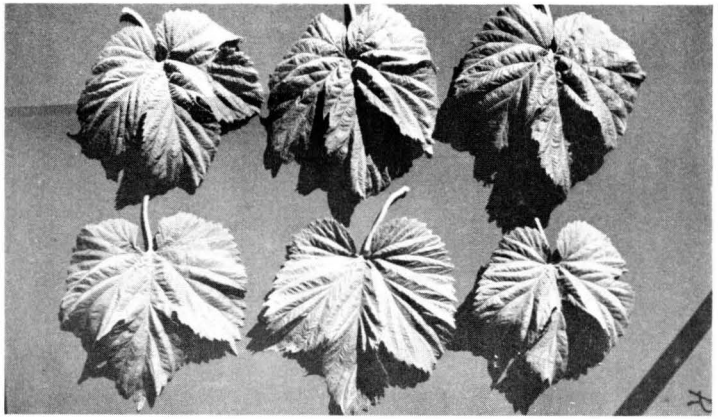
Bullion (Willamette Valley)



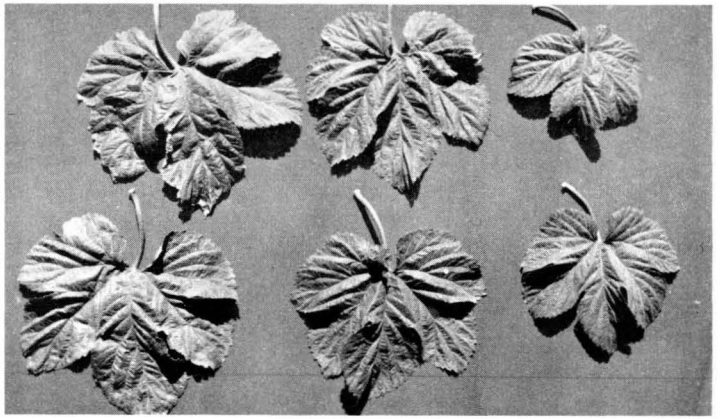
128-I (Willamette Valley)

PLATE II

Fuggle (Willamette Valley)

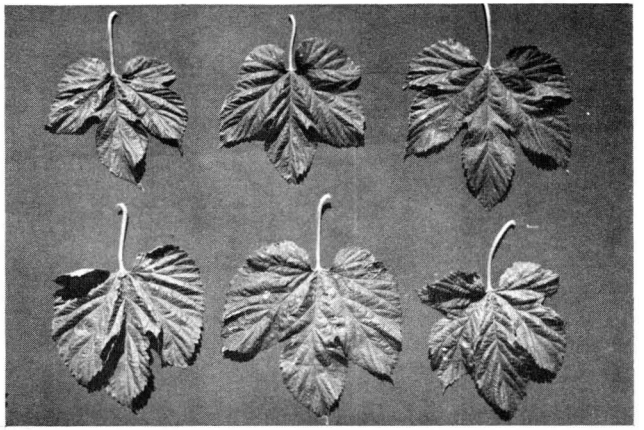


Fuggle (Willamette Valley)

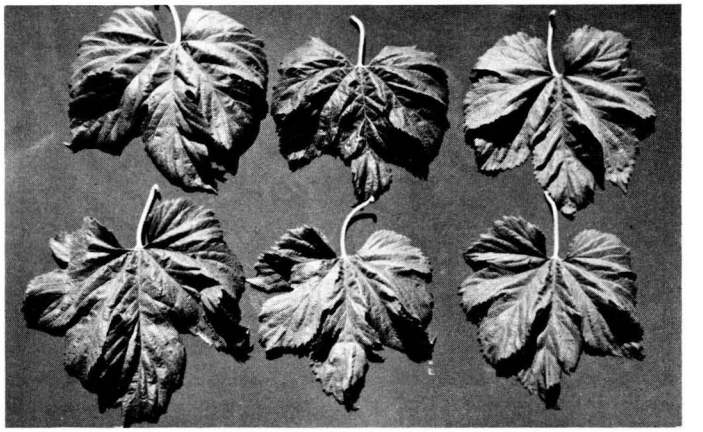


128-I (Willamette Valley)

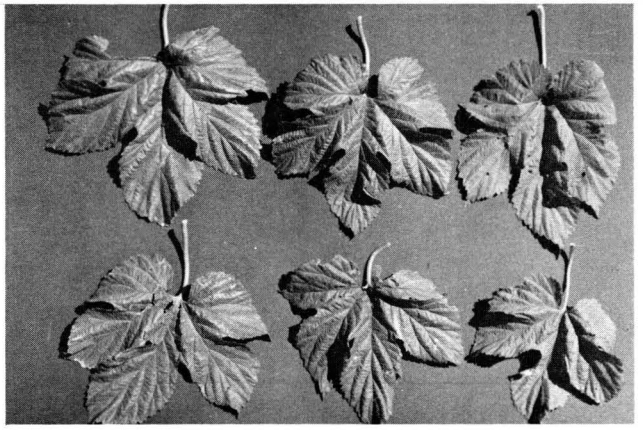
PLATE III



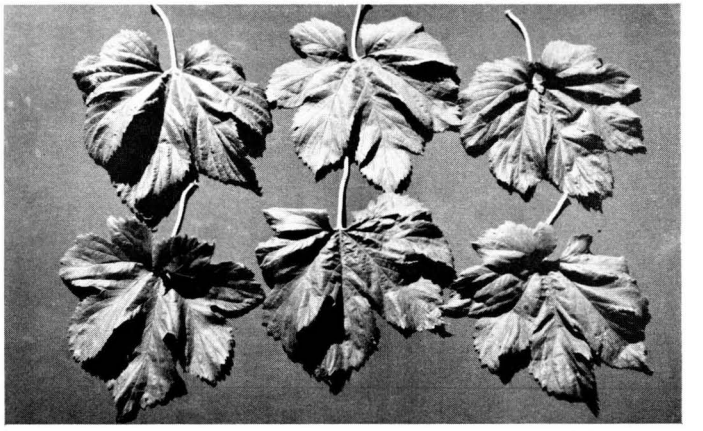
Early Cluster (Yakima Valley)



Bullion (Willamette Valley)

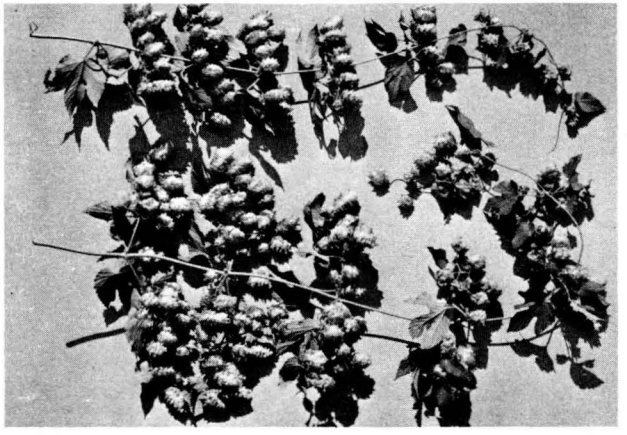


Late Cluster (Yakima Valley)

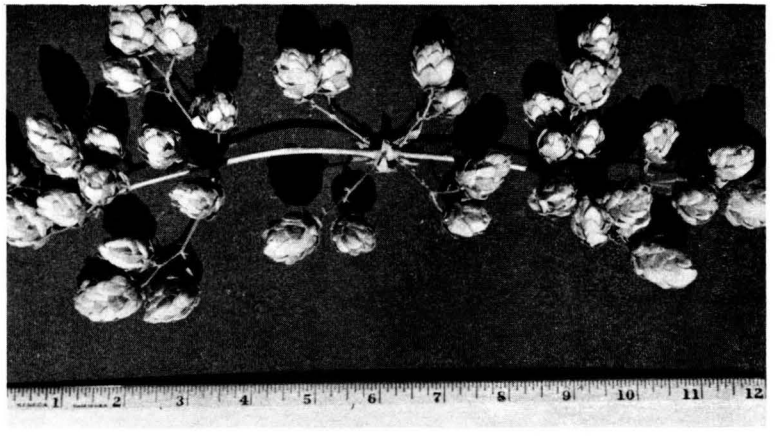


Brewers Gold (Willamette Valley)

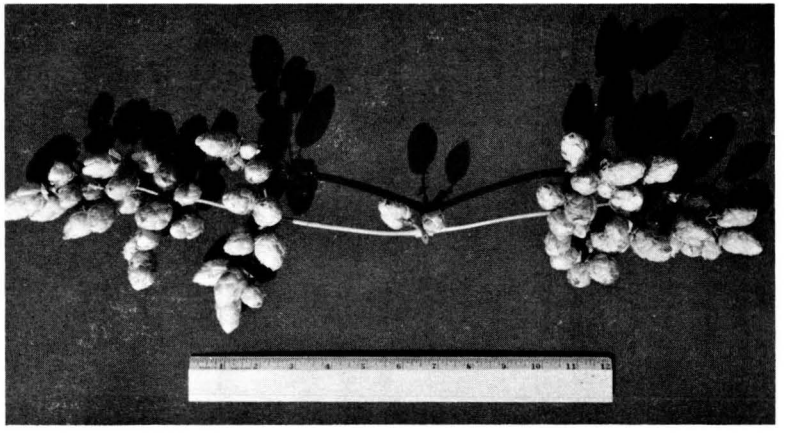
PLATE IV



Late Cluster (Yakima Valley seedless)



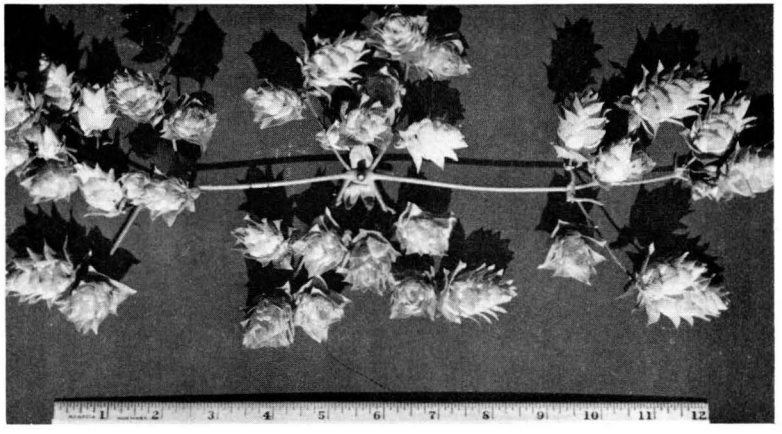
Fuggle (Willamette Valley seedless)



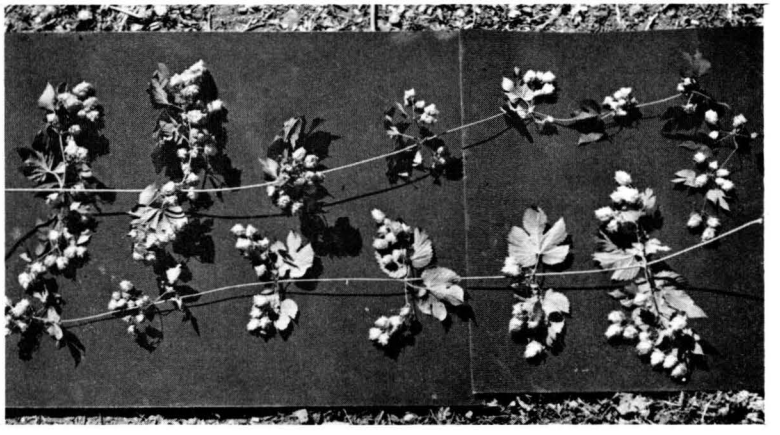
Late Cluster (Willamette Valley seeded)

Fuggle (Willamette Valley seeded)

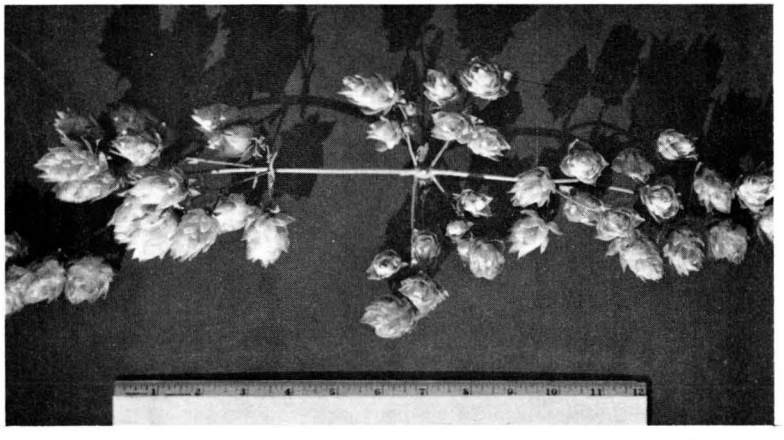
PLATE V



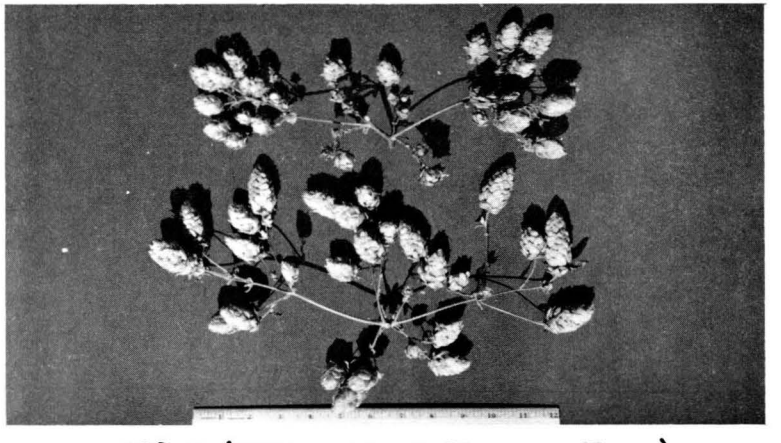
Brewers Gold (Willamette Valley seedless)



Bullion (Willamette Valley seeded)

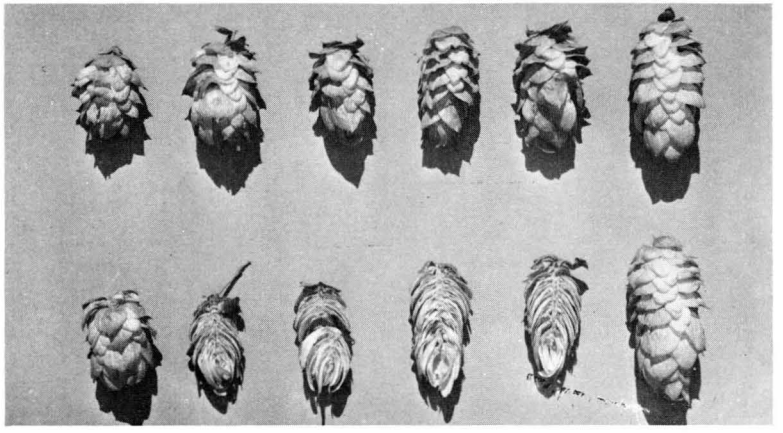


Brewers Gold (Willamette Valley seeded)

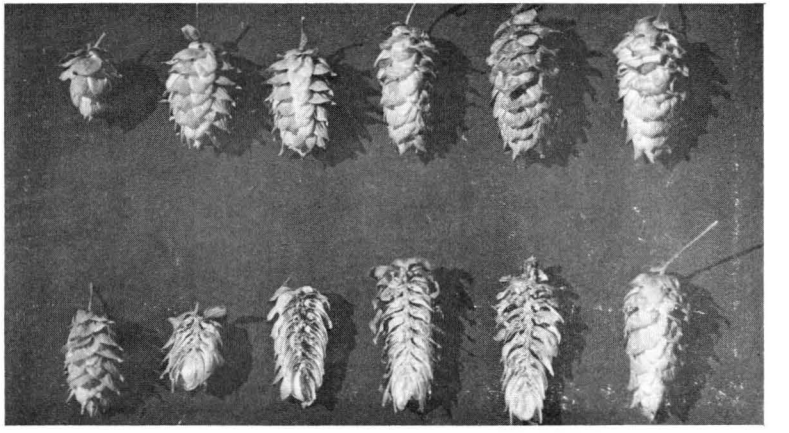


128-I (Willamette Valley seedless)

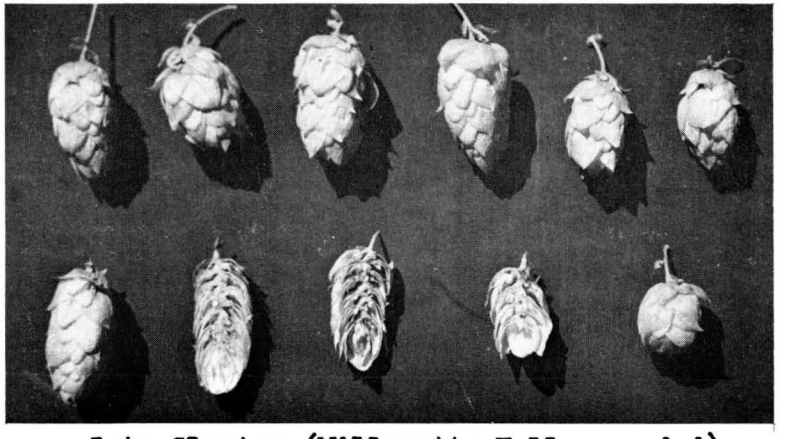
PLATE VI



Late Cluster (Yakima Valley seedless)



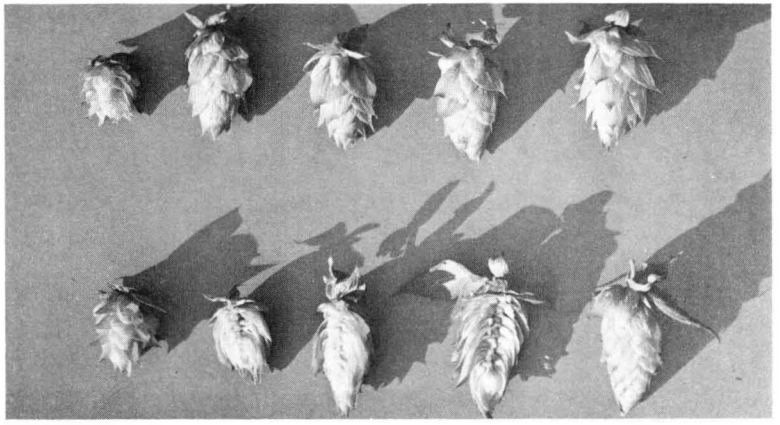
Early Cluster (Yakima Valley seedless)



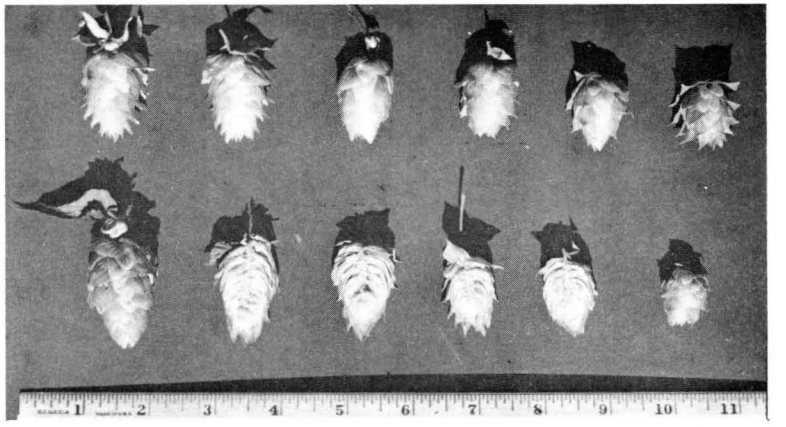
Late Cluster (Willamette Valley seeded)

Early Cluster (Willamette Valley seeded)

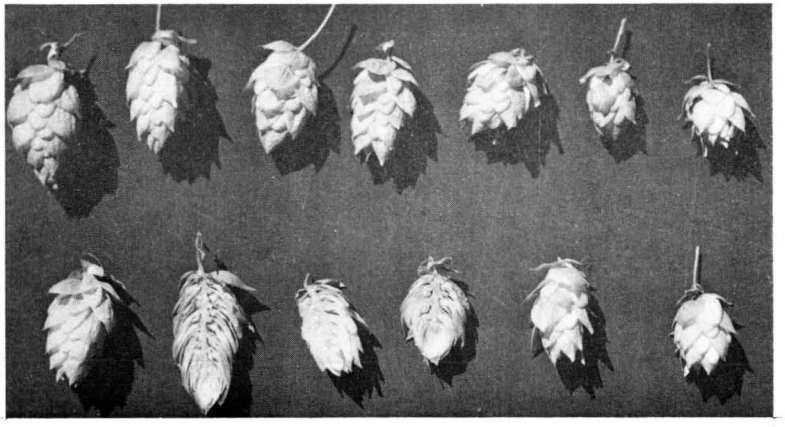
PLATE VII



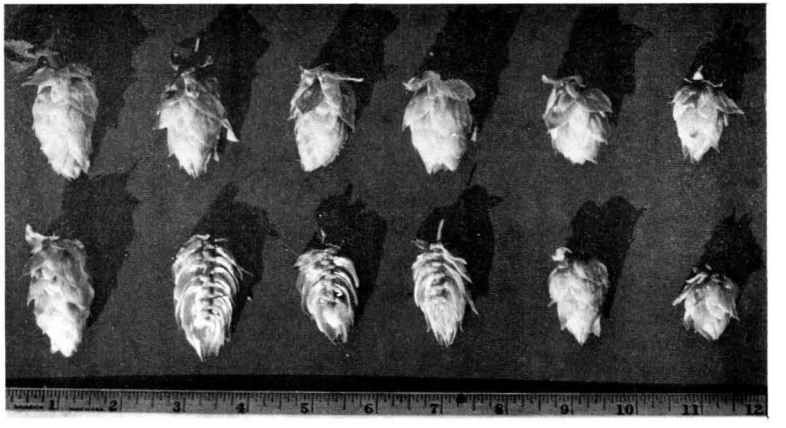
Bullion (Yakima Valley seedless)



Brewers Gold (Willamette Valley seedless)

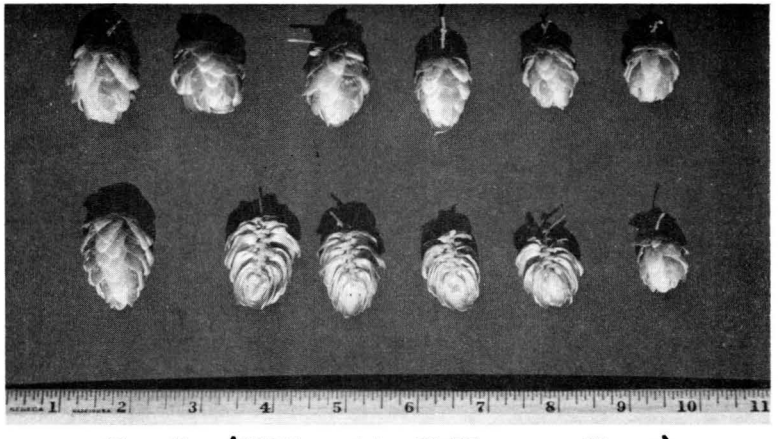


Bullion (Willamette Valley seeded)

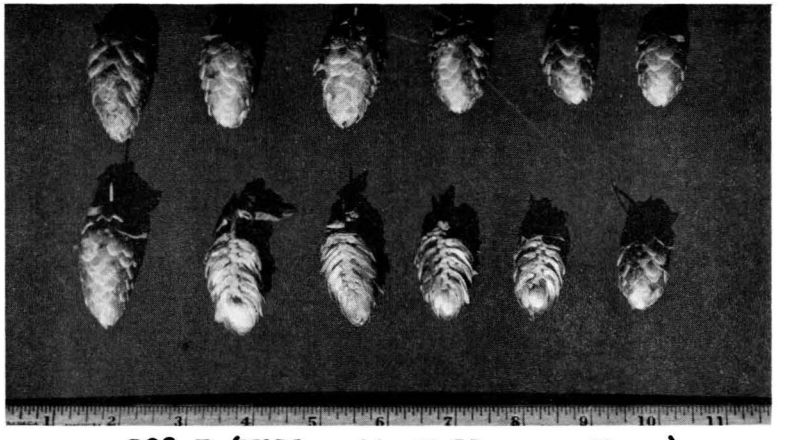


Brewers Gold (Willamette Valley seeded)

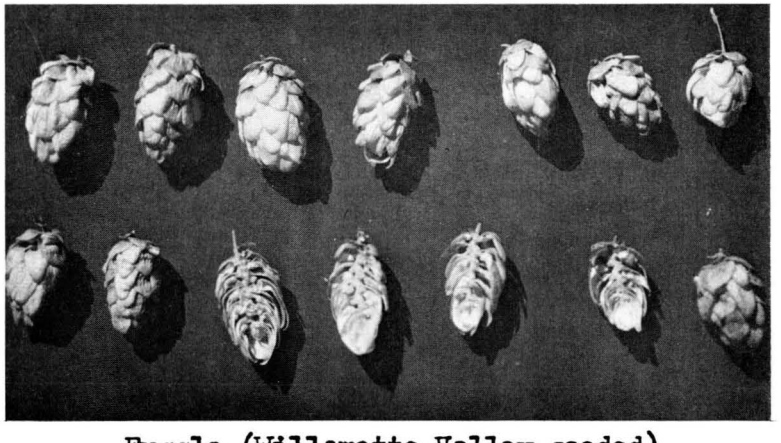
PLATE VIII



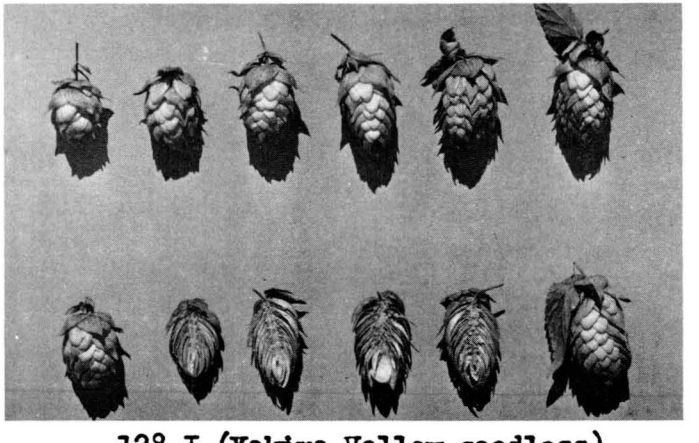
Fuggle (Willamette Valley seedless)



128-I (Willamette Valley seedless)



Fuggle (Willamette Valley seeded)



128-I (Yakima Valley seedless)

PLATE IX

Inheritance of Several Traits in Hops

Objectives:

To study segregation in progenies of parental clones selected on basis of downy mildew reaction for several traits, most of which are of economic significance, and to determine as well as possible gene actions involved in inheritance of these traits.

Procedures:

22 crosses and their 6 male and 6 female parents were planted in a triple lattice experiment of three replications in 1958. An additional three replications of 11 crosses and 9 parents were planted at the same time. A planting plan of this trial is given in the Appendix (pages 117-119) of the 1958 Annual Report of Hop Investigations.

Since 1959, data have been collected on: alpha-acid and beta-acid (one year, 8 crosses); leaf color, stem color, and stripe color (one year, all crosses); sex (one year, all crosses); flowering date of males and females and coning dates and maturity dates of females (one year, 8 crosses). Following field inoculation in 1962, extensive data were collected on downy mildew reaction.

Data will be studied on the basis of frequency distributions, heritabilities and calculated expected gains from selection, trait correlations, and regression of single crosses on parents. Diallel analysis will be made of most of the data in 2 x 2, 3 x 3, and other combinations (the full set of diallels was not obtained). The data have all been entered on IBM cards and are now undergoing analysis.

Results:

No summaries have been completed at this writing.

Survival Study of Bagged Laterals

(C. E. Zimmermann)

Objectives:

This study was initiated to determine if lateral survival could be increased when the amount of vegetation under the bag was reduced either by removing leaves or restricting the elongation of the laterals.

Reasons for undertaking the work:

Flowering laterals are bagged during the last three weeks of June, prior to the time inflorescences become receptive to fertilization. Parchment bags remain on laterals for approximately two months and removed after cones are no longer receptive to pollen. The breeding block is planted under a twelve foot trellis as a safety measure, since all breeding work involves a ladder. Laterals bagged on the upper one-third of the plant

produce more seed from artificial pollination than the lower portion of the vine. Generally, less than 50% of the bagged laterals on a vine are alive when harvested. Laterals which do not survive limit the scope of the breeding program as well as any other study conducted with pollination work. At maturity an unbagged lateral will attain a length of thirty inches, with several nodes and an average of eight cones borne on each node. At bagging time, laterals have an average length of less than eighteen inches and with four visible nodes.

Procedure:

Five female genotypes with a wide range in flowering dates were selected for the study. Each genotype had one plant which represented a treatment and had three laterals bagged with one of the three bagging methods. The three bagging methods employed were as follows:

Entry 1, Lateral cut back to three nodes and leaves removed from each node.

Entry 2, Apical bud removed from lateral (leaving three to six nodes with leaves).

Entry 3, Lateral intact, but leaves removed only from first three nodes.

Bagged laterals were not pollinated, since survival was considered the preliminary to seed set. Bags were removed approximately two months after initial bagging, and each lateral was evaluated for cone development and overall survival.

Results and discussion:

Results of the bagging methods are summarized in the following table:

Table 12. Survival of female hop laterals bagged for two months. Each treatment represented one plant with three bagged laterals.

Genotype	Entry	No. of laterals alive	Green leaves	Dead Burrs	Undeveloped cones	Seed bearing cones
	1	3	3	1	2	1
307	2	3	3	2	1	2
	3	3	3	0	1	3
	1	3	3	0	3	0
314	2	3	3	2	1	1
	3	2	2	0	2	2
	1	2	2	2	2	2
210	2	(1)*	(1)	1	0	0
	3	0	0	0	0	0
	1	2(1)	1(2)	3	1	0
403	2	3	(3)	3	0	0
	3	1	(1)	1	0	0
	1	1	(1)	1	1	0
404	2	2(1)	1(2)	1	1	1
	3	3	2(1)	0	3	2

* Numbers in parentheses note the number of laterals that were dead at the apex or had partially dead leaves.

Since a breeding program depends on the production of seed, it is reasonable to assess a bagging method by the production of potential seed bearing cones. Data show that the removal of leaves from the first three nodes (entry 3) produced the greatest number of seed bearing cones in relation to the number of laterals alive. Entry one and two gave similar results, since in both methods the apex of the laterals was removed. A common observation was the presence of dead burrs following a two month bagging period, but with the removal of leaves from the first three nodes a substantial decrease in dead burrs occurred under the bags in comparison with the other two methods. It appeared that the removal of the apex was detrimental in the production of cones and may also be harmful to seed production, since the primary source of auxin production has been removed from the lateral.

Summary:

A preliminary study using different bagging methods on female laterals indicated that an increase in cone production can be obtained with the removal of leaves from the lateral nodes prior to bagging.

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.

Advantage was taken of an exceptionally severe natural infection by downy mildew in the spring of 1962 to obtain extensive records on the field reaction of many varieties and breeding lines of hops.

Objectives:

1961 Annual Report, p. 37.

Procedure:

Each hill of each clone was examined and the number of systemically infected shoots counted and recorded. The clone was then rated as Resistant (R), Intermediate (I), or Susceptible (S) based on the number of infected shoots. In some cases the categories I_1 and I_2 were used to designate a particular type of reaction that sometimes occurred. I_1 = systemically infected shoots present but the fungus failed to sporulate because of an apparently hypersensitive reaction which resulted in death of the shoots before sporulation. Actually this reaction represents a high level of field resistance. I_2 = infected shoots with hypersensitive reaction but sporulation occurred before shoot death.

Results:

Of 187 clones evaluated in the breeding block, 82 were resistant, 46 susceptible and 59 intermediate in downy mildew reaction. A detailed table of the reaction by clones is found in the appendix to this report.

The evaluation of 33 clones of wild American hops collected from the Rocky Mountains in 1957 and 1960 showed that all but 1 (Colorado 5-1) were quite susceptible to systemic shoot infection. Detailed data are tabulated in the appendix to this report.

An evaluation of about 20 male lines showed that many had good resistance to systemic shoot infection. Data on downy mildew reaction were obtained also from material in the 1962 observation block and the seedling nursery. These data are tabulated in the appendix.

Evaluation of Advanced Lines for Verticillium Wilt Resistance

In 1962 several small infestations of Verticillium wilt were found in Oregon. All were in the Fuggle variety except in 1 case where an experimental planting of 135-I was made in a wilt infested area. 135-I in this case showed severe wilt symptoms. Because of the widespread distribution of *Verticillium* in potential hop-growing soils a greenhouse test was undertaken to determine the reaction of certain advanced lines of hops to several prevalent strains of *Verticillium*.

Procedure:

Verticillium dahliae strains from potato, mint, hop and V. albo-atrum from potato were increased on sterile barley straw in the laboratory. The infested straw containing microsclerotia of V. dahliae and dark mycelium of V. albo-atrum was used to infest greenhouse potting soil at the rate of 0.3 gms per 6 inch pot. Rooted tip cuttings of the commercial hop varieties Fuggle, Brewers Gold and Late Cluster, and of 7 experimental lines (107, 108, 112, 128, 135, 139 and 144) were planted in the infested soil. Non-inoculated controls were provided for each hop line. Each line was replicated 4 times.

Results:

After 3 months' growth, none of the plants showed clear cut symptoms of wilt. Stems of each plant were assayed for infection in the laboratory. A few stems were systemically infected. The strain of Verticillium dahliae from hops infected one plant each of lines 135 and 144, 2 plants of line 108, and 1 plant of the Fuggle variety. The strain of V. dahliae from mint infected one plant each of Brewers Gold and Late Cluster hops. The strain of V dahliae from potato and the strain of V. albo-atrum, also from potato, failed to infect any of the lines tested.

The low incidence of infection obtained could indicate a high degree of tolerance by the lines tested to the fungal strains used. It could also indicate an inadequate testing procedure. For this reason, conclusion will be witheld until the experiment has been repeated.

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

C. E. Zimmermann

Previous agronomic trials on hops have involved numerous studies concerned with cropping and management practices. The need for modifying these practices still remains but the approach has become more efficient with the use of recent fundamental knowledge. The purpose of this line project is to provide these modifications, but the approach has been altered to include physiological studies in conjunction with agronomic trials.

In 1962 agronomic studies were confined to six lines of work:
(1) Effect of commercially formulated gibberellic acid (GA_3)on hops,
(2) Maturation study of GA_3 treated hops,
(3) Effect of trellis heights on performance of hop varieties,
(4) Test conducted with a chemical gametocide,
(5) Date of pruning and training on Late Cluster, and
(6) Two stringing studies.

Effects of Gibberellic Acid on Fuggle Hops.

Objectives:

To determine the effect of three formulations of gibberellic acid (GA_3) on seeded hops.

Reasons for undertaking the work:

Following the favorable response noted in a previous trial conducted with technical GA_3, it was necessary to determine the activity of commercial formulations of GA_3 which contain wetting agents. Surfactants or wetting agents increase the adsorption and uptake of the chemical applied to the plant. Therefore the addition of these agents can alter plant response with a given quantity of chemical.

Nature and extent of previous work:

See 1961 Annual Report, p. 39.

Procedure:

Two commercial formulations of GA_3 obtained from Merck & Co. Inc. for this trial were "Gibrel" a 0.5% solution of potassium gibberellate and "Gibrelate 400" a 4% liquid concentrate of ethylene glycol monobutyl ether gibberellate. The other chemical used in this trial was the technical grade of potassium gibberellate which was formulated in our laboratory with ethanol. The treatments used in 1962 are given in Table 1.

Table 1. GA treatments on seeded Fuggle hops, 1962.

Entry	Treatment
1	2 ppm technical GA_3
2	5 ppm technical GA_3
3	15 ppm technical GA_3
4	2 ppm "Gibrel"
5	5 ppm "
6	15 ppm "
7	2 ppm "Gibrelate"
8	5 ppm "
9	15 ppm "
10	Check

The ten entries consisting of five hill plots were replicated six times in a randomized block design. Chemical treatments were applied with a knapsack sprayer and each plot was isolated with a plastic sheet barrier at the time of application. All plots were treated on June 7th, at which time hop vines were approximately five feet in height. One gallon of aqueous solution was used on the 30 hills of each treatment.

Experimental Results:

Data were obtained on yields, cone size and flowering date. Quality data were provided by S. T. Likens.

Table 2. Data obtained in gibberellic acid trial on seeded Fuggle, 1962.

Treatment at 5' stage	Yield lbs./Ac.	Ave.cone wt. (mg)	Ave.cone lgth. (mm)	Mls.oil per 100 g.	% α acid	% β acid
2 ppm T GA_3	1590	161 abc	32 ab	0.98	6.13	2.30
5 " " "	1560	132 de	28 cd	0.97	6.84	2.06
15 " " "	1610	132 de	29 bcd	0.95	6.05	2.41
2 " "Gibrel"	1580	156 bc	30 bc	0.97	5.88	2.53
5 " "	1640	143 cd	29 bcd	0.94	6.28	2.43
15 " "	1610	118 e	26 d	0.97	6.04	2.32
2 " Gibrelate	1610	172 ab	33 a	0.95	6.20	2.42
5 " "	1490	153 bcd	30 bc	0.92	5.95	2.53
15 " "	1700	139 cde	30 bc	1.00	6.12	2.40
Check	1590	178 a	32 ab	0.94	6.68	2.12
Mean	1610	148	30	0.96	6.22	2.36
LSD (.05)	N.S.	21	2	N.S.	N.S.	N.S.
CV (%)	9.6	9.7	5.6	10.2	11.0	11.4

Four off-station trials were conducted at three locations with the different formulations of gibberellic acid. These results are given in Table 3.

Table 3 Summary of off-station gibberellic acid trial on hops, 1962.

	Treatment	Yield/Ac bale	Cone wt.(mg)	Cone lgth(mm)	Ml.oil 100g	% α acid	% β acid	Dry-down %
Kerr's Seeded Brewers Gold Trial (Harvest 9-20, 130 H's each)								
Rn 9	5 ppm @ 5 ft. & 5 ppm @ cone - Gibrel	12.1	197	31	2.58	8.1	3.8	28.2
Rn 11	5 ppm @ 5 ft. - Gibrel	12.4	180	30	2.47	8.2	4.0	28.2
Rn 13	5 ppm @ 5 ft. & 10 ppm @ cone - Gibrel	11.2	188	33	2.53	7.7	4.2	28.1
Rn 14	Check	11.9	206	32	2.65	8.7	3.8	29.4
Rn 15	5 ppm @ 5 ft. - Gibrelate	12.0	197	31	2.68	9.4	3.9	29.3
Rn 17	10 ppm @ cone - Gibrel	11.2	212	34	2.59	7.8	4.2	29.2
Kerr's Seeded Fuggle Trial (Harvest 8-19, 160 H's each)								
1	5 ppm @ 5 ft. & 5 ppm @ cone - Gibrel	7.5	151	33	0.58	6.9	2.6	25.6
2	5 ppm @ 5 ft. - Gibrel	6.7	133	32	0.66	6.9	2.7	22.1
3	Check	7.7	133	29	0.74	7.2	2.5	24.0
Schwabauers Seeded Fuggle Trial (Harvest 8-23, 112 H's each)								
Row 6	5 ppm @ 5 ft. - Tech. Gibrel	5.2	140	25	0.67	4.4	2.2	28.2
Row 12	Check	5.6	139	30	0.82	5.1	2.2	27.1
Row 16	5 ppm @ 5 ft. - Gibrel	4.4	139	27	0.73	4.7	2.3	25.4
Row 81	Check	6.4	163	30	0.92	6.1	2.5	26.8
Row 86	5 ppm @ 5 ft. - Gibrelate	6.1	153	28	0.83	6.0	2.5	27.6
Lewis Brown H-L Seedless Fuggle Trial (Harvest 9-5, 6 H's each)								
1	5 ppm @ 5 ft. - Gibrel	7.4	97	18	0.58	4.8	2.3	26.1
2	5 ppm @ 5 ft. - Tech. GA	6.4	93	18	1.62	5.6	2.2	26.4
3	5 ppm @ 5 ft. - Gibrelate	8.2	91	18	1.50	5.8	2.2	25.0
4	Check	7.0	114	21	1.50	5.4	2.6	26.9

Two of the trials were conducted on the Ray Kerr Ranch, one trial on the John Schwabauer Ranch, and the other on the Project's Seedless Yard. The latter trial was the only one in which hop project personnel were involved at application time. Treatments at the Ray Kerr Ranch were applied with a commercial sprayer, whereas treatments at the other two locations were applied with a knapsack sprayer. Approximately 35 gallons of solution were applied at the 5 foot stage on the Kerr Ranch and 175 gallons at the cone stage. Applications of 20 gallons per acre were applied for each treatment at the Schwabauer Ranch, and 35 gallons per acre were applied for each treatment at the Lewis Brown Yard.

Discussion:

Treatment of hops at the 5-foot stage of growth with three different formulations of GA_3 did not result in a yield change. The difference in yield response from that obtained in the previous trial with GA_3 may be attributed to two factors. First, the solution was applied with a knapsack sprayer as compared with a sprinkling can in the previous trial, and secondly, the solution was applied at a later time during the growing season due to a late spring infection of downy mildew which required retraining the plots.

The same amount of solution was applied with the knapsack sprayer as that applied with the sprinkling can, but with the sprayer only a small percentage of the mist actually adsorbed to the hop foliage, whereas with the sprinkling can all of the solution either adhered to the vine foliage or to the sucker growth due to the overhead type application. This difference is important since it appears that a given quantity of GA_3 is necessary per plant to achieve the response of increased cone set. The downy mildew infection necessitated re training some of the vines due to an infection in the apical bud which caused an uneven maturity when the five foot stage of growth was treated. The cone size appeared to be the only factor which was altered by applications of GA_3 and it was similar to that noted in a previous trial. An obvious decrease in cone size, readily noted in the field, was related to an increase in cone set with higher applications of GA_3.

Variable results obtained on off station trials with gibberellic acid could again be related to the technique in applying the solution, since all plots were treated with a spray type applicator in which there was a quantitative lack of control in amount of chemical applied per hill. Yield differences on the Kerr trial with Brewers Gold were small, but it appeared that the five ppm at five feet resulted in a small increase and the application at coning reduced yields in all treatments. Three individuals rated each treatment of the Kerr trial as to its machine pickability and they unanimously agreed that range 9, 13 and 17 picked hard, in that the vines were not clean, more hops went on to the discard belt, and shattering was pronounced. In all three cases the treatments received an application of Gibrel at the coning stage. Range 13 produced hops that were rated as the hardest picker, and Range 15 as the easiest. These observations are similar to station trials in which the coning treatment produced cones with long, tough petioles. No definite conclusions could be drawn from the Kerr or Schwabauer trial on Fuggle. Yield differences in the Schwabauer trial could be attributed to variable field conditions which were noticeable at harvest time. A small trial conducted with H-L Seedless Fuggle resulted in an apparent decrease in cone size along with a probable yield increase.

Summary:

Foliar applications of 2, 5, and 15 ppm of three formulations of GA_3 applied at the five foot stage did not produce a yield change. No differences were noted among treatments for alpha- and beta-acid or oil. Cone size decreased with an increase in GA_3 application. This difference was evident under field conditions along with an increase in cone number per vine. An increase in number of cones from exogenous GA_3 is probably related to the quantity of chemical absorbed per plant. Treatment of Brewers Gold, a high yielding variety, gave a response with various treatments similar to that obtained with the Fuggle variety.

Maturation Studies on Gibberellic Acid Treated Hops.

(C. E. Zimmermann and S. T. Likens)

Objectives:

See Annual Report, p. 63, 1961.

Procedures:

Studies were conducted on a check and three treatments of gibberellic acid (GA_3) applied to seeded Fuggle. The following chemicals were applied at the rate of ten gallons per acre when hops were four to five feet in height; 5 ppm Gibrelate, 5 ppm Gibrel, and 5 ppm Technical GA_3. Cone samples were periodically harvested by hand from 20 treated and 20 non-treated plants, and the samples were analyzed for quality components and measured for susceptibility to cone breakage. Sampling for maturity data began as soon as cones were large enough to pick, and continued at a 2-5 day interval until one month after the normal harvest date.

Experimental Results:

Maturity data are summarized in Table 2. Twenty hills were harvested from each of the treatments on August 22, and these data are summarized in Table 1. The quality data recorded in Table 1 were determined with machine picked hops, whereas the maturity data reported are from hand picked hops.

Table 1. Data obtained from 20 hill plot of GA_3-treated Fuggle.

5 ppm at 5 ft. stage.	Green Yield in lbs.	Mls. oil per 100 g.	% α acid	% β acid
Gibrelate	121.0	0.92	6.42	2.26
Gibrel	120.6	0.87	6.00	2.33
Tech. GA_3	108.0	0.92	5.63	2.28
Check	110.6	0.96	6.66	1.80

Table 2. Summary of Maturity Data on Seeded Fuggle Treated with GA_3, 1962.

Sampling Date	Mls.oil/100g.				% α acid				% β acid,				% dry matter				Cone wt.(mg)				% shatter			
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
8/7	--	--	--	--	--	--	--	--	--	--	--	--	17.1	17.6	17.4	17.6	125	118	115	121	38.7	36.3	39.6	46.3
8/8	0.70	0.30	0.30	0.40	6.07	6.29	6.13	5.30	2.81	2.74	2.60	2.21	16.7	17.5	16.7	17.6	124	120	112	112	--	--	--	--
8/10	--	--	--	--	6.07	5.67	5.38	4.17	2.21	2.53	2.65	2.38	17.0	18.7	20.2	17.8	--	--	--	--	45.7	46.6	39.5	45.9
8/13	0.95	0.85	0.81	0.84	6.39	7.52	6.83	5.50	2.58	1.78	1.77	1.82	19.3	19.5	20.5	19.8	177	139	150	124	56.4	54.2	55.0	43.0
8/15	1.42	1.32	1.04	0.85	6.67	6.61	6.52	5.57	2.25	2.46	2.59	2.37	21.7	21.4	20.0	21.5	148	143	142	124	--	--	--	--
8/17	1.33	1.29	1.11	1.10	6.98	6.22	5.82	5.89	2.53	2.38	2.64	2.91	21.3	22.0	21.0	21.2	169	157	131	131	62.5	57.2	55.7	55.2
8/20	2.10	--	--	1.53	6.62	--	--	4.65	2.28	--	--	2.15	22.0	--	--	22.3	176	--	--	136	61.3	--	--	57.2
8/22	2.03	2.02	1.83	1.85	5.99	6.69	7.46	5.22	2.67	2.52	2.54	2.34	24.6	23.1	24.6	24.3	198	156	165	159	62.0	63.8	58.7	61.5
Harvest																								
8/24	1.84	2.02	2.05	1.73	4.85	6.13	6.15	4.63	3.55	2.18	2.61	2.19	22.7	25.5	25.2	25.0	171	161	165	150	57.2	59.0	54.1	58.7
8/29	2.08	1.81	2.49	1.78	4.90	6.05	7.09	4.89	2.30	2.56	1.89	1.90	23.3	23.9	23.5	24.4	162	155	154	138	68.6	65.4	66.7	56.7
9/7	2.10	2.16	2.49	1.82	5.42	5.53	5.58	4.10	2.52	2.50	2.68	2.62	26.9	26.9	26.8	26.1	185	175	157	149	66.4	70.2	64.1	62.7
9/19	2.29	2.42	2.48	2.10	7.57	6.17	6.42	6.59	2.13	2.91	2.71	1.97	27.6	27.6	27.2	26.9	177	165	161	127	66.8	74.6	69.3	66.0

Treatments
I 5 ppm Gibrelate (GA_3) @ 5 foot stage
II 5 ppm Gibrel (GA_3) @ 5 foot stage
III 5 ppm Tech. GA_3 @ 5 foot stage
IV Check

Discussion:

Maturity data from Table 2 show a similarity in the initial trend of oil synthesis for the four treatments. Gibrel and Gibrelate treated hops had a more rapid accumulation of oil that tended to stabilize at harvest time. Oil data from technical GA_3 treated hops represent a normal rate of oil synthesis, in that maximum oil yield was reached after the accepted harvest date (8/20), but the oil yield was higher than normal.

Cone dry matters were identical for all treatments and similar to the Fuggle curves obtained in previous years (1960 AR, page 104). Cone weights were quite variable in this trial, but a general increase was noted up till harvest time after which the rate became much slower. Tests showed that shatter percentage of GA_3 treated hops increased from 35 to 70% during the season. Differences in cone breakage were not noted prior to harvest, whereas after the normal harvest date cones from treated hops showed a significant susceptibility to breakage. This difference may have been due to the larger cones produced by the treated hops, but it is not clear whether this observation is a cause or effect relationship. Fuggle usually maintain a fairly constant amount of alpha acid during cone development, and this same trend was noted by all treatments but with considerable variation. There is a tendency for the alpha acid content of treated hops to be higher than that of the check, but this difference is not observed with hops which were machine picked (Table 1).

The similarity of yield between treated and untreated hops (Table 1) and the dissimilarity of alpha acid and oil content of treated and untreated hops (Table 2) is in complete contrast with data obtained in a three year trial with gibberellic acid on hops (1961 AR page 39). Both trials were conducted with five ppm of GA_3 applied at the five foot stage of growth, but two methods of application were employed. In the previously reported three year trial, a sprinkling can was used in applying the chemical solution, whereas in this trial, as in the trial reported previously in this AR, a knapsack sprayer was employed. The application with the sprinkling can applied 35 gallons of solution per acre and with the knapsack sprayer only a ten gallon per acre application was applied. This difference in quantity of GA_3 available for plant absorption may be responsible for the differences in variables obtained in this study. The significance of this would be that in the application of GA_3 to hops it is of the utmost importance to apply a constant amount of available chemical per plant in order to obtain a favorable consistent response.

Preliminary studies conducted in 1962 indicated that ten micrograms of aqueous GA_3 applied to the apex of a hop plant gave a response similar to that noted, in a three year trial, when 5 ppm was applied as a spray at the 5 foot stage. It is reasonable to postulate that ten micrograms of GA_3 were taken up by the hop plant when 35 gallons of a 5 ppm solution was applied with a sprinkling can, since the response was comparable to that obtained with the quantitative application of 10 micrograms to the apex. It is then conceivable that an application with a knapsack sprayer applying only ten gallons per acre, and with the solution under pressure, that the plant was capable of absorbing far less than the 10 micrograms required for a favorable response.

Summary:

The response obtained from GA_3 is dependent on the quantity of hormone absorbed by the plant at the time of application. Inconsistent results can be explained by differences in hormone uptake by the plant. Sub-optimum amounts of GA_3 taken up by the plant produced cones which were larger and more susceptible to shattering. This is a single year's data and will require additional tests for a firm conclusion. This trial also produced hops with an increased amount of oil as well as an increase in alpha acid yields. Differences in quality were not evident with machine picked hops at harvest time.

Height of Trellis Study

Objectives:

To test the performance of six hop varieties grown under different trellis heights.

Nature and extent of previous work:

A recent study conducted at Wye College noted a gain in yield per hill with an increase in trellis height. The small yield increase was due to more cones being produced on the upper parts of the vine which did not develop on a low trellis due to apical damage. An additional advantage noted was the even distribution of laterals on the vine which facilitated machine picking. They concluded that a high trellis wirework was most advantageous with vigorous hop varieties.

Procedure:

Six hop varieties were planted in the early spring of 1961 in a tria replicated three times with three different trellis heights. The varieties consisted of three commercial and three experimental lines with wide differences in their performance. The three trellis heights consisted of 16, 18, and 20 feet. Plots were maintained in 1961, but were not harvested, therefore data presented in this report are from one year old plants which have not reached their potential production. Each hill had two vines trained on each of the three strings. Harvest weights were obtained in all treatments.

Experimental Results:

Quality data were provided by S. T. Likens. Yield and quality of six hop varieties was not altered when grown under three trellis heights. Therefore the data summarized below give an indication only of the differences in varietal performance since no significant difference was noted with these variables when grown under different trellis heights.

Data obtained from height of trellis study conducted with 6 hop varieties, 1962.

	Fuggle	Late Cluster	Brewers Gold	144-I	135-I	128-I
Yield/Ac.(lbs.)	1120 b	1080 b	1380 b	1760 a	1150 b	1960 a
% α	5.67 c	6.46 c	7.57 b	2.94 d	2.67 d	8.67 a
% β	2.77 c	3.22 c	4.16 b	4.63 ab	5.42 a	4.98 ab
Harvest date	9/5	9/21	9/18	9/11	9/11	9/21

Values followed by the same alphabetical letter are not significantly different at the 5% level.

Though yield and quality were not altered by a different trellis height, a change was noted in the growth habits of the six varieties tested. It was noted with the higher trellis heights that there was a more even distribution of the cone bearing laterals on the vine, and the absence of the tangled "head" characteristic of some varieties. This change in growth was characteristic of the more vigorous varieties, namely Late Cluster, Brewers Gold, and selection 135-I. These varieties had less harvest loss from machine picking when grown on the higher trellis.

The overall performance of the six varieties was considered good, especially that of 128-I and 144-I, since the plants were considered one year old stock.

Summary:

Six varieties of hops were not influenced by three different trellis heights during the first year of study. Several years' data will be needed before conclusions can be drawn regarding effects of trellis heights and varietal performance.

Test with a Chemical Gametocide

Objectives:

See 1959 Annual Report, page 92.

Nature and Extent of previous work:

See 1959 Annual Report, page 92.

Studies conducted in 1959 with the chemical gametocide showed a severe phytotoxicity with concentrations above 0.50%, hence in 1960 lower concentrations were employed with no apparent damage to yield. The treatments were applied at definite dates with no regard to the flowering of the hop plant; therefore, the receptive period and subsequent pollination was not related with the date of treatment. Variable results noted in 1960 could also have been caused by a difference in pollen density during the receptive period of the plants. The trial conducted in 1962 attempted to control the availability of pollen and still maintain conditions similar to that which would occur under commercial field conditions.

Procedure:

Twenty-one Fuggle hills were each bagged with ten parchment bags prior to the receptiveness of the female inflorescence. Three concentrations of FW-450 in a water solution; 0.50%, 0.25%, and 0.125%, were applied as a spray to the plants on two different dates (Table 1). Each concentration was applied once, either on 7/10 or 7/17 and twice on 7/10 and 7/13. The plants were uniformly trained and all flowered during the period 7/8 - 10. The date of pollen availability was accomplished by artificially pollinating the bags on the date noted in Table 1 prior to their removal. Five bags were involved with each pollination. Each lateral was tagged to identify the treatment at harvest. An additional five laterals were picked from each plant for comparison and these were considered as having unlimited availability of pollen during the flowering season, since they were not bagged initially. Cone samples were picked and threshed by hand.

Experimental results:

Data obtained on seed set are listed in Table 1.

Table 1 Data obtained from gametocide trial on Fuggle, 1962.

Treatment Conc.	Treatment Date	Date Pollen Available	Cone wt. (grams)	Seed wt. (grams)	% Seed by wt.
0.50%	7/10	7/14	56.1	9.33	16.6
		7/16	37.5	2.87	7.7
		Unlimited	33.7	3.01	8.9
0.50%	7/10	7/11	35.0	3.11	8.9
		7/13	9.3	0.31	3.3
		Unlimited	39.5	2.44	6.2
0.50%	7/10 &7/17	7/11	21.3	2.13	10.0
		7/13	--	--	--
		Unlimited	32.9	2.14	6.5
0.50%	7/10 &7/17	7/14	30.0	1.83	6.1
		7/16	17.0	0.57	3.4
		Unlimited	27.0	0.45	1.7
0.25%	7/10	7/14	40.6	6.09	15.0
		7/16	--	--	--
		Unlimited	52.4	4.05	7.7
0.25%	7/10	7/11	28.5	2.29	8.0
		7/13	29.0	2.67	9.2
		Unlimited	34.6	2.77	8.0
0.25%	7/10 &7/17	7/11	30.3	2.93	9.7
		7/13	9.3	0.51	5.5
		Unlimited	35.4	2.55	7.7
0.25%	7/10 &7/17	7/14	--	--	--
		7/16	32.0	1.45	4.5
		Unlimited	30.0	0.58	1.9
0.125%	7/10	7/14	15.5	1.91	12.3
		7/16	26.8	1.83	6.8
		Unlimited	38.9	2.63	6.8
0.125%	7/10	7/11	16.4	1.65	10.1
		7/13	7.3	0.52	7.1
		Unlimited	40.9	3.49	8.5
0.125%	7/10 &7/17	7/11	22.0	2.53	11.5
		7/13	10.6	0.50	4.7
		Unlimited	39.4	2.79	7.1
0.125%	7/10 &7/17	7/14	67.0	9.11	13.6
		7/16	39.8	0.08	0.2
		Unlimited	37.3	1.41	3.8
0.50%	7/17	7/14	15.4	1.51	9.8
		7/16	9.0	0.18	2.0
		Unlimited	58.0	4.27	7.4
0.50%	7/17	7/17	18.0	0.90	5.0
		7/19	18.7	0.97	5.2
		Unlimited	41.0	2.46	6.0
0.50%	7/17	7/20	35.9	5.36	14.9
		7/22	14.0	0.06	0.4
		Unlimited	50.0	2.11	4.2
0.25%	7/17	7/14	41.5	5.49	13.2
		7/16	19.2	0.63	3.3
		Unlimited	53.5	3.70	6.9

Table 1 Cont. Data obtained from gametocide trial on Fuggle, 1962.

Treatment Conc.	Treatment Date	Date Pollen Available	Cone wt. (grams)	Seed wt. (grams)	% Seed by wt.
0.25%	7/17	7/17	48.7	2.62	5.4
		7/19	23.5	0.21	0.9
		Unlimited	64.0	2.01	3.1
0.25%	7/17	7/20	32.9	1.68	5.1
		7/22	7.8	0.05	0.6
		Unlimited	71.8	1.25	1.7
0.125%	7/17	7/14	36.5	2.64	7.2
		7/16	22.0	0.36	1.6
		Unlimited	78.7	3.53	4.5
0.125%	7/17	7/17	23.0	2.58	11.2
		7/19	32.5	0.71	2.2
		Unlimited	65.5	2.89	4.4
0.125%	7/17	7/20	55.0	7.72	14.0
		7/22	4.5	0.07	1.6
		Unlimited	81.3	4.49	5.5

Discussion and conclusions:

No phytotoxicity was indicated with any of the treatments. Yield data were not obtained, but it appeared that all treatments had a normal yield. Untreated plants which were open pollinated contained an average of 14.2 seed by weight. Though many of the treatments had a seed content which was lower than the check, the difference could have been caused by a variation in pollen density and a difference in receptiveness. The treatments gave variable results with regard to pollen availability and time of chemical application, but there was an indication that seed production was reduced when pollination immediately preceded chemical application. Response from the three concentrations used in this experiment was similar with the different dates of application.

The chemical gametocide FW-450 (alpha, beta, dichloroisobutyrate) is probably most active during the reduction division process in the formation of pollen from the pollen mother cell and only limited information is available for substantiating proof of ovule sterility. It is assumed from previous studies, that foliar applications of aqueous sprays are readily translocated upward and downward in the plant. In this study some laterals were bagged at the time of chemical application and did not receive a foliar spray, but responded similar to those treated directly.

The reduction of seed formation through the use of gametocide appeared to be related to the stage of growth and/or the stage of ovule development. This type of response was similar to that noted in 1960 and would indicate that the present gametocide treatments would not have commercial application in gaining seedlessness. If seedlessness (less than 3% seed by weight) could be obtained it probably would involve a precise timing of chemical applications and ovule or plant development. This problem appears to be insurmountable on a commercial scale at the present time.

Date of Pruning and Training

Objectives:

See 1956 Annual Report, p. 104.

Reasons for undertaking the work:

See 1956 Annual Report, p. 104.

Procedure:

See 1959 Annual Report, p. 85, for modifications of original report. Procedures used in 1962 are given in Table 1.

Table 1. Date of pruning and training trial on Late Cluster, 1962.

Entry	Pruning treatment -	Training treatment	Remarks
1	Fall 12/7/61	Early vines (5/4)	Vines 18 to 36 in. when trained
2	Fall 12/7/61	Late vines (5/10)	Vines 18 to 36 in. when trained
3 1/	Early growth (4/5)	Early vines (5/16)	Vines 24 to 48 in. when trained
4	Early growth (4/5)	Late vines (5/23)	Vines 24 to 36 in. when trained
5	Late growth (5/4)	Early vines (5/31)	Vines 24 to 36 in. when trained
6	Late growth (5/4)	Late vines (6/11)	Vines 24 to 48 in. when trained

1/ Standard treatment (check)

Experimental results:

Data were obtained on yield, cone weight, cone length and flowering date. Quality data were provided by S. T. Likens. These data are given in the following table.

Table 2. Data obtained in date of pruning and training trial on Late Cluster, 1962.

Entry	Yield lbs/ acre	Av. cone weight (mg)	Av. cone length (mm)	Mls. oil per 100 grams	% alpha acid	% beta acid	Date initial burr
1	2070	161	32	0.63	5.73 c	3.76	7/16
2	1800	168	32	0.67	5.40 c	3.85	7/15
3	1930	164	32	0.72	5.81 bc	3.77	7/15
4	2080	175	32	0.75	6.97 a	3.98	7/17
5	1720	157	30	0.67	6.71 ab	4.17	7/24
6	1800	180	32	0.72	7.40 a	3.77	7/29
Mean	1900	167	31	0.69	6.33	3.88	--
LSD(.05)	N.S.	N.S.	N.S.	N.S.	0.87	N.S.	--
CV(%)	14.8	9.5	3.8	20.5	9.1	12.6	--

Discussion:

The third year's results were obtained in the Late Cluster Prune and Train Trial and are summarized in Table 2. The trial in 1962 was conducted with two strings per hill, with two vines trained on each string, as compared with three strings per hill in the previous two years. This change was necessary to eliminate the entanglement at the wire which caused difficulty at harvest time.

No significant differences were noted for any treatment variables studied, except percent alpha acid. Results indicated that an increase of alpha acid resulted with late training. This difference may have resulted from a difference of maturity at harvest time. All plots were harvested on September 17th and observations at this time were that the early pruned and early trained plots were more susceptible to shattering than the later trained hops. Cone breakage at harvest time was related to the difference in flowering dates and this loss factor may have influenced the change in alpha acid content. The previous two years in which this trial was conducted did not show any significant differences for any of the variables studied.

Summary:

Three years' results indicated that wide differences in dates of pruning and training of Late Cluster had no effect on yield, cone size, oil content, or content of beta acid. Late training increased alpha acid and delayed flowering. The lower alpha acid content of early trained hops could have been due to cone breakage observed at harvest time.

Two Stringing Studies Conducted in 1962.

I. Chemical Treatment of Hop String

Most of the hops in the USA are grown on coir hop strings, but due to variation in price and availability of coconut fiber, it has been possible for the introduction of competitive products. Paper twine has been introduced and has received favorable acceptance in most areas due to ease of handling and also its rapid decomposition in soil, which is an advantage to the grower, since vines are returned to the soil, and the persistence of string would be a hindrance to field machinery. Coir string has shown a remarkable resistance to rot as compared with the paper twine.

Normal stringing practice is to anchor string onto a cedar stake or a wire stake, but a practice in California is to place the string six to eight inches into the ground and anchor with a metal clip, thereby eliminating the use of a stake. This practice necessitated the use of a string resistant to rot; therefore, the coir string has dominated in this area.

This study was initiated to determine the rot resistance of paper string treated with chemical preservatives.

Procedure:

Chemical treatment

1. Untreated
2. Copper Napthanate (2% in mineral spirits)
3. Pentachlorophenol (5% in mineral spirits)

The basal 20 inches of paper twine (215' per pound weight) were soaked in the chemical and allowed to dry prior to their use. On June 6, 1962 two strings were strung per hill, and each treatment involved 20 hills or a total of 40 strings. Basal ends of twine were covered with six inches of soil. Strings were maintained for a five month period and subjected to normal climatic conditions and cultural practices.

Results and Discussion:

1. Untreated A majority of the strings were rotted off at the soil surface at the end of three months and after five months all strings had rotted.

2. Pentachlorophenol 50% of the strings had completely rotted after five months and only six strings had a moderate rot and would have supported hops. Vines were not on the strings the last six weeks of the trial and some of the results are projected as to what condition might have occurred if the vines were present. The remaining strings were severely rotted to the point where they would not have supported a hop vine.

3. Copper Napthanate 36 strings out of 40 had little to moderate rot, but all would have supported hops. Only four strings were rotted sufficiently that there may have been a question as to whether they would have supported a hop vine.

Summary:

On the basis of this one year trial it would appear that copper napthanate was effective in retarding rot. However, the results are not extensive enough for a firm conclusion. No phytotoxicity was evident from the chemicals, and no noticeable effects were observed.

II Comparison of Different Hop String

Hop selection 128-I has displayed the inability to remain upright when grown on paper string. The variety does not possess the usual number of climbing hair found on most varieties and this in turn has added to its difficulty in remaining attached to paper string. This study was conducted to determine if the coarse surface of coir string would aid in the upright growth of this variety.

Procedure:

Three blocks of 38 hills each were strung with three different types of string. The three types included a heavy coir, paper string (215 feet per pound weight), and flax string (65 pound tensile strength). Flax string obtained from the Canadian Ribbon Tape Co. Ltd., Montreal, Canada consisted of 8 strands fused together into a ribbon approximately

1/8 inch wide. Two vines were trained on each of the two strings per hill. All vines were stripped three feet above ground and arched at the four foot level.

Results:

Vine evaluation per hill at the end of 4 months.

Vine Condition	Coir Hills	Paper Hills	Flax Hills
Good	25	8	--
Fair	--	2	6
Slipped	3	13	10
Down	9	5	17
Dead	1	10	5

Discussion:

Vines were rated good if they were tightly wrapped around the string and had not slipped on any portion of the string. Fair vines were those in which the apex had strayed from the string and later returned, forming a loop somewhere along the length of the string. Slipped vines were recorded if the apex had slipped 12" or more below the top wire. Down vines consisted of one or both strings on the ground due to breakage. Flax string usually broke at the mid point, whereas coir broke at or near the attachment on the top wire. The five down hills listed under the paper string did not result from breakage of the string itself but rather a complete slippage of the vine off from the string. This occurred after the vine had slipped and winds whipped the vine in such a manner as to cause the stake to be pulled from the ground and the vine finally slipped off from the unfastened string. The dead vines recorded were caused by a loop in the lower portion of the vine which developed during the movement of the vine on the string. This loop appeared to block water transport, since a gradual wilt appeared as a symptom.

These preliminary observations would indicate that flax ribbon, at the present time, does not hold a potential in the hop business and that coir has a definite advantage over paper when used on hops with few or small climbing hair. A three acre yard of 128-I, planted off-station, was arched at three feet and a field observation indicated no dead vines and a few vines that had slipped on the string.

Summary:

Paper twine can be satisfactorily used with most hop varieties, but varieties such as 128-I may require a string with a coarse surface, such as coir, to aid the apex in maintaining contact with the string during its upward movement. A one year trial indicated that coir string was advantageous in the prevention of slippage over that of paper or flax string.

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

S. T. Likens

Objectives:

1. To support the hop breeding program by chemical evaluation of experimental lines and parental stock for all possible quality characteristics and to develop new methods for assessing hop quality.

2. To support the hop-producing industry by initiating, or cooperating in, experiments leading to better understanding of the production of hops. Examples of this type of work include:

a. Establishment of maturation characteristics.

b. Determination of the effects of fertilizers, gibberellic acids or other agronomic influences on hop quality.

c. Leaf analysis correlations with fertility plots.

d. Determination of source and cause of quality changes during drying, baling and storage.

e. Investigation into causes of shattering.

3. To support the brewing industry by initiating, or cooperating in, experiments designed to improve the degree of precision involved in the purchase and use of hops. Examples of this type of work are:

a. Clarification of quality standards upon which purchases are made.

b. Development of a method for determination of the fate of hop-volatiles during brewing.

c. Determination of influence of hops on yeast metabolism.

4. To support hop research in other states (Washington, Idaho and California), to the extent which time permits, by analysis of samples from experimental trials. This work is restricted to trials which will result in general benefit to the hop industry.

In order to carry out the objectives stated above, this line project currently maintains 8 lines of work with the following work-plan numbers and titles:

AC-1. Factors influencing storageability.
AC-2. (USBA 8) Characterization of experimental lines by chemical analysis of strobiles.
AC-3. (USBA 23) Isolation of hop volatiles from brewing products.
AC-4. Investigation into analytical methods.

AC-5. Service work for cooperative agronomic and breeding trials.
AC-6. (USBA 20) Investigation into the cause of cone-breakage (shattering).
AC-8. Influence of hops on fermentation products.
AC-9. Quality changes during drying and baling.

The report which follows will be in the order of this work-plan list.

AC-1 FACTORS INFLUENCING STORAGEABILITY

Summary:

Although it has been possible to preferentially destroy myrcene in the oil of hops by compression (see AC-9), removal of this compound has not resulted in improved α-acid storage stability as expected. With the exception of loss of myrcene (not believed to be a desirable component from the standpoint of hop quality), neither the essential oil nor the α or β-acid content of hops were found to be seriously affected by compression during 6 months' storage at room temperature.

There appears to be no relation between the storage stability of either α-acid or oil content of Bullion hops and the degree of ripeness.

Objective:

To learn the identity of the factor (s) responsible for the accelerated deterioration of the quality components of certain hop varieties.

Reasons for undertaking this work:

If the objective of this work plan can be accomplished, processing methods or storage conditions might be controlled in a way to arrest the storage deterioration. This would bring about large savings to brewers, increase the precision of hopping rates and permit more general use of certain varieties which grow well but whose sales are limited as a result of their poor keeping qualities.

Nature and extent of previous work:

A great deal of work over the past 50 years has been done on this problem. Since the deterioration has generally been accepted as chemical oxidation of α-acid, most attempts have been by direct assault on the two factors: (1) reducing the rate of deterioration by reducing storage temperature (successful but only practical to a certain point) and, (2) reduction of the available supply of oxygen, mainly by exchange of air with inert or reducing gases (only moderately successful).

Procedure:

It was determined that large losses of hop oil are associated with the destruction of lupulin granules incurred during baling (1961 AR, p. 71). This was later shown to be primarily due to the loss of a single component -- myrcene (This AR, work plan 9). It has further been found that the build-up of oil content during maturation is largely a result of myrcene accumulation (This AR, below). Burgess (1951 Wye Coll. Ann. Rpt.) has shown that myrcene

is catalytic to the oxidative deterioration of α-acid.

The work to be reported here is a test of the hypothesis that α-acid stability can be improved by:

1. Avoiding the presence of large amounts of myrcene in the oil by early picking.

2. Preferential destruction of myrcene by increasing bale density (increased lupulin breakage during compression).

3. Additional support by comparing hand-picked hops (no lupulin breakage) against machine-picked hops (lupulin breakage occurring in the machine).

Results and Discussion:

The first test of storage stability as related to picking date was carried out over an extended storage period of 17 months at 35°F. with Bullion hops harvested from Aug. 21 to September 11, 1961 (for experimental methods see AR 1961, p. 67). During the time the oil content rose from 2.60 to 4.27 ml./100g. in the green hops. As stored the freshly baled hops ranged from 2.56 to 3.50 ml./100g. α-acid losses over the storage period ranged from 40 to 50% with the exception of one sample which lost only 19% (Aug. 25). Although the less losses occurred in the samples picked in August than in those picked in September, the results certainly do not indicate a close relation of α-acid loss with original oil content or with harvest date.

As was pointed out last year (1961 AR p. 68), losses in hop oil during processing may be inversely related to maturity. If so, this is apparently a temporary situation which disappears during storage for the data for overall oil losses (Table 1) do not show such a relation.

The main tests of the hypothesis (myrcene vs. α-acid stability) were carried out on loose vs. compressed (24 lb./cu.ft.) samples of the varieties Brewers Gold and Fuggle. Well-ripened, seedless Brewers Gold from the Lewis-Brown farm was machine-picked on Sept. 19, dried, and one-half of the lot was baled the following day into 1 lb. samples at 24 lb./cu. ft. in the laboratory baler. The plywood covers were left on the bales and all samples transferred to a storage room whose temperature remains quite constant from 68 to 70°F. but without humidity control.

Duplicate bale samples were withdrawn at intervals and analyzed for α-acid, β-acid and oil content. At the same time a loose sample was taken for the oil determination and duplicate α-acid and β-acid analyses run on it. All oil samples were dried with Na_2SO_4, sealed in ampoules, and stored at -5°F. until gas-chromatographic analyses could be made.

Table 1. Deterioration of α-acid and oil during processing and storage (Bullion, Kerr 1961).

Pick Date		α-acid %	% α-acid recovered after 17 mo.	Oil content (ml./100g.)	% of oil recovered after: Dry bale stor.		Overall
8/21	Green	9.6		2.60			
	Dry	8.6		2.61	100		
	Bale 1	10.2		2.56		98	
	Bale 2	6.5	64	0.76		30	29
8/25	Green	9.5		3.08			
	Dry	9.5		2.94	95		
	Bale 1	9.9		3.04		100	
	Bale 2	8.0	81	1.09		36	35
8/28	Green	10.3		3.44			
	Dry	9.7		3.24	94		
	Bale 1	9.7		3.19		98	
	Bale 2	6.1	62	1.15		36	33
9/1	Green	9.6		3.72			
	Dry	8.2		3.65	98		
	Bale 1	10.0		3.31		91	
	Bale 2	4.9	49	0.88		27	24
9/4	Green	7.9		3.92			
	Dry	9.8		3.60	92		
	Bale 1	9.9		3.42		95	
	Bale 2	5.5	56	1.14		33	29
9/6	Green	8.2		4.27			
	Dry	10.0		3.78	89		
	Bale 1	10.1		3.50		93	
	Bale 2	6.2	61	1.37		39	32
9/11	Green	10.0		3.88			
	Dry	9.9		3.86	98		
	Bale 1	10.5		3.39		99	
	Bale 2	5.4	51	1.80		59	46

Green, Dry and Bale, analyzed Aug. and Sept. 1961.
Bale 2 analyzed Jan. 1963 (16-17 months at 35°F.)

Table 2. Detailed composition of hop oil from loose and baled (24 lb./cu.ft.) Brewers Gold during 160-day storage period at room temperature. *

Time	Loose						Bale					
(days)	Total	Myrcene	Hum.	B-cary.	MNK	Others	Total	Myrcene	Hum.	B-cary.	MNK	Others
1	3.19	2.635	.198	.077	.016	.265	2.89	2.192	.229	.110	.022	.337
7	2.95	2.238	.277	.081	.016	.392	2.13	1.457	.204	.114	.015	.345
35	2.45	1.713	.203	.124	.025	.390	1.35	.743	.177	.085	.017	.328
96	2.04	1.251	.223	.093	.021	.452	0.99	.443	.175	.109	.017	.251
160	1.25	.716	.154	.053	.019	.307	0.51	.108	.102	.040	.015	.244

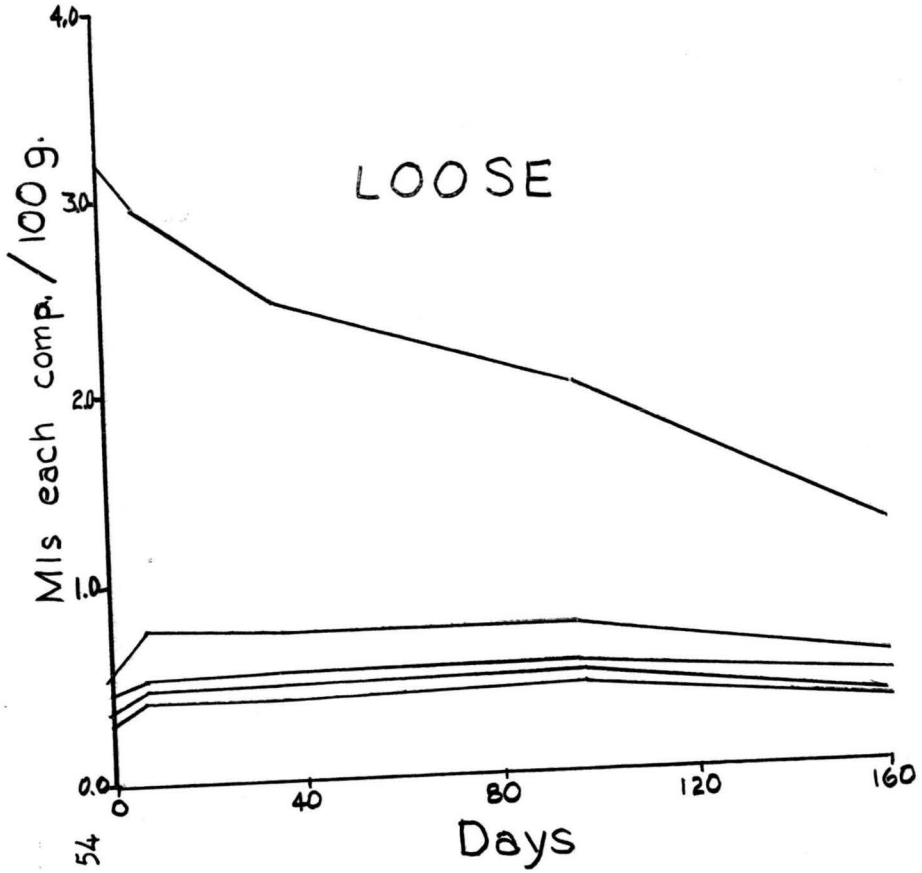
* Total and each component expressed in ml./100g. dry hops.

Table 3. Percent of the oil and of the myrcene remaining during 160-day storage period. Brewers Gold (3.19 = 100% oil, 2.635 = 100% myr.)

Time	Loose		Bale		Ratio: % Myr. baled
(days)	Oil	Myrcene	Oil	Myrcene	% Myr. loose.
1	100	100	90.6	83.2	.832
7	92.5	84.9	66.8	55.3	.651
35	76.8	65.0	42.3	28.2	.434
96	63.9	47.5	31.0	16.8	.354
160	39.2	27.2	16.0	4.1	.151

Table 2 gives the detailed analyses of the oil samples, and these data are expressed graphically in figure 1. It is clear that compression accomplished the desired effect of reducing the myrcene content of the hops appreciably in the early stages of the test, i.e., prior to the onset of α-acid deterioration, and that this was not done at the expense of the other oil components. Table 3 shows that the proportion of myrcene in the oil from baled hops to the oil from loose hops kept decreasing throughout the period so that, according to the hypothesis, a more favorable environment was continually developing for improved α-acid stability in the baled hops.

Figure 1. Composition of loose and baled hop oils during 6 months room temperature storage.



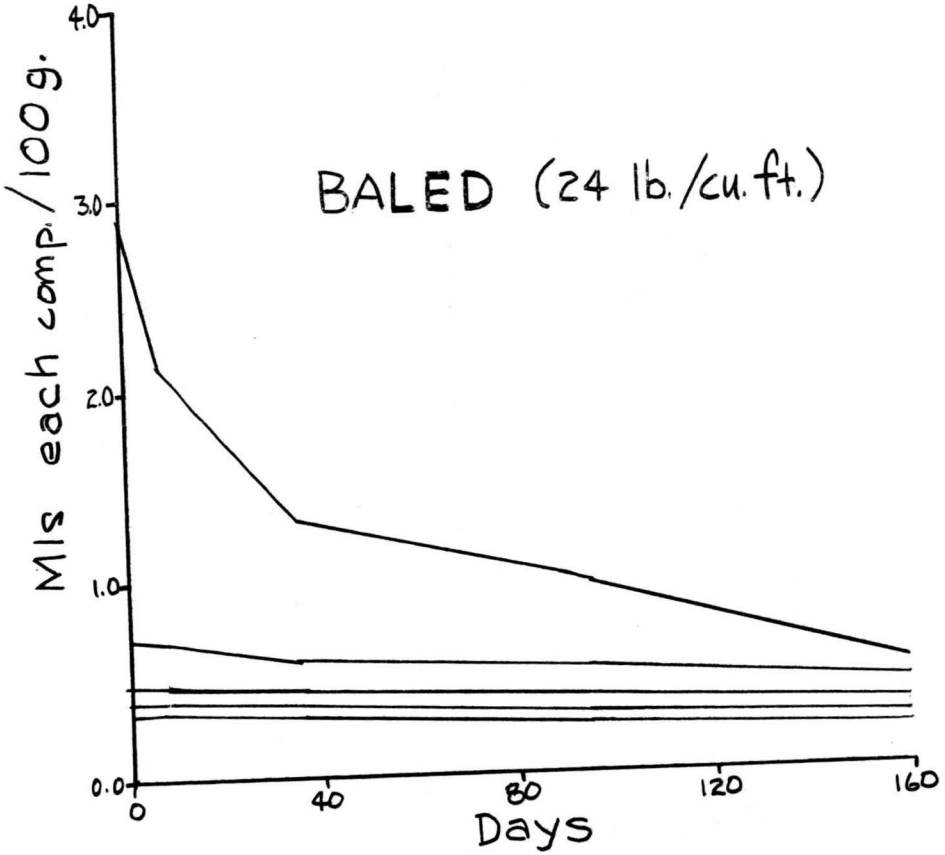


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Table 4. Effect of compression on machine-picked Brewers Gold stored at R.T.

Storage time(days)	α-acid(%) loose	α-acid(%) baled	β-acid(%) loose	β-acid(%) baled	Oil content(ml./100g.)* loose	Oil content(ml./100g.)* baled
1	8.8	8.6	5.3	5.2	3.19(2.64)	2.89(2.19)
7	8.5	8.5	5.0	5.0	2.96(2.24)	2.13(1.45)
35	8.1	7.7	3.8	4.1	2.45(1.71)	1.35(0.74)
96	6.5	6.3	2.9	2.6	2.04(1.25)	0.99(0.44)
160	4.3	4.2	2.3	1.9	1.25(0.72)	0.51(0.11)

* Values in parenthesis are myrcene in ml./100g. dry hops.

Table 4 includes the α- and β-acid data and it clearly establishes that for the variety Brewers Gold, baled samples, with less myrcene, do not have an advantage over the high-myrcene loose samples from the standpoint of α-acid or β-acid stability during storage.

It is interesting to note that 35°F. storage is about 7 times as effective for preserving hop oils as 68°F:

	7 months at 35°F.	1 month at 68°F.
Loose	81% remaining	78% remaining
Baled	47% remaining	47% remaining

The data for 35°F. was taken from the 1961 crop (AR 1961, p. 74) and the 68°F. data was graphically interpolated from Table 3.

Storage tests with Fuggle began with the harvest of 2 lots of well-ripened hops on Sept. 9 from the East Farm, one hand-picked and one machine-picked. These were dried at 135-140° and the following day one-half of each lot was baled in 1 lb. units at 24 lb./cu.ft. and transferred to the storage room (68-70°F.). Analyses were begun immediately and continued periodically. Detailed composition of the oils is given in the appendix and the results are summarized in the remaining tables.

Due to use of single samples the results are more erratic than the Brewers Gold data but the same indications are evident thus far:

1. The oil content of the baled hops diminishes much more rapidly than that of loose hops (Table 5).

2. The loss in oil content is primarily a result of myrcene degredation (Table 1, appendix).

3. There was little loss in the α-acid content of hand-picked hops until after the 2nd month but when the loss occurred there was no apparent relationship to compression or to the myrcene content (Table 6).

4. Machine-picked hops began to lose α-acid sooner than hand-picked ones, but the loss was not associated with compression or myrcene content (Table 7).

Table 5. Percent of the oil and of the myrcene remaining during 164-day storage period. Fuggle (2.130 = 100% oil, 1.453 = 100% myrcene)

	Hand Picked					Machine Picked				
	Loose		Bale		Ratio	Loose		Bale		Ratio
Time (days)	Oil	Myrcene	Oil	Myrcene	%Myr. bale/ %Myr. loose	Oil	Myrcene	Oil	Myrcene	%Myr. bale/ %Myr. loose
0	95.3	89.1	81.2	71.2	.799	92.5	84.9	65.7	59.5	.700
½	94.4	85.7	75.6	69.2	.807	90.6	83.9	76.5	64.9	.773
1	94.3	84.9	85.9	71.5	.842	87.3	81.0	77.4	62.4	.770
2	99.9	91.9	92.9	77.9	.847	80.3	72.1	79.8	64.1	.889
4	100.0	89.3	68.0	53.7	.601	84.0	58.4	58.1	45.8	.784
7	100.0	87.9	69.4	46.7	.531	87.8	79.4	61.0	47.3	.595
21	100.0	100.0	54.5	39.0	.390	77.9	72.8	47.4	33.8	.464
51	89.6	79.5	53.5	36.9	.464	80.2	70.6	44.2	25.8	.365
77	84.1	66.3	58.2	33.1	.499	72.3	65.5	40.3	25.6	.390
164	62.9	53.1	35.2	20.3	.382	53.9	42.2	27.6	13.2	.312

In addition, this test indicates that a consistent lowering of oil content, α-acid content and β-acid content results from machine picking. α-acid β-acid and oil are lowered by 7 to 15% and baling appears to aggravate the loss. The suggestion is that lupulin is physically lost during picking to the extent of 7-12%, with an additional 2-5% loss in baling. (Tables 8 and 9)

Table 6. Effects of compression on hand-picked Fuggle hops stored at R.T.

Storage time(days)	% α-acid		% β-acid		Oil content (ml./100g.) loose		baled	
	loose	baled	loose	baled	total	myr.	total	myr.
0	6.7	6.7	3.1	3.1	2.03	1.30	1.71	1.03
½	5.9	7.4	2.8	3.1	2.01	1.25	1.61	1.01
1	6.3	6.8	3.0	3.2	2.01	1.24	1.83	1.04
2	6.6	6.5	3.2	3.2	2.13	1.33	1.98	1.13
4	6.0	5.7	3.5	3.6	2.13	1.30	1.45	0.78
7	6.3	6.6	2.8	3.1	2.13	1.28	1.48	0.68
21	6.3	6.1	3.1	2.6	2.13	1.45	1.17	0.57
51	6.6	5.6	2.3	2.5	1.91	1.16	1.14	0.54
77	6.2	5.3	1.9	2.3	1.79	0.96	1.24	0.48
164	4.5	4.8	1.8	2.0	1.34	0.77	0.75	0.30

Table 7. Effects of compression on machine-picked Fuggle hops stored at R.T.

Storage time(days)	% α-acid		% β-acid		Oil content (ml./100g.) loose		baled	
	loose	baled	loose	baled	total	myr.	total	myr.
0	5.3	5.9	2.7	2.8	1.97	1.23	1.40	0.86
½	6.2	6.5	2.5	2.6	1.93	1.22	1.63	0.94
1	5.9	6.0	2.7	2.8	1.86	1.18	1.65	0.91
2	6.1	6.0	3.0	2.8	1.71	1.05	1.70	0.93
4	5.8	6.3	2.8	2.8	1.79	0.85	1.24	0.67
7	5.9	6.4	2.6	2.9	1.87	1.15	1.30	0.68
21	6.2	5.2	3.0	2.4	1.66	1.06	1.01	0.49
51	5.3	5.6	2.2	2.2	1.71	1.03	0.94	0.37
77	5.0	5.3	1.9	1.9	1.54	0.95	0.86	0.37
164	4.0	4.2	1.6	1.5	1.15	0.61	0.59	0.19

Table 8. Effect of machine-picking on the α- and β-acid content of Fuggle hop.

	% α-acid						% β-acid					
	Loose			Bale			Loose			Bale		
Time	Hand	Mach.	Diff.	Hand	Mach.	Diff.	Hand	Mach.	Diff.	Hand	Mach.	Diff.
0	6.7	5.9	0.8	6.7	5.3	1.4	3.1	2.7	.4	3.1	2.8	.3
½	7.4	6.5	0.9	5.9	6.2	0.3	2.8	2.5	-.3	3.1	2.6	.5
1	6.8	6.0	0.8	6.3	5.9	0.4	3.0	2.7	.3	3.2	2.8	.4
2	6.5	6.0	0.5	6.6	6.1	0.5	3.2	3.0	.2	3.2	2.8	.4
4	5.7	6.3	-0.6	6.0	5.8	0.2	3.5	2.8	.3	3.6	2.8	.8
7	6.6	6.4	0.2	6.3	5.9	0.4	2.8	2.6	.2	3.1	2.9	.2
21	6.1	5.2	0.9	6.3	6.2	0.1	3.1	3.0	-.1	2.6	2.4	.2
51	5.6	5.6	0	6.6	5.3	1.3	2.3	2.2	.1	2.5	2.2	.3
77	5.3	5.3	0	6.2	5.0	0.8	1.9	1.9	0	2.3	1.9	.4
164	4.8	4.2	0.6	4.5	4.0	0.5	1.8	1.6	.2	2.0	1.5	.5
Mean	6.15	5.74	0.41	6.14	5.57	0.59	2.75	2.50	0.25	2.87	2.47	
% loss		6.7% loss			9.6% loss			9.1% loss			14% loss	

Table 9. Effect of machine-picking on oil content of Fuggle hops.

	Loose			Bale		
Time	Hand	Mach.	Diff.	Hand	Mach.	Diff.
0	2.03	1.97	0.06	1.71	1.40	0.31
½	2.01	1.93	0.08	1.61	1.63	-0.02
1	2.01	1.86	0.15	1.83	1.65	0.18
2	2.13	1.71	0.42	1.98	1.70	0.28
4	2.13	1.79	0.34	1.45	1.24	0.19
7	2.13	1.87	0.26	1.48	1.30	0.18
21	2.13	1.66	0.47	1.17	1.01	0.16
51	1.91	1.71	0.20	1.14	0.94	0.20
77	1.79	1.54	0.25	1.24	0.86	0.40
164	1.34	1.15	0.19	0.75	0.59	0.16
Mean	1.96	1.72	0.24	1.44	1.23	0.21
% loss		12.3% loss			14.6% loss	

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Conclusions:

1. The hypothesis that α-acid storage stability is increased by the selective destruction of myrcene through compression must be rejected. Compression to 24 lb./cu.ft. was shown to effect neither the α-acid content nor the β-acid content either initially nor at any point during the test period of 5 months at room temperature.

2. Compression has an immediate effect on the oil content through reduction of myrcene. Other components of hop oil are relatively stable towards both compression and storage.

3. Reduction of storage temperature from 68°F. to 35°F. appears to reduce the deterioration rate of hop oil (myrcene) by a factor of 7.

4. Machine picking reduces the α-acid, β-acid and oil content of Fuggle by 8 to 10% (probably through loss of lupulin) but does not influence their storageability.

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

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:

Analysis of 19 lines used in breeding revealed several which contained very low α-acid contents. Rejection of these is being considered by S. N. Brooks.

421 samples from the genetic trial have been analyzed for α- and β-acids. These are being evaluated statistically for heritability of these characters.

All lines and selections in the observation stage of testing in Oregon, Washington and Idaho have been analyzed for α-acid, β-acid and oil. The best of these have been subjected to detailed analyses.

No work has been done on other bittering agents.

Idaho O-11 was sampled periodically throughout the season and found to mature in a similar manner to Late Cluster.

Results and discussion:

Seventeen lines (Table 1) used as parental stock in the breeding program were harvested, dried, baled, and held in frozen storage until analysis. Samples were not obtained for 4 additional lines: 107-I, 135-I, Bullion, and BB 215-2. Two additional samples, G-2071-3 and 128-I have been included although they have not yet been used as parents.

Although a certain lack of confidence is usually associated with a single year's data, the results of the examination of this material for its α-acid content is surely indicative in view of the relatively normal α-acid values for the commercial varieties which were grown, processed, and analyzed under similar conditions. The following breakdown shows the proportion of

	Less than 2% α	2 - 4.5% α	Over 4.5%
experimental	6	2	5
commercial	0	2	4
	6	4	9

breeding material which fails to meet the 4.5% α-acid requirements of new lines to be developed from them. The significance of these data cannot be clarified until evaluation of the heritability of α-acid has been completed on the genetic experiment by S. N. Brooks.

The composition of the α-acids for their cohumulone content have not been completely determined and will be reported when finished.

It is interesting that while the majority of the α-acids are extremely low, the total oil content of most of the lines represented here are relatively high, i.e., 4 are lower than Late Cluster and only 1 is lower than Early Cluster.

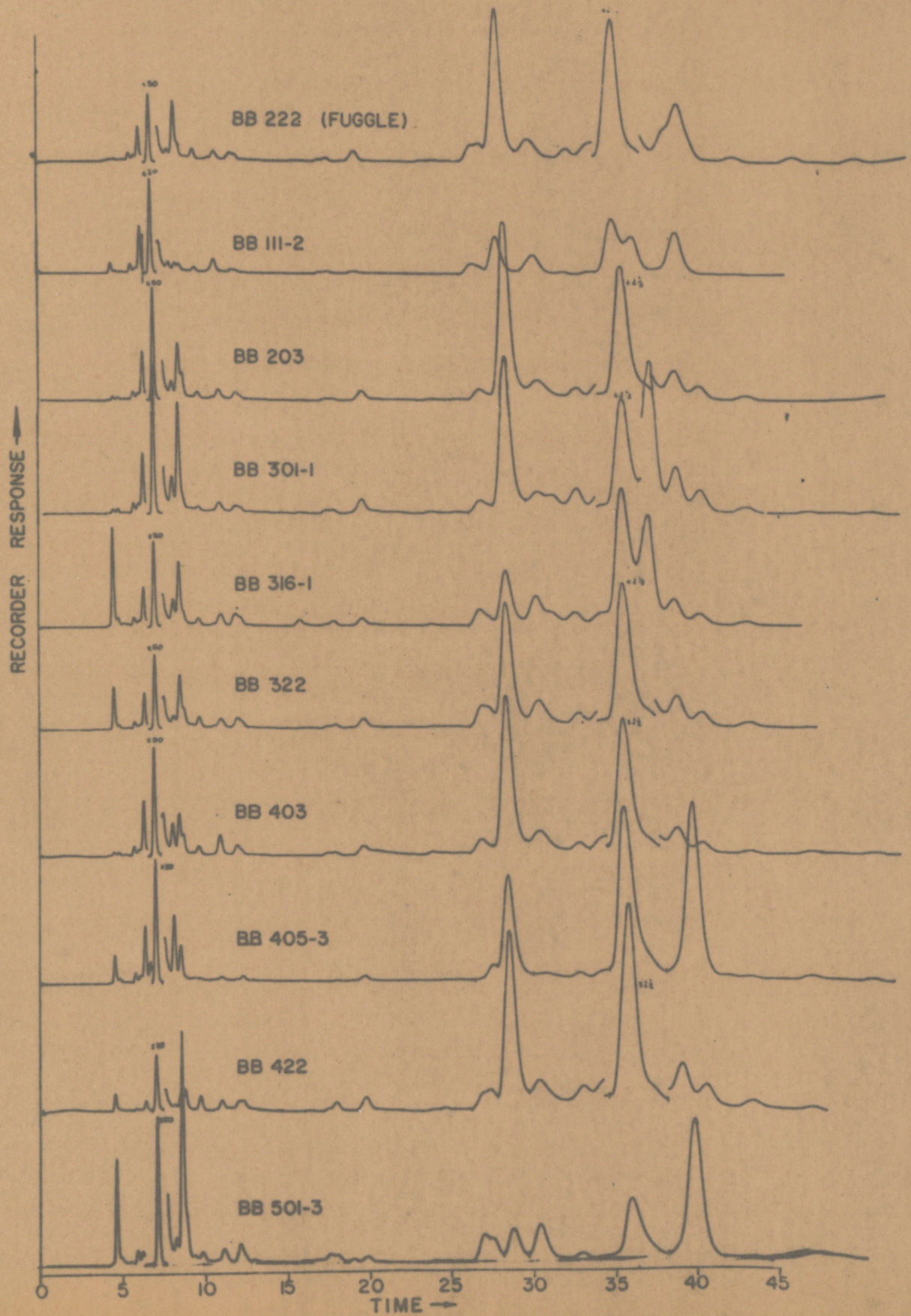
It is difficult to compare oil-composition data for many lines such as is given in Table 1, therefore the composition-profiles are presented in Figures 1 and 2. These are entered as a matter of record only, since at the present their interpretation is doubtful. It can be noted, however, that many of the commercial varieties which have been developed and found acceptable over a long period of years have very similar profiles while many of those recorded here diverge markedly. Gas chromatographic conditions employed for the profiles shown here were: Beckman G.C.-2, Hydrogen flame detector, 1/8" by 25' aluminum column packed with 2% (w/w) butanediolsuccinate on 60/80 mesh Chromosorb W. Sample size was 0.2 microliter with 1:1 splitting ratio. Operating temperature was 130°C, isothermal.

Towards accomplishment of objective 2, analyses for α- and β-acids on 421 samples of hops from the genetic experiment have been turned over to Dr. Brooks for statistical correlations etc. It has been observed that methanol extracts of some of these samples have excellent stability when held at -8°F. (as is the case with extracts of male flowers) while others exhibit poor stability characteristics (Table 2). These observations will be checked and, if found reliable, will be used as preliminary data for further investigation of the cause of varietal differences in stability features.

Table 1. Chemical description of parental stock [1/]

Sample	(H.D.)	% α	% β	α-acid Composition % CoH	% AdH	% H	Oil Composition Total oil	% Myr.	% Hum.	% B-C	% MNK	% ?	% Others
BB 111-2	(9/10)	2.2	2.4	25.7	14.1	60.2	1.51	76.8	4.9	2.7	0.9	---	14.7
BB 122(L.C.)	(9/4)	7.0	4.8	35.2	11.8	52.5	0.81	79.1	4.2	1.7	1.7	---	13.3
BB 203	(9/13)	1.3	2.7	27.2	12.4	60.4	1.50	57.0	23.3	9.0	0.4	---	10.3
BB 222(Fu)	(8/22)	4.5	1.7	24.1	10.6	65.3	1.14	39.3	27.5	10.1	1.5	---	21.6
BB 301-1	(9/10)	1.6	4.3	42.8	17.2	40.0	1.36	61.1	14.1	6.1	0.5	6.8	11.4
BB 311(B.G.)	(9/4)	7.1	3.9	46.1	8.6	45.3	2.68	67.8	6.9	4.3	0.9	2.0	18.1
BB 316-1	(9/21)	1.4	3.9	14.6	6.8	78.6	0.67	56.9	12.6	3.7	1.1	---	17.4
BB 322(Ha)	(8/31)	3.2	3.4	17.0	12.0	70.8	1.07	44.8	31.2	8.0	1.6	---	14.4
BB 403	(9/18)	1.3	4.3	44.6	13.9	41.5	1.60	56.4	23.8	7.5	0.7	---	11.6
BB 405-3	(9/18)	2.0	3.8	38.5	16.6	44.9	1.70	62.9	12.8	5.2	0.5	---	18.6
BB 422(BA)	(9/4)	3.7	6.0	35.2	4.4	60.4	1.07	33.4	44.5	9.5	0.1	---	12.5
BB 501-3	(9/21)	4.6	2.2	35.1	11.0	53.9	1.04	72.5	4.8	1.4	0.6	8.7	11.7
BB 507-3	(9/7)	0.9	1.9	31.4	21.9	46.7	0.66	71.5	10.0	3.0	0.3	3.5	11.7
BB 511-3	(9/10)	1.7	2.4	41.5	17.7	40.8	1.33	78.7	6.7	2.3	0.2	4.0	8.1
BB 522(E.C.)	(9/7)	5.3	3.9	41.3	12.3	46.4	0.59	64.8	10.7	5.3	2.6	2.5	14.1
15-S	(8/29)	6.0	6.4	55.0	15.8	29.2	0.28	21.0	37.1	10.1	1.4	---	30.4
50-S	(9/4)	9.3	3.1	26.6	8.8	61.9	1.71	32.2	22.0	4.9	2.1	---	38.8
G 2071-3		5.2	3.6	45.2	7.7	47.1	0.78	50.9	6.9	3.9	0.4	---	37.9
128-I (#164)		10.9	5.4	28.6	11.9	64.5	2.12	51.0	20.7	7.4	0.3	---	20.6

1/ Elimination of low α-acid parental material is being considered by S. N. Brooks.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BB 203
BB 301-1
BB 316-1
BB 322
BB 403
BB 405-3
BB 422
BB 501-3
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0
5
10
15
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25
30
35
40
45
TIME

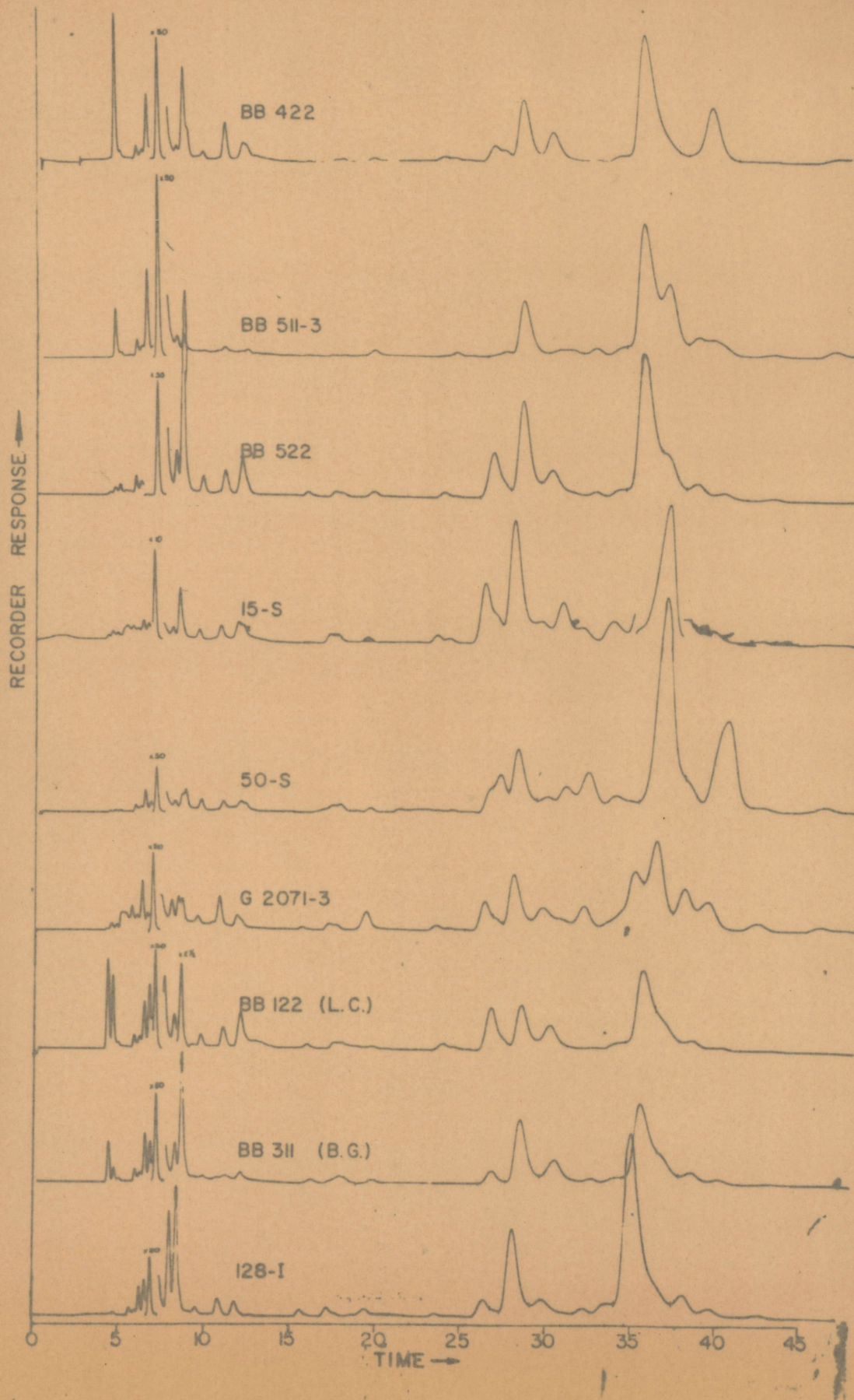
BB 422
BB 511-3
BB 522
15-S
50-S
G 2071-3
BB 122 (L.C.)
BB 311 (B.G.)
128-I
RECORDER RESPONSE
0
5
10
15
20
25
30
35
40
45
TIME

Table 2. Stability of methanol extracts of some samples from the genetics trial.

Identification	α-acid(%D.B.) 1st anal.	α-acid(%D.B.) 2nd anal.	β-acid(%D.B.) 1st anal.	β-acid(%D.B.) 2nd anal.	No.days after ext'n. 1st anal.	No.days after ext'n. 2nd anal.
1073-2	2.56	1.81	3.88	3.61	17	150
2001-1	1.68	1.69	6.80	6.11	23	149
2051-2	5.23	4.16	2.00	2.18	49	125
2063-3	4.48	1.78	4.60	1.83	17	95
2082-1	5.12	5.09	5.33	4.89	26	96
3013-1	2.63	2.51	5.17	4.96	19	96
3049-3	5.45	4.09	1.17	1.10	20	95
3073-2	4.77	3.80	1.61	1.65	20	101
3100-1	3.95	2.52	2.69	3.12	19	95
4010-3	2.17	1.49	2.51	2.35	1	100
4018-3	2.97	2.09	1.88	2.02	10	173
4020-1	4.13	3.26	2.70	2.90	10	187
4060-1	3.98	3.59	1.97	2.03	3	173

Analysis of all OSU, WSU, and U of I experimental lines and selections have been completed and are summarized for up to 3 years in Tables 3, 4, and 5. Those lines meriting Brewers inspection have been subjected to detailed analyses (Table 6). While the Washington and Idaho materials are selections from Early and Late Cluster and consequently of similar analysis to those varieties, the Oregon offerings to the Brewing industry display a good range of oils, α-acids, and cohumulone ratios from mild to strong. Such a range offers a good possibility for selection of varieties which can satisfy a broader spectrum of Brewers needs.

As a result of expression of lack of interest in bittering agents other than α-acid by the USBA Hop Research Committee, no work of this nature was done this year. β-acid contents have been reported, however, on all lines and selections. The reason for this is: in view of several reports concerning the adverse effect of β-acid on α-acid stability, it seems desirable to maintain a record of this component until the question is settled.

Complete characterization of lines reaching off-station testing was confined this year to O-11,a Cluster type, being developed by R. R. Romanko at the Univ. of Idaho at Parma (Table 7). O-11 was grown in a commercial yard and sampled periodically. On the basis of oil analysis, cone weight, and α-acid, O-11 appears to mature very similarly to the Late Cluster in the surrounding yard. O-11 has a potential for approximately twice the oil content of Late Cluster and contains somewhat more α-acid than Late Cluster.

Table 3. Chemical quality data on experimental lines being developed at Corvallis, Oregon. 1/ All analyses on dried samples.

Identification	α-acid (%D.B.)			β-acid (% D.B.)			Oil content(ml/100g D.B.)		
	1960	1961	1962	1960	1961	1962	1960	1961	1962
OB-801	8.7	8.2	9.3	4.4	4.3	6.1	0.45	0.49	1.12
OB-802	3.4	4.6	1.3*	3.0	3.7	5.8*	0.31	0.90	1.76
OB-808	5.9	3.2	3.4	3.7	4.1	5.6	0.48	0.82	0.98
OB-812			8.6			8.0			0.35
OB-813		5.8	3.3		5.3	2.8		1.92	2.24
OB-818	5.1	5.0	6.8	1.7	2.9	3.9	0.55	0.89	1.16
OB-831		6.3	6.2		4.1	5.0		1.43	1.68
OB-833	7.6	5.8	6.6	3.6	3.8	3.8	0.58	0.51	1.17
OB-837		4.8	4.2		4.0	6.9		0.61	0.66
OB-839		4.9	6.4		4.6	7.6		0.90	0.89
OB-840		4.8	6.0		3.9	5.2		0.40	1.16
OB-841			5.5			4.1			1.10
15-S	7.3	6.1	6.0	6.4	4.4	6.4	0.81	0.54	0.28
50-S	8.6	7.2	9.3	2.2	2.3	3.1	1.02	1.39	1.71
128-I			10.9			5.4			2.12
G-2071-3		7.1	5.7		2.6	3.6		1.04	0.78

1/ USDA-OAES hop breeding and varietal improvement program, Stanley Brooks. Moisture contents on 1962 samples range from 9 to 11%.

* Analyses verified by re-run.

Table 4. Chemical quality data on experimental lines or selections being developed at Prosser, Wash. 1/ All analyses on dried samples.

Identification	α-acid (%D.B.)			β-acid (%D.B.)			Oil content(ml/100g D.B.)		
	1960	1961	1962	1960	1961	1962	1960	1961	1962
E-1	6.6	5.7	6.8	2.6	3.4	4.6	0.21	0.31	1.37
E-2 2/	7.1	5.2	7.8	2.7	3.1	5.0	0.23	0.30	0.59
E-2 A	7.9	5.3	5.0	2.3	3.4	3.7	0.61	0.32	0.41
E-5	7.4	5.9	8.6	2.0	3.2	5.6	0.22	0.56	0.51
E-9	7.0	6.5	6.9	1.5	3.4	4.4	0.48	0.63	0.47
E-10	6.5	5.8	8.1	2.5	3.0	4.9	0.36	0.48	0.40
E-21 2/	5.4	5.4	7.3	2.2	3.5	4.7	0.36	0.38	0.60
E-21 A	--	5.2	7.0	--	3.3	4.7	--	0.47	0.63
L-1 2/	6.2	4.3	6.0	2.7	3.1	4.1	lost	0.20	0.48
L-1 A	--	5.8	7.9	--	3.4	4.7	--	0.50	0.84
L-2	5.0	6.3	8.3	3.1	4.1	5.5	0.22	0.36	0.55
L-2 A	--	7.0	8.7	--	4.3	5.7	--	0.75	0.88
L-3	5.1	5.6	8.2	3.8	3.9	5.5	0.25	0.82	0.73
L-4	5.6	5.2	8.1	2.5	3.9	5.4	lost	0.28	0.55
L-8 2/	5.9	6.6	9.5	4.4	3.9	5.8	0.40	0.22	0.69
L-8 3/	--	--	7.8	--	--	5.3	--	--	0.69
L-9 4/	--	4.8	7.1	--	3.2	4.7	--	0.51	0.89
L-16 a (9/4)	5.9	4.5	7.2	4.2	3.1	5.2	0.45	0.35	0.29
L-16 b (9/13)	--	5.2	8.6	--	3.3	5.4	--	0.42	0.67
L-16 c (9/13)	--	--	8/4	--	--	5/4	--	--	0.44

1/ Irrigation Experiment Station, WSU, by C. B. Skotland.
2/ Presented for Brewers Inspection Dec. 11, 1962 at Corvallis.
3/ Gasseliry
4/ Row 6, Rep. II.

CRe5-5, AC-2

Table 5. Chemical quality data on experimental lines of selections being developed at Parma, Idaho 1/ All analyses on dried samples.

Identification	α-acid (% D.B.) 1961	α-acid (% D.B.) 1962	β-acid (% D.B.) 1961	β-acid (% D.B.) 1962	Oil content (ml/100g D.B.) 1961	Oil content (ml/100g D.B.) 1962
13.4% M.C.						
01	*5.8	7.4	2.1	2.1	--	1.31
03	*6.9	7.8	2.1	4.8	--	1.04
04	2.6		2.7		--	0.85
05	*2.4	4.3	0.8	2.2	--	0.85
06	*4.6	4.7	1.6	1.6	--	0.75
07	--	5.2	--	2.5	--	0.82
09(early pick)	--	5.2	--	3.4	--	0.80
09(late pick)	3.7	4.1	1.8	1.6	--	1.17
010	2.1	2.3	2.4	4.4	--	
011(Batt)	*5.5	10.5	2.2	4.6	--	1.71
011(open)	*--	10.1	--	3.9	--	1.23
015	--	5.0	--	2.1	--	
017	*--	5.3	--	4.1	--	0.81
020	*--	7.0	--	4.8	--	1.48
EC 1	6.0	7.8	2.6	4.1	--	
EC 2	5.5	8.6	2.8	4.1	--	1.09
EC 3	6.4	9.4	3.3	4.8	--	
EC 4	5.9	8.9	2.3	4.7	--	1.03
EC 5	6.7	8.3	3.4	4.3	--	0.90
EC 6	8.9	8.2	1.2	3.9	--	0.72
EC 7	6.1	8.3	3.4	3.5	--	0.94
EC 8	6.0	8.7	3.4	4.1	--	0.94
EC 11	4.6	7.7	2.8	4.1	--	
107-I	*2.4	4.5	1.8	1.9	0.83	0.99
108-I	*4.8	5.0	4.2	4.7	1.07	0.90
128-I	*6.0	6.5	3.4	4.3	0.90	1.48

1/ Parma Branch Experiment Station, U of I, by R. Rob't. Romanko.
* Submitted for Brewers inspection 1962.

Table 6. Detailed analysis of promising lines or selections:

Sample	Mls.oil /100g	Oil composition %Myr.	%Hum.	%B-cary.	%MNK	% α-acid	% β-acid	Co H ratio
OREGON (1961) 1/								
OB-801	0.49	38.4	22.0	7.8	2.5	8.2	4.4	.52
OB-826	2.32	61.5	6.1	2.2	1.0	8.2	4.6	.40
OB-830	0.81	27.2	19.2	7.8	4.5	6.6	2.4	.19
OB-831	1.43	43.1	18.8	7.1	1.2	6.3	4.0	.50
OB-835	1.12	41.1	17.5	9.1	1.2	7.3	2.4	.43
OB-839	0.90	35.2	21.2	9.5	1.6	4.9	4.6	.44
15-S	0.54	38.2	21.9	6.7	3.8	6.1	4.4	.51
50-S	1.39	49.8	15.9	7.3	1.3	7.2	2.2	.29
WASHINGTON (1962)								
E-2	0.59	51.6	15.0	6.1	3.0	7.8	5.0	.37
E-21	0.60	47.1	13.4	6.2	2.5	7.3	4.7	.36
L-1	0.84	49.4	14.8	6.1	2.7	6.0	4.1	.46
L-8	0.69	50.5	14.7	5.5	2.7	9.5	5.8	.47
IDAHO (1960)								
0-11 2/	1.23	70.2	5.0	3.1	2.2	10.1,9.1	--	.68
0-11 3/	1.71	73.2	4.4	2.2	1.8	10.5,9.2	--	.50
108-I	0.90	57.8	16.7	6.9	1.2	5.0	--	.38

1/ Samples of 1961 lines which were described as promising in 1960 or 1961.
2/ Obendorff Ranch
3/ Batt Ranch

Table 7. Maturation characteristics of Idaho 0-11. 1/

Date	Dry matter(%) 0-11	L.C.	Cone Wt.(mg DM/cone) 0-11	L.C.	Oil content (ml/100g) 0-11	L.C.	αacid (%) 0-11	L.C.
8/27	17.4	15.9	99	89	0.58	0.36	8.0	6.7
8/29	17.5	17.1	--	107	0.81	0.39	9.2	6.5
9/5	21.4	18.6	110	102	1.10	0.63	8.5	5.2
9/10	18.9	23.4	121	142	1.46	0.57	6.9	6.1
9/12	20.3	23.4	125	129	1.64	0.64	9.5	5.7
9/19	22.1	21.2	125	123	1.73	0.98	8.1	5.9
9/24	22.8	21.3	100	106	1.86	0.98	6.9	5.5
9/26	24.6	22.8	129	125	2.13	0.99	9.0	5.3
10/1	23.3	28.2	116	142	2.22	1.09	8.5	5.7

1/ Fresh, hand-picked samples air-mailed to OSU. DM, Cone wt. and Oil content determined on green hops. α-acid determined spectrophotometrically on dried subsamples.
'Late Cluster' series used for comparison in this table are the 160 lb. N/A samples from Idaho fertility trial which was conducted at the same location.

AC-3 ISOLATION OF HOP VOLATILES FROM BREWING PRODUCTS.

Summary:

Only about 1/3 of hop oil recovered from either distillations or from direct extractions is volatile when dealing with extremely small amounts (20 microliters). Recoveries from distillations range from 3% for myrcene and 29% for β-caryophyllene to 34% for humulene. Distillation periods over 4 hours do not help appreciably. Recoveries of hop oil by direct extraction from water alcohol mixtures are found to be inversely proportional to the alcohol content of the aqueous phase. A new trap is being built which should improve the extraction efficiency for the distillation procedure to be used in recovery of hop oil from beer samples.

Objective:

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:

It is hoped that the objective of this work plan can be achieved to a degree suitable for routine determination within one or two years.

Reasons:

A method for the qualitative and quantitative estimation of hop oil from the products of various stages is needed before a critical examination of its contribution to the brewing process can be made.

Nature and extent of previous work:

A series of aromatic concentrates were recently isolated from all stages of brewing. Gas chromatographic analyses of these concentrates failed to verify the presence of hop oil. It is believed, however, that the failure resulted from inadequate resolution on the chromatographic column because hops boiled in pure water (to avoid malt-volatile interference) produce aromatic concentrates with characteristic hop oil chromatograms.

Two other methods have been published for the isolation of aroma-concentrates from beer. Harold et al. (1) verified the presence of certain hop oil constituents, but their method requires large volumes of beer and several days' work. Strating and Venema (2) used a simpler method but did not find hop oil in their concentrates. The method this work plan intends to refine requires only 10 to 15 liters of sample and about 5 hours to produce.

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(1) Harold, Hildebrand, Moriesson, and Murray, J. Inst. Brew.66: 395-398(1960).
(2) Strating and Venema, J. Inst. Brew. 67: 525-528(1961).

Procedure:

The 'crude' method employs steam distillation of two 7-liter beer samples (dripping the condensate through about 5 inches of pentane in a Wright-Connery trap) for 4 hours. The pentane extracts from each still are combined, dried with Na_2SO_4, the solvent removed. The concentrate is measured, sealed in a glass ampoule and stored at -5°F.

Gas chromatography is isothermal (160°) on a 5% butanediolsuccinate column.

By this method myrcene is lost, indicating excessive oxidation. This shortcoming will be eliminated. At present nothing is known of the degree of recovery under these conditions. Recoveries will be determined. Several methods of improving gas chromatographic resolution will be tried. These will include (1) temperature programming (2) lower coating rates, (3) longer columns, (4) more selective coatings and (5) preliminary separation of oxygenated and hydrocarbon fractions.

Results and discussion:

Work on this work-plan is just beginning. A special trap has been built which will allow a continual stream of nitrogen to flush the system throughout the distillation period (Figure 1).

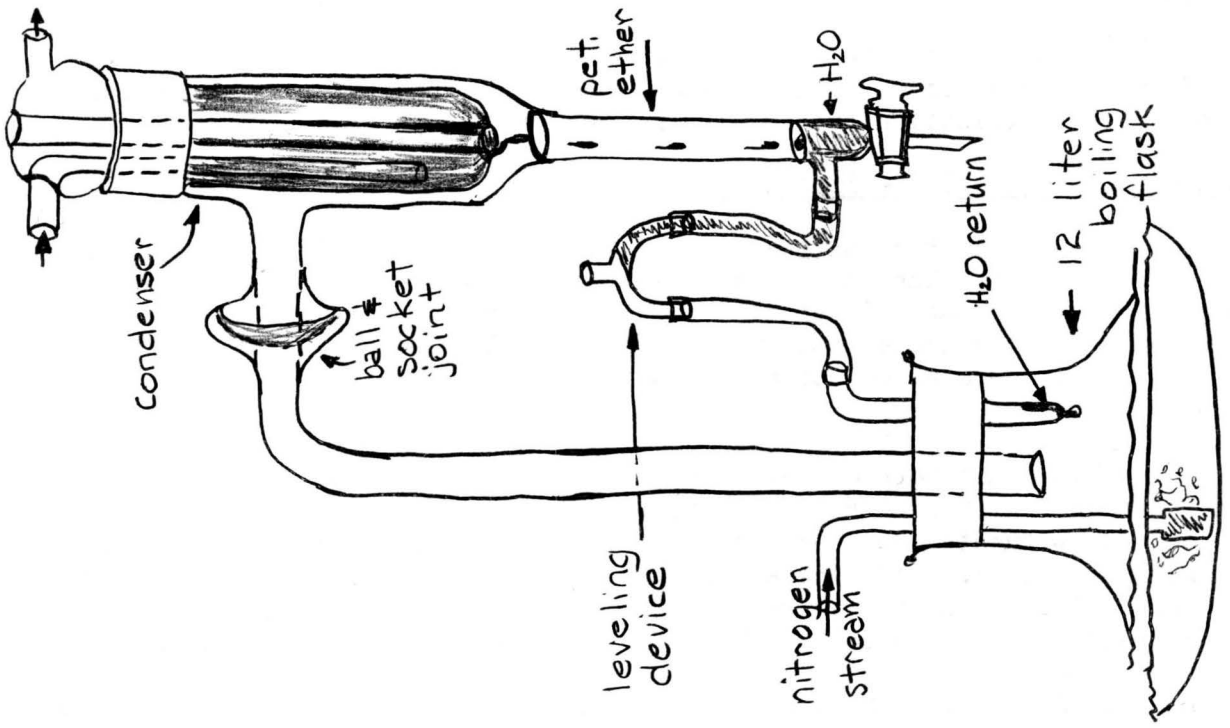

Figure 1. Distillation set-up for isolation of hop oil from dilute solutions (3 ppm).

A recovery trial, using this trap, indicated extremely low recoveries are obtained (Table 1). The two collections (0-4 hours and 4-7 hours) indicate that the poor recovery is not a matter of distillation time.

Table 1. Recovery of hop oil from 3 ppm solution in water.

Time (hrs.)	Ml. conc. rec.	% recovered		
		Myr.	β-cary.	α-cary.
0-4	7.5	3.3	29	34
4-7	3.0	0	1.1	1.8

A second alternative, establishment of a partition at the pentane: aqueous interface must be rejected, since the second collection period enjoyed fresh pentane but did not contain a sufficient quantity of oil. The third possibility, physical loss, has a degree of substantiation in that, after the distillation, the top portion of the 12-liter distilling flask (above the water level) was coated with a resinous film indicative of polymerized oil.

A new trap is being built which should improve extraction efficiency by preventing recycling of the oil. This trap will have simultaneous condensation of the sample distillate and of pentane vapors on the same cold-finger condenser.

The difficulties which can be expected to arise have been accented by the revelation of the poor recovery of a simple extraction (by shaking) of hop oil from relatively concentrated (1000 ppm) water: alcohol solutions with pentane (Table 2). In this experiment 10 mls. of pentane were shaken 5 minutes with 10 mls. aqueous phase (from 0 to 75% alcohol) containing 20 microliters hop oil. The choice of volumes was made on the basis of the amounts, and possible alcohol concentrations, to be expected in the actual trap of the distillation system.

Table 2. Distribution of hop oil in the system water: alcohol: pentane. (10 ml. pentane, 10 ml. aqueous phase, 20 microliters hop oil)

Composition aqueous phase	% recovery in pentane extract					
	tot.oil	vol.oil	myrcene	α-cary.	β-cary.	MNK
0 % EtoH	60	22	16	35	23	71
3 " "	55	17	10	21	22	38
75" "	55	13	8	12	16	32

It can be seen that even with pure water 30 to 80% of some components are lost, and as the alcohol content increases (as will be the

case with beer distillates) lower recoveries can be expected. Successive extractions may show improved recovery, especially with the higher alcohol content of the aqueous phase.

In both cases, distillation and direct extraction, the isolate produced is only about 1/3 volatile. This apparently indicates that serious deterioration of the oil occurs after distillation from the flask.

Conclusions:

Extraction of low concentrations of hop oil in water-alcohol solutions brings about special problems. Possibly the worst is resinification and deposition onto the glassware of certain constituents.

AC-4 INVESTIGATION INTO ANALYTICAL METHODS.

Summary:

Attempts to duplicate the artificial storage tests reported by Burgess (Wye Ann. Rpt. 1951) using hop extracts in a heated environment were not carried far enough for useful conclusions. Hop extracts (solvent removed) appeared to require in excess of 1 hour at 80°C. to deteriorate sufficiently to evaluate deterioration rates as they might be affected by various treatments.

Separation of small quantities of hop oil (or isolates of flavor concentrates of beer) into hydrocarbon and oxygenated fractions works very well.

The method of Rigby and Bars (1) was tried and only minor modifications made it suitable for use in our laboratory.

The conductometric method for determination of isohumulone in beer was evaluated and found unsuitable for adaption to the 2-point method developed for hop extracts (AR 1961, 78-84).

Object, reasons, etc.:

See Ann. Rpt. 1959, p. 113.

Results and discussion:

Artificial storage tests:

1 ml. of petroleum ether extracts of hops (5 g. with 100 ml. solvent) were added to 100 ml volumetric flasks and the solvent removed. These were then placed in an 80°C. oven and pairs removed at intervals. At the end of the test period all were made to 100 ml. with alkaline methanol and the α- and β-acids determined by the U.V. method.

The oxidation of α-acid in this test was less than expected and a second series was run including added hop oil to one set (0.25% redistilled oil added prior to petroleum ether extraction).

U.V. absorbing materials resulting from degredation increased the A_{275} readings sufficiently to make the results in Table 2 questionable. When α-acid is calculated as "% remaining" as indicated by the A_{325} reading, Table 3 results.

A single trial on samples from a test group of the Fuggle Baling and Storage Experiment (AC-1) was extracted, solvent removed with O_2,

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(1) Rigby, F. L. and Bars, A. Proc. ASBC, 1961, pp. 46-50.
(2) Hudson and Cooper, J. Inst. Br. 66: 298-301. 1960.

residues exposed to 80°C. for 90 minutes, then analyzed by U.V. for α-acids and β-acids. The results are in line with the conclusion in AC-1 that low myrcene content resulting from baling is not related to increased α-acid stability.

Table 1. Deterioration of α- and β-acids in hop extracts at 80°C.

Time	L.C. (1961)		Fuggle (1962)	
Min.	% α	% β	% α	% β
0	4.71	4.20	4.10	2.26
20	4.41	4.28	4.06	2.20
40	4.35	4.18	3.86	2.11
60	4.30	4.13	3.50	1.95
120	4.20	3.68	3.37	0.28

Table 2. Deterioration of Late Cluster extracts in presence of added hop oil.

Time	No oil		Oil added		
Min.	% α	% β	% α	% β	
0	4.49	3.79	4.21	3.77	
10	4.39	3.75	4.41	3.45	
20	4.21	3.70	4.15	3.14	
40	4.35	3.24	4.55	2.99	
60	4.41	3.39	4.05	1.72	
120	2.39	0	0	0	) U.V. method
240	0.54	0	0	0	) doubtful

Table 3. % A_{325} remaining after exposure to 80°C.

Time	No oil	Oil added
0	100	100
10	99	96
20	97	93
40	94	94
60	96	74
120	49	30
240	31	27

Table 4. Effect of baling on stability of α-acid and β-acid in extracts. *

Sample	Oil cont. (ml/100g)	Myrcene (ml/100g)	α-acid		β-acid	
			before	after	before	after
Hand pick, loose	2.02	1.29	6.13	6.05	2.82	1.72
bale	1.70	1.03	6.14	5.95	2.81	2.19
Mach. pick, loose	1.97	1.23	4.89	4.91	2.48	1.57
bale	1.40	0.87	5.47	5.30	2.55	1.83

* Extracts exposed 90 minutes at 80-84° in drying oven.

CRe5-5, AC-4

Separation of small quantities of hop oil into hydro carbon and oxygenated fractions.

Conditions

Sample: 100 µl Fuggle hop oil (MPB-1, 1.40 ml/100g, 61.8% myrcene, 19.3% humulene, 5.8% β-cary, 1% MNK, 12.1% others)

Fractionating

Column: 80/150 mesh silicic Acid (Reagent Grade) 32 x 7 mm (in 10 ml burette) (covered with pentane)

Method: 1, 100 µl hop oil
2, 2 cc pentane
3, First 6 mls pentane eluate discarded
4, Collected 10 mls pentane eluate (in 12 ml conical cent. tube)
5, Added 2 cc ethyl ether
6, Collected and discarded next 6 mls after testing
7, Collected 10 mls ether eluate (in 12 ml conical centrifuge tube)

Concentrated samples from steps 4 and 7, removed solvent with N_2 stream and tubes in hot water bath. Found no residue in sample collected in Step 6.

Chromatographed whole hop oil and fractions collected on 1/8" x 25' BDS (5%) @ 160°C. 23.8 psi He, 1:3 split ratio, 2 x 10^4 attenuation, HF (15/15)

Results indicated complete and sharp separation of the two groups of compounds. Method should be excellent for resolving fermentation products from hop and malt volatiles from beer.

Modification of Rigby-Bars (1) isohumulone and α-acid determination in wort.

Difficulty with emulsions led to experiments with other solvents (Table 5) using a rocker-type shaker with about 60 inversions per minute.

Table 5. Emulsion ratings of various solvents.

Emulsion	Before centrifuging	After centrifuging
worst	cyclohexane	cyclohexane
	iso-octane	iso-octane
	heptane	petroleum ether
	n-hexane	heptane
least	petroleum ether	n-hexane

(1) See footnote under "Summary" this section.

Further experimentation indicated that emulsions remaining after shaking could be broken with a stirring rod and recentrifuged.

Noted U.V. interference by use of certain neoprene stoppers.

The method as decided upon was as follows:

50 mls. wort or beer (degassed), 3 ml. 6N HCl, and 25 ml. iso-octane into 100 ml glass-stoppered cylinders. Shake 20 minutes and transfer contents to centrifuge tube. Centrifuge 5 minutes at 2000 r.p.m. and if emulsion remains, break it with stirring rod and re-centrifuge. Transfer 10 ml. iso-octane to test tube containing 10 mls. acid methanol and shake. Dilute 5 mls iso-octane layer to 25 mls. with alkaline methanol and read A_{235} and A_{360}.

Calculate isohumulone and α-acid:

ppm iso. $\quad 48.5\ A_{235} - 26.5\ A_{360}$

ppm α $\quad 80\ A_{360}$

Conductometric determination of isohumulone in beer.

The conductometric method for determination of isohumulone in beer (1) was studied to determine the applicability of a 2-point modification similar to that made for α-acids (1961 AR). The change in the excess-titrant portion of the titration graph was found to have too low a slope to put sufficient reliance in two single readings. It was decided that, at the present at least, promise of success was too small to justify continuing and the work was abandoned.

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(1) Hudson and Cooper, J. Inst. Br. 66: 298-301. 1960.

AC-5 SERVICE WORK FOR COOPERATIVE AND AGRONOMIC TRIALS.

Summary:

Analyses on 27 experimental lines, 1 maturity series on a variety and 4 maturity series on a fertility trial were done for R. R. Romanko at U of I Branch Station at Parma, Idaho. Analyses on 20 lines and 8 virus infected samples were done for C. B. Skotland of WSU Irrigation Experiment Station at Prosser, Wash. Analyses were done on 136 samples from various agronomic trials reported under CRe5-4 (Zimmermann).

Object, reasons, etc:

See AR, 1959.

Results:

IDAHO

Cooperative work with R. R. Romanko (Plant Pathologist) U of I at Parma, Idaho) included α-acid, β-acid and oil content determinations on 27 lines and selections (Table 1), and the maturation characteristics of Idaho 0-11 (see AC-2), detailed analyses of 2 samples of 0-11 and 1 sample of 108-I for cohumulone ratios and oil composition (see AC-2), and a series of periodic samples of 4 entries in a nitrogen fertility trial for α- and β-acids, oil content, cone weight, moisture content and Kjeldahl nitrogen (Table 2).

WASHINGTON

Twenty samples from C. B. Skotland's (Plant Pathologist, Irrigation Expt. Sta., Prosser, Wash.) selection program were analyzed for α-acid, β-acid, and oil content (see AC-2). Also 8 samples from his disease nursery were analyzed for α- and β-acids (Table 3).

OREGON

Late Cluster prune and training experiment --

As often happens, the 3rd year's data indicates a significant change brought about by the treatment after 2 years of non-significant data. Such is the case with the α-acids from samples of this trial, statistical manipulation suggests that the α-acid content of Late Clusters can be raised by late treatment and may be lowered by Fall treatment. If the data for the full 3 years (Table 4) is examined it can be seen that the highest α-acids have consistently been associated with late pruning and the lowest α-acids with Fall pruning.

The oil content has consistently shown no tendency to respond to any of the treatments.

Table 1. Chemical quality data on lines or selections being developed at PARMA, IDAHO.

Identification	∝-acid (% D.B.) 1961	∝-acid (% D.B.) 1962	β-acid (% D.B.) 1961	β-acid (% D.B.) 1962	Oil content (ml/100g D.B.) 1961	Oil content (ml/100g D.B.) 1962
13.4% M.C.						
01	5.8	7.4*	2.1	2.1	--	1.31
03	6.9	7.8*	2.1	4.8	--	1.04
04	2.6	3.7	2.7	3.5	--	0.85
05	2.4	4.3	0.8	2.2	--	0.85
06	4.6	4.7	1.6	1.6	--	0.75
07	--	5.2	--	2.5	--	0.82
09(early pick)	--	5.2	--	3.4	--	0.80
09(late pick)	3.7	4.1	1.8	1.6	--	1.17
010	2.1	2.3	2.4	4.4	--	0.62
011(Batt)	5.5	10.5*	2.2	4.6	--	1.71
011(Obendorf)	--	10.1*	--	3.9	--	1.23
015	--	5.0	--	2.1	--	0.56
017	--	5.3*	--	4.1	--	0.81
020	--	7.0*	--	4.8	--	1.48
EC 1	6.0	7.8	2.6	4.1	--	0.94
EC 2	5.5	8.6	2.8	4.1	--	1.09
EC 3	6.4	9.4	3.3	4.8	--	1.00
EC 4	5.9	8.9	2.3	4.7	--	1.03
EC 5	6.7	8.3	3.4	4.3	--	0.90
EC 6	8.9	8.2	1.2	3.9	--	0.72
EC 7	6.1	8.3	3.4	3.5	--	0.94
EC 8	6.0	8.7	3.4	4.1	--	0.94
EC 11	4.6	7.7	2.8	4.1	--	0.88
107-I	2.4	4.5	1.8	1.9	0.83	0.99
108-I	4.8	5.0	4.2	4.7	1.07	0.90
128-I	6.0	6.5	3.4	4.3	0.90	1.48

* Submitted for brewers inspection 1962.

Table 2. The maturation of IDAHO Late Cluster at 4 nitrogen levels*

Date	% Dry matter 120 N	% Dry matter 160 N	% Dry matter 200 N	% Dry matter 240 N	mg. d.m. per cone 120 N	mg. d.m. per cone 160 N	mg. d.m. per cone 200 N	mg. d.m. per cone 240 N
8/17	13.9	14.1	12.9	13.1	74	73	72	79
8/22	14.8	16.4	16.4	16.4	78	90	92	93
8/27	15.9	16.4	16.0	16.9	81	89	85	79
8/29	17.1	17.1	17.2	17.6	113	107	88	91
9/3	17.5	16.7	18.0	18.7	124	106	113	107
9/5	19.7	18.6	20.0	16.8	93	102	119	102
9/10	20.0	23.4	16.0	18.5	89	142	105	120
9/12	20.9	23.4	25.8	23.9	125	129	154	159
9/19	19.4	21.2	20.5	20.5	128	123	128	136
9/24	22.2	21.3	21.8	21.7	129	106	130	133
9/26	22.6	22.8	21.4	21.6	122	125	119	138
10/1	23.8	28.2	22.8	22.8	124	142	144	143
10/3	27.5	29.3	25.8	22.5	142	--	146	129

Table 2. The maturation of Idaho Late Cluster at 4 nitrogen levels (cont.)

Date	mls. oil per 100g. d.m.				% α-acid			
	120 N	160 N	200 N	240 N	120 N	160 N	200 N	240 N
8/17	0.18	0.12	0.26	0.13	5.4	4.2	4.2	3.4
8/22	0.23	0.20	0.20	0.30	5.5	5.6	7.3	5.5
8/27	0.21	0.36	0.21	0.30	4.7	6.7	5.1	4.6
8/29	0.49	0.39	0.29	0.38	6.2	6.5	4.9	6.6
9/3	0.57	0.40	0.56	0.53	6.4	6.3	6.5	7.7
9/5	0.51	0.63	0.58	0.40	6.5	5.2	6.4	7.0
9/10	1.08	0.57	0.72	0.72	6.3	6.1	6.6	8.0
9/12	1.11	0.64	0.87	0.84	6.9	5.6	6.3	7.1
9/19	1.29	0.98	1.05	1.14	6.8	5.9	6.2	7.5
9/24	1.08	0.98	1.15	1.03	7.0	5.5	7.8	7.9
9/26	1.37	0.99	1.17	1.39	7.7	5.3	7.5	7.1
10/1	1.19	1.09	1.28	1.32	6.9	5.7	7.5	8.5
10/3	1.45	1.02	1.22	1.25	7.5	—	6.9	6.9

Date	% β-acid				% Nitrogen (Kjeldahl)			
	120 N	160 N	200 N	240 N	120 N	160 N	200 N	240 N
8/17	2.9	3.6	4.0	4.1				
8/22	3.2	3.4	2.8	3.2				
8/27	3.3	5.3	4.5	3.9				
8/29	3.2	4.1	3.5	3.9				
9/3	2.5	4.0	2.8	3.7				
9/5	3.8	4.6	3.9	3.9				
9/10	4.0	4.0	4.0	3.7				
9/12	4.0	4.1	4.3	5.0				
9/19	4.1	4.9	5.4	4.5				
9/24	4.1	4.1	3.7	4.1				
9/26	4.1	3.7	3.0	4.6				
10/1	4.2	4.1	5.3	3.0				
10/3	4.0	—	3.9	4.0				

* Grown single rep. commercial farm. Hand picked and air mailed to OSU. % D.M., cone weight and oil content determined on green hops. Subsamples dried (130°F.), baled and held at -5°F. until analysis for α- and β-acid and Kjeldahl nitrogen.

Table 3. Chemical analysis of samples from virus disease nursery, PROSSER, WASH.

		Treatment	% α	% β
Row 1	Rep. II	$E_2 + V_2$	6.0	3.7
" 2	" "	$E_2 + V_1$	8.8	2.7
" 3	" "	E_2 or injected roots	7.5	3.9
" 4	" "	$E_2 + V_3$	9.0	4.1
" 5	" "	V_2	4.2	3.1
" 6	" "	V_1	5.8	4.2
" 7	" "	E_2	6.9	4.3
" 8	" "	V_3	6.8	3.6

Table 4. 3-year summary of the effect of pruning and training on Late Cluster.

Prune time	Training	% α-acid			Mls. oil/100g.		
		1960	1961	1962	1960	1961	1962
Fall	1st crop	6.79	5.78	5.73	0.54	0.53	0.63
	2nd crop	6.34	6.48	5.40	0.63	0.59	0.67
Early Spring	1st crop	6.59	6.42	5.81	0.63	0.64	0.72
	2nd crop	6.52	6.57	6.97	0.55	0.59	0.75
Late Spring	1st crop	6.73	7.37	6.71	0.49	0.60	0.67
	2nd crop	7.41	6.49	7.40	0.49	0.61	0.72

Overall it can be said that if pruning practices affect α-acids, it will be that Fall pruning lowers them and late Spring pruning raises them. It seems safe to conclude that the oil content of Late Cluster is unaffected by a wide range of pruning and training practices.

Height of Trellis Trial

No significant differences in the α- or β-acid contents were observed to result from the main treatment -- trellis heights 16, 18, and 20 feet. For full details of this experiment see CRe5-4 (Zimmermann).

Gibberellic Acid Trials

Analyses for α- and β-acids and for oil content were determined on the following trials:

1. Kerr Ranch — Fuggle (seeded),
2. Schwabauer Ranch — Fuggle (seeded),
3. Univ. Farm (L.B.) — Fuggle (seedless),
4. " " (E.F.) — Fuggle (seeded) MATURITY SERIES,
5. " " (E.F.) — Fuggle (seeded) RATE - TIME,
6. Kerr Ranch — Brew. Gold (seeded).

For discussion on these trials see CRe5-4 (Zimmermann).

AC-6 (USBA 20) INVESTIGATION INTO THE CAUSE OF CONE BREAKAGE (SHATTERING).

Summary:

Fuggle cones are tougher during the day than during the night. This does not provide a complete picture since no information is available on pickability. It may be that detachment is easier at night so that night picking (commercial) could produce less shatter.

The method for testing cone breakage in green hops is felt to be satisfactory from the standpoint of precision. Correlation of results of tests on green and dry hops were not accomplished this year.

Gibberellic acid has been found to produce cones which are more susceptible to shattering. This is a single year's data and will require additional tests for a firm conclusion. (Complete report in this AR, CRe5-4).

As expected, seedless Fuggle was found to produce much tougher cones than seeded Fuggle. We hope to pursue the relation between plant hormones and development of the cones.

Measurement of detachment force has been initiated for the purpose of completing the picture of cone breakage and bruising incurred during the picking operation. Initial results indicate the instrument selected for this purpose will be adequate to measure relatively small differences in pickability.

Objectives:

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

B. To determine the extent to which various factors involved in the production of hops influences the shattering encountered during processing. Tentatively these will include:

1. Maturation
2. Varieties
3. Fertility

Duration, reasons, etc:

See 1961 AR p. 63.

Results:

Tests of cone breakage on Fuggle at 8 A.M., 11 A.M. and 2 P.M. indicated cones were tougher around noon. A similar test series on Aug. 14 and 15 (1 week prior to maturity) supported this and further indicated that cones were appreciably more fragile during the night (Table 1). It was not possible to tell whether this effect was related to either temperature or to relative humidity. It is probable that the effect is actually a result of turgidity changes associated with active water uptake which is largely independent of temperature or relative humidity.

Table 1. Change in cone toughness during a 21 hour period (Fuggle, fresh).

Time	R.H.	Temp.	% D.M.	% whole cones Samp.1	Samp.2	Samp.3	Average
8 AM	60	64	20.1	46.2	45.0	48.7	46.6
11 AM	24	77	20.5	51.7	53.0	51.7	52.1
2 PM	20	85	18.8	--	50.0	51.3	50.7
1 AM	90	64	19.4	38.4	41.7	--	40.0
5 AM	92	57	19.3	36.0	32.7	32.0	33.6

In this test both whole and broken cones were recovered and weighed. It made no difference if the % whole cones were based on the original sample weight or on the weight which was recovered.

The precision of the method (30 minute tumble with #7 rubber stopper beginning 30 minutes after sample is picked) was found to be in the range of ±3% (Table 1) which would be adequate for evaluation of new varieties.

Shatter tests were made periodically on a check and 3 treatments of 2-4 ppm gibberellic acid on Fuggle; 1. Gibrelate 400 (an ester), 2. Gibrel (technical GA_3 with spreader), 3. Technical GA_3. Chemicals were applied when the hops were 4 to 5 ft. high. For a detailed report of this experiment see this AR, CRe5-4.

During the season the % whole cones dropped from 60% to 35%.

Gibrelate '400' and Gibrel produced larger cones but they were more susceptible to shatter than either technical GA_3 or the check. It is not clear whether this observation is a cause and effect relationship or simple coincidence.

No indication of an "optimum" harvest date during which shatter is low was observed although this is generally experienced by hop growers.

Two samples of seeded and seedless Fuggle (Stauffer) were tested for shatter, using the method for fresh hop. Although there was a substantial difference in cone sizes, it would in no way account for the difference in shatter.

Date	% whole cones Seeded	Seedless
8/23	28.6	73.6
8/27	24.3	70.1

A precision-dynamometer was acquired for the purpose of determining the detachment force required for cone removal and a special adaptor was built to make the instrument suitable for use with hops. Due to the lateness of acquisition only very preliminary measurements could be made to determine its ability to indicate the differences which are encountered in hop picking.

Results of the few tests made indicated the following:

1. Good reproducibility between flowering branches on the same vine.

2. Detachment forces required decrease from the apex to the base of the sidearms.

3. Detachment force decreases from the top of the vine downward.

4. There are wide differences between varieties. The detachment forces range from 250 grams to 750 grams and we believe differences of 100 grams could be easily detected between treatments.

AC-8 THE INFLUENCE OF HOPS ON THE FERMENTATION PRODUCTS OF BREWERS YEAST.

Summary:

Using a crude method of isolation of an aromatic fraction of beer which was developed for the isolation of hop volatiles, several isolates were made of hopped and unhopped fermenters. Gas chromatograms of these indicated the enhancement of at least 9 components by the presence of hops and inhibition of production of one component. On this basis it was concluded that hops affect the metabolism of brewers yeast in a manner which results in variation in the products of fermentation and hence possible variation in flavor and/or aroma of associated brews.

Objective:

To determine the extent to which the presence of hop extractives modifies the fermentation products of Brewers yeast.

Justification:

Hops have a well-known antibiotic effect, largely resulting from their α-acid content. Anti-biotic activity is, of course, a manifestation of a certain degree of disturbed metabolic activity in micro-organisms. That hops possess this quality makes them reasonable suspects as carriers of biochemical agents capable of influencing the normal metabolic paths in any micro-organism but that the degree or direction of change is not always deleterious.

To the brewer the side reactions and excretory products of alcoholic fermentations of yeast -- the higher alcohols, esters, aldehydes and organic acids -- are basic to the flavor properties of beer. The involvement of metabolic modifiers from hop extractives then becomes important from the standpoint of flavor modification.

Nature and extent of previous work:

References have been made in several literature sources to the fact that hops have an effect on yeast fermentations, but none have followed this up with actual experimental work of any kind until the recent paper of Welch, et al., in The American Brewer (Feb. 1963). A complete literature survey is being prepared by J. Harland Anderson in connection with publication of the material reported here and cooperative work in his own laboratory at Blitz-Weinhard Brewing Co., Portland, Oregon.

Duration:

After 2 or 3 years (1964 AR or 1965 AR), the accomplishment should be evaluated and the project re-written if it is desirable to continue.

Procedure:

1. Improve the isolation method. Specifically, this would involve carrying out the extraction (steam distillation in a Wright-Connery, re-cycling apparatus) under either inert atmosphere or vacuum.

2. Determination of the type of partition which occurs at the petroleum ether: ethanol-water interface in the trap of the distillation apparatus.

3. Comparison of isolates from fermented worts with similar isolates from simple fermentation for the purpose of establishing a controlled environment.

4. After establishment of a controlled fermentation environment, tentative identification of major fermentation products by GLPC on 2 columns and IR spectra if isolation of sufficient material is possible.

5. Comparison of fermentation products in the absence of hop extracts with those in the presence of hop extracts. In the event of a positive influence, various fractions of the hops would be examined to determine its origin.

6. Examination of data for evidence of survival of hop oil through extraction and fermentation.

This work would be carried out at O.S.U. with the close cooperative efforts of Blitz-Weinhard Brewing Co. so that the facilities of each could be used to fullest advantage to accomplish the objective.

Results and discussion:

Isolation of volatile, aromatic concentrates from samples of brew at various stages of processing (Table 1), was accomplished by the method employed for the isolation of hop volatiles described in last year's AR (p.84). The examination of these samples was of preliminary nature to determine whether or not hops exerted sufficient influence on fermentation characteristics to be observed by this technique.

Chromatograms of isolates from samples number 1, 4, 6, 14 and 15 (Table 1) were compared with a chromatogram of pure hop oil from the same lot of hops used in the brews for the purpose of establishing the contribution of hops to the volatile concentrate. These are displayed in figure 1. Careful examination of these led to the conclusion that the test method would not show peaks brought about by addition of hops.

With that information it was possible to compare hopped and unhopped fermenters (samples 2 and 8 of Table 1) and hopped and unhopped fermenters after ruh (3 and 10, Table 1). These are displayed in figure 2.

Peaks 1 through 8 arise from malt (see figure 1) and were considered suitable for adjusting the size of the samples to be chromatographed so that the remaining peaks would be comparable. Peaks 22 and 34 have appeared inexplicably in various samples, some prior to fermentation, (figure 1) and, at the present, must be considered spurious.

Components 29, 31, 33, 36, 37, 40, 47, 48 and 52 appear to have been enhanced by the presence of hops while production of component 53 was severely inhibited.

Conclusions:

On the basis of comparisons of chromatograms of isolates from hopped versus unhopped fermenters, it must be concluded (at least as a working hypothesis) that the presence of hops does affect the metabolism of brewers yeast in a manner which results in variations in the aromatic fractions of the resulting brew, and that these changes may very well bring about variations in the flavor and/or aroma of those brews.

Table 1. Description of samples taken and amounts of isolate obtained. All samples from Blitz-Weinhard Brewing Co.

Sample No.	Boil time	Date	Stage in Brewing	Mg. isolate (4)	Chromatographed
1	--	5/11	Unhopped wort	64.6	(1)
2	--	5/25	Unhopped fermented (2)	50.0	(5)
3	--	6/19	Unhopped Ruh (2)	43.9	(5)
4	5 min. (3)	5/2	Wort	42.2	
5	"	6/4	"	53.5	(1)
6	"	5/2	Spent hops	193.7	
7	"	6/4	"	159.2	(1)
8	"	5/2	Fermented wort	27.8	(5)
9	"	6/19	"	35.0	
10	"	5/7	Ruh	55.4	(5)
11	"	6/27	"	175.4	
12	"	5/15	Polish	49.9	
13	"	6/27	"	72.7	
14	60 min. (3)	5/7	Wort	41.4	(1)
15	"	5/7	Spent hops	169.5	(1)
16	"	5/14	Fermented wort	47.1	
17	"	5/21	Ruh	76.6	

(1) Figure 1
(2) Laboratory fermentation in 5 gallon milk cans.
(3) Hopping rate of 90 lbs./kettle (435 bbls.) on 0.81 g./liter
(4) 14 liter samples
(5) Figure 2

FIGURE 1

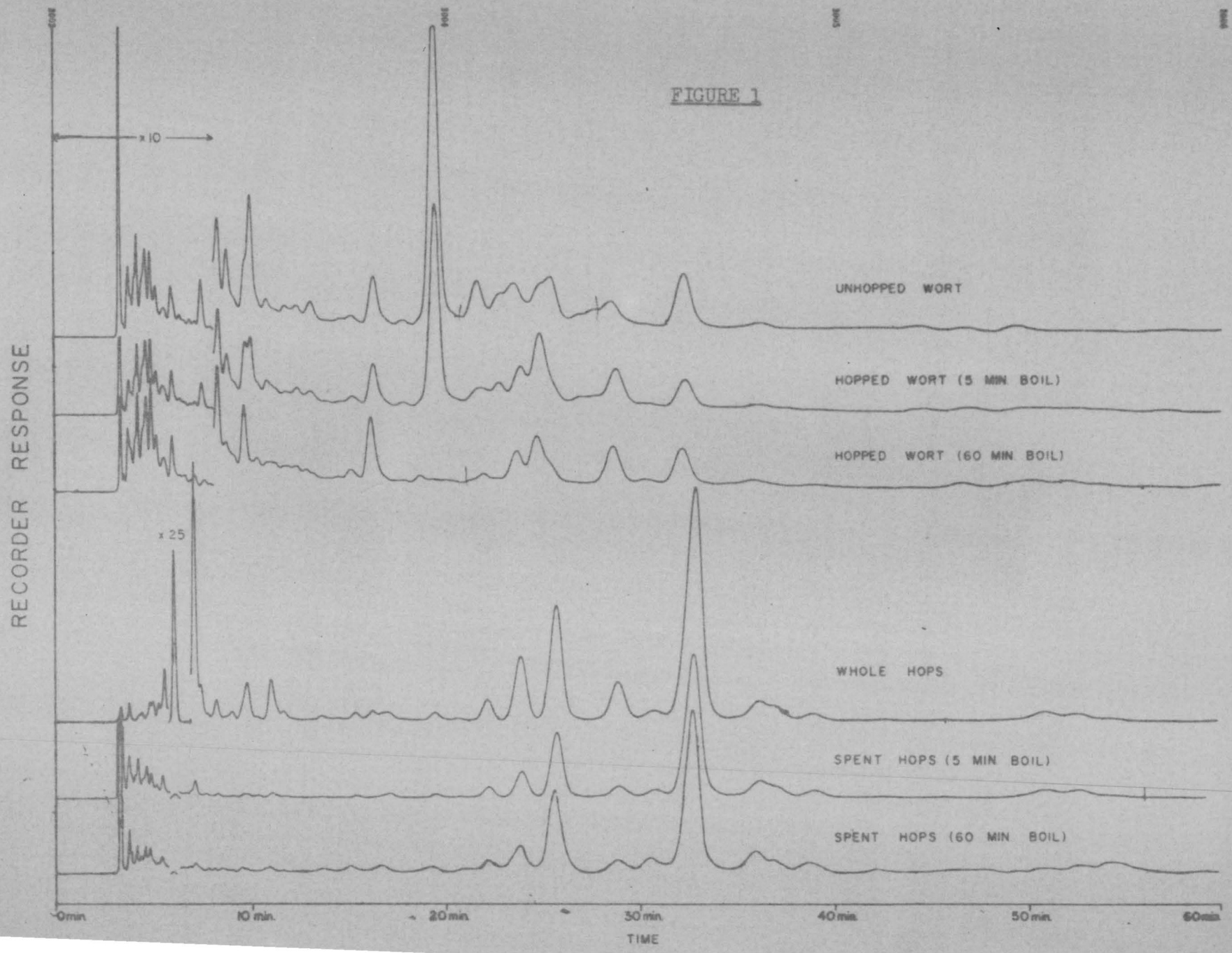
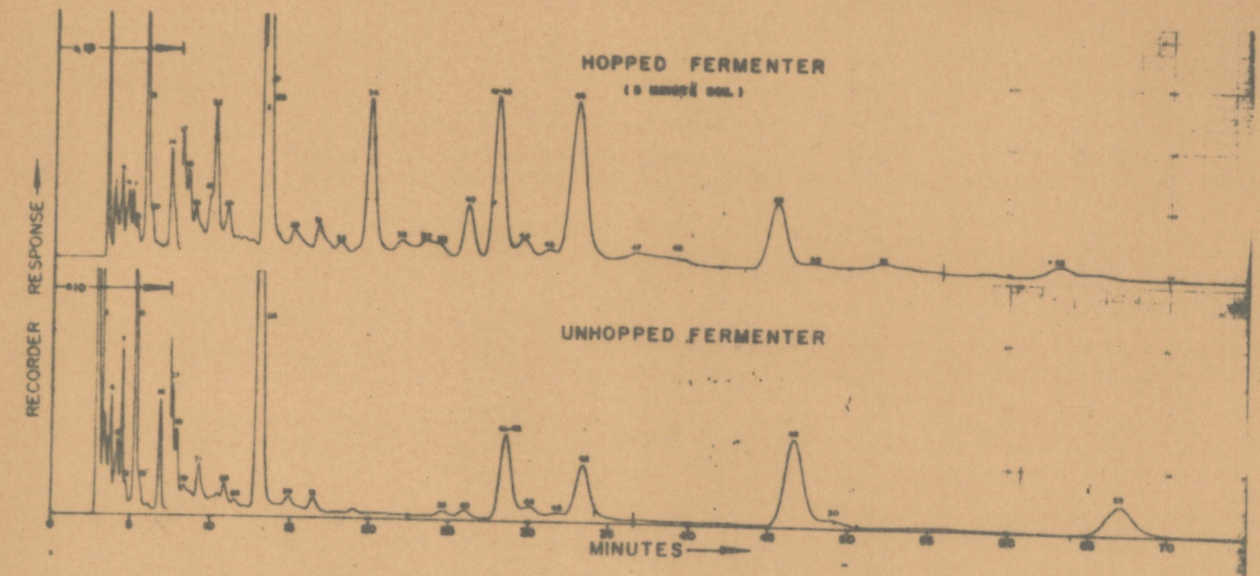
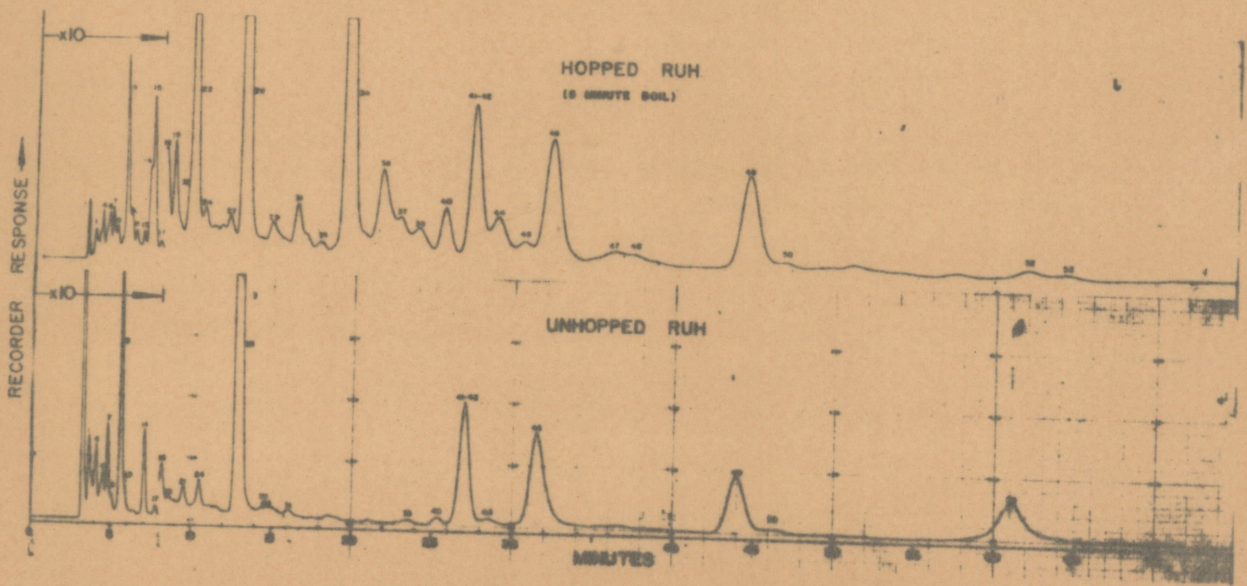

x 10
UNHOPPED WORT
HOPPED WORT (5 MIN. BOIL)
HOPPED WORT (60 MIN. BOIL)
x 25
WHOLE HOPS
SPENT HOPS (5 MIN. BOIL)
SPENT HOPS (60 MIN. BOIL)
RECORDER RESPONSE
0 min.
10 min.
20 min.
30 min.
40 min.
50 min.
60 min.
TIME

FIGURE 2


HOPPED FERMENTER
UNHOPPED FERMENTER
RECORDER RESPONSE
MINUTES


HOPPED RUH
UNHOPPED RUH
RECORDER RESPONSE
MINUTES

AC-9 QUALITY CHANGES DURING DRYING AND BALING.

Summary:

Analyses of oils from the bale-density experiment reported last year indicate that oil losses resulting from baling are brought about by lupulin damage with subsequent preferential disappearance of myrcene.

No new work was initiated on the 1962 crop.

Objective:

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

Duration, reasons, etc:

See AR 1961, p. 67.

Results:

The data, etc. reported here is actually a completion of the work reported last year (1961 AR p. 70-74) under Factors Influencing Storageability. Since the change in oil content and in the composition of the oil was a direct result of baling, it seemed appropriate to put this data under AC-9 this year.

The amount of oil lost by 6 lots of hops including 4 varieties as a result of bale-densities from loose up to 36 lb./cu.ft. was reported last year in Tables 1 and 2 pp. 71 and 73-4. Oil samples collected from 2 widely different varieties, Late Cluster and Brewers Gold were analyzed by gas chromatography 1/. The results (Table 1) indicate that the loss of oil is primarily a result of myrcene polymerization in both varieties.

Photographs of opened cones from loose, 12, 24, and 36 lb./cu. ft. bales showed clearly that lupulin damage was directly associated with the increased density. As suggested last year this fact is undoubtedly associated with myrcene exposure and loss.

No new work was started in 1962 under this work plan but, if time permits, some work on maintaining lower temperatures during baling is anticipated.

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1/ Conditions: Flame ionization detector. 2 µl sample. 1/8 in. x 25 ft. column packed with 5% butanediolsuccinate. Temperature, 160°.

Table 1. The composition of oil recovered from hops baled to various densities. * (Complete data in Appendix).

Variety	Component	Ml.oil/100g.at given bale density(lb./cu.ft.) 1.57(loose)	12.0	24.0	32.0
Brewers Gold	Myrcene	2.808	1.802	1.470	0.909
	humulene	0.266	0.206	0.254	0.238
	β-caryophyllene	0.141	0.124	0.158	0.143
	methylnonylketone	0.019	0.019	0.025	0.025
	others	0.566	0.452	0.487	0.478
	Total	3.800	2.603	2.394	1.793
Late Cluster	Myrcene	0.594	0.473	0.270	0.189
	humulene	0.095	0.079	0.090	0.088
	β-caryophyllene	0.038	0.034	0.035	0.032
	methylnonylketone	0.020	0.022	0.019	0.019
	others	0.172	0.165	0.159	0.140
	Total	0.919	0.773	0.573	0.468

* All results (except the loose samples) are averages of analyses of oils from duplicate bales.

Table 2. Bale density and oil composition for Late Cluster and Brewers Gold (1961 samples, see this rept. CRe5-5, AC-9)

Variety	lb./cu.ft.	ml. oil/ 100 g.	% myr.	% hum.	% β-cary.	% MNK	% other
Brewers Gold	1.57	3.80	73.9	7.0	3.7	0.5	14.9
	12	2.79	68.3	7.6	4.6	0.8	18.7
	12	2.42	70.2	8.3	5.0	0.7	15.8
	24	2.45	60.2	11.4	6.8	1.0	20.6
	24	2.34	62.6	9.8	6.4	1.1	20.1
	32	1.85	53.7	11.9	7.3	1.3	25.8
	32	1.74	47.5	14.8	8.7	1.5	27.5
Late Cluster	1.08	0.92	64.6	10.4	4.1	2.2	18.7
	12	0.84	62.6	9.7	4.2	2.9	20.6
	12	0.71	59.5	10.9	4.6	2.8	22.2
	20.5	0.60	46.6	14.1	5.6	3.4	30.3
	24.0	0.55	47.4	17.5	6.7	3.2	25.2
	30.5	0.51	40.1	18.4	7.1	3.5	30.9
	36	0.43	40.4	19.3	6.8	4.7	28.8
100% whole L.C.	12	0.88	62.5	10.6	4.2	2.4	20.3
100% broken L.C.	12	0.43	50.3	11.8	4.5	2.8	30.6

APPENDIX

Cultural Practices

Low rainfall during January and February provided favorable soil conditions for spring field work. All hops were plowed during the first week of April and the friable soil structure present after plowing may in part have been due to a lower moisture level in the soil profile, but another factor apparently was the addition of lime in the fall of 1960.

Fertilizer was applied to all plots immediately after plowing at the rate of 110 pounds of nitrogen and 75 pounds each of phosphorus and potassium per acre. The breeding block, nursery stock, and genetics trial received only 75 pounds of nitrogen on an acre basis. All plots were pruned by the third week in April and training was completed by May 18th.

The month of May provided ideal moisture conditions for downy mildew infection with 24 rainy days recorded during the month. Initially the disease was curbed by clean farming practice of spike removal followed by hilling the crowns, but the infection persisted throughout the summer and necessitated the use of dust to avoid cone infection. Dithane was dusted on all hops in early July and during the month of August a program was initiated on a 5-day schedule with four applications of Zineb applied prior to harvest. Systox was applied to all plots on the East Farm during the latter part of June for aphid control. The Lewis Brown and Smith yard was sprayed with Metasystox at the rate of 1/2 pound per acre, but it appeared that one application of Metasystox was inadequate for aphid control when compared with two applications applied in 1961. Systox gave excellent aphid control except in the Late Cluster prune and train trial on which moderate to heavy populations appeared by harvest time in mid-September.

Following the completion of the irrigation fertility trials a preliminary study of hop root distribution revealed the presence of a plow sole eight to ten inches below the soil surface. It was apparent that the plow sole limited moisture movement and also that it may have affected the distribution of hop roots. Thirty ton of stable manure was applied to this area during the month of June, indicated on the field map as the Bullion and Early Cluster areas. The area was plowed to a depth of 14 to 16 inches with a single bottom range plow, powered with a tractor crawler. The area was disked and levelled following the plowing operation. This area was planted to Bullion and Early Cluster during the late fall of 1962.

Experimental plots on the East Farm were irrigated only once, with an application of four inches applied during late June and early July. The Smith Yard was irrigated twice, once during late June and again during mid-July, and each application applied approximately two to three inches of water. The two applications were necessary due to the light soil in the yard. The observation block and breeding nursery on the East Farm received three irrigations of two inches each. This practice was followed to help eliminate the loss of cuttings planted in the spring.

Machine harvest of plots started on August 22nd and terminated with the harvest of late varieties on September 17th. Harvest was accomplished over a one month period due to the differences in maturity of treatments and varieties. The actual time spent harvesting was probably less than one week

due to the efficiency of the hop picking machine which is adapted to "spotty" harvesting.

The Lewis Brown yard was dismantled in the fall of 1962 and the area returned to the horticulture department of Oregon State University. The yard was maintained during the last several years as a seedless experimental area under a land agreement with the Horticulture Department. The field map of the Smith Yard is not included in this report, since the outline of the area remained the same as last year. Following the harvest of the East Farm the area was limed at the rate of two tons per acre with beet lime. This lime is a byproduct of the sugar beet industry and contains about 10% added Magnesium Carbonate which may contribute the necessary Mg for our soils.

A platform was constructed and adapted to a hydraulic lift mounted on a Ford tractor. The system is capable of lifting the platform to a height of 16 feet, which enables an individual to reach a 20 foot trellis. The system was used for hauling hops to the picking machine and also for replacing hop poles in the yard. The efficiency of both operations was greatly increased with this equipment in comparison with the wooden cart used in the past.

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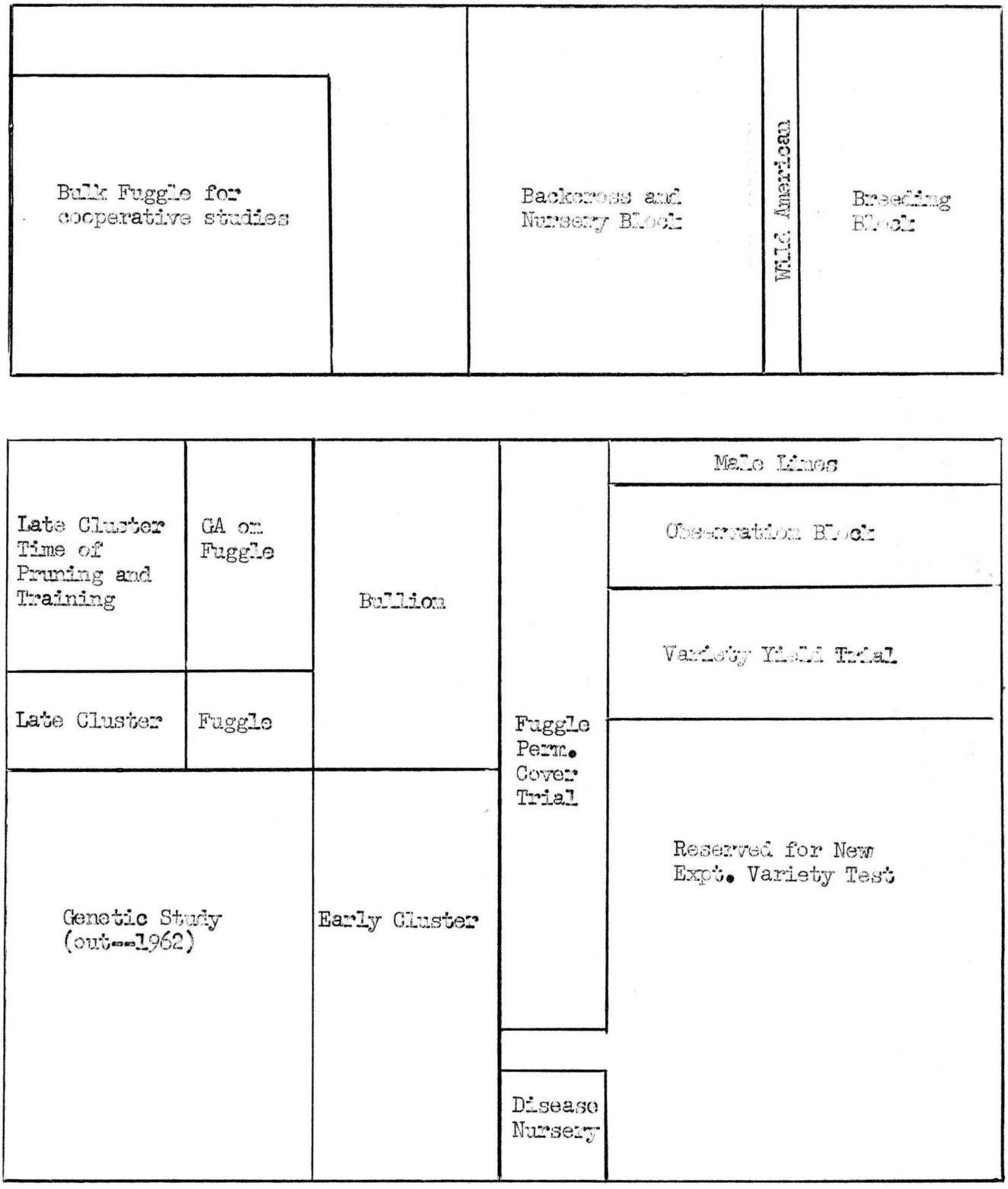
Field Map of Hop Investigations, College East Farm, 1962.



Downy Mildew Reading -- Breeding Block, June 7, 1962. (C.E.H.)

Acc. No.	Hills	Spikes	Rating
C 50008	1	7	S
C 19012	5	0	R
C 50024	1	1	I
C 50040	1	0	R
C 19081	1	0	R
C 19086	1	0	R
C 50075	1	0	R
C 19087	1	0	R
C 50091	1	2	I
C 19022	5	10+	S
C 19069	1	0	R
C 19013	5	10+	S
C 19011	5	0	R
C 50028	1	0	R
C 53001	1	0	R
C 54002	1	0	R
C 19063	4	10+	S
C 54003	1	3	I
C 54004	1	0	R
C 54010	1	0	R
C 19014	5	3	I
C 19070	1	0	R
C 53023	1	0	R
C 19004	5	0	R
C 19089	1	0	R
C 19091	1	0	R
C 19032	5	0	R
C 54029	1	0	R
C 19024	6	4	I
C 19020	5	10+	S
C 51104	1	0	R
C 54015	1	10+	S
C 54014	1	10+	S
C 54074	1	10+	S
C 54006	1	0	R
C 54005	1	0	R
C 19065	3	3	I
C 50056	1	5	S
C 19066	1	3	I
C 19067	1	0	R
C 19072	1	1	I
C 19071	1	0	R
C 53037	1	1	I
C 19026	5	5	I
C 19033	4	2	I
C 53050	1	0	R
C 19093	1	0	R
C 19092	1	0	R

Acc. No.	Hills	Spikes	Rating
C 50054	1	1	I
C 19094	1	1	I
C 19027	5	8	I
I 19001	5	3	I
C 19074	1	4	I
C 19073	1	10+	S
C 19015	5	10+	S
C 53007	1	2	I
C 52018	1	0	R
C 52020	1	10+	S
C 19084	1	0	R
C 19083	1	0	R
C 19076	5	10+	S
C 19018	5	7	I
C 50052	1	2	I
C 53013	1	0	R
C 54066 M	1	0	R
C 19008 M	2	10+	S
C 52046 M	1	0	R
I 19003	5	10+	S
C 19036 M	2	9	S
C 19080	1	6	S
C 19041 M	2	10+	S
C 52005	1	2	I
C 19085 M	2	10+	S
C 19029	5	10+	S
C 19050 M	2	4	I
C 19099	1	4	I
C 19097	1	1	I
C 19058 M	2	8	I
C 19056 M	1	7	S
I 19005 M	2	3	I
C 19057 M	2	7	I
C 19051 M	2	10+	S
C 19053 M	2	10+	S
C 51061 M	2	10+	S
C 19052 M	1	10+	S
C 19043 M	2	4	I
C 19045 M	1	3	I
C 19046 M	2	7	I
C 19044 M	2	9	S
C 19037 M	2	0	R
C 19006 M	2	10+	S
C 52047 M	1	0	R
C 52048 M	1	2	I
C 52040 M	1	0	R
C 52042 M	1	1	I
C 52043 M	1	0	R

Downy Mildew Reading -- Breeding Block, June 7, 1962. (cont.)

Acc. No.	Hills	Spikes	Rating
C 52044 M	1	0	R
C 19010 M	2	0	R
C 52045 M	1	0	R
C 19009 M	2	6	I
C 19039 M	2	1	I
C 19038 M	1	10+	S
C 19040 M	2	0	R
C 19048 M	2	6	I
C 58111 M	2	6	I
C 19047 M	2	10+	S
C 19049 M	1	6	S
C 19055 M	1	0	R
C 19007 M	2	10+	S
C 51101 M	1	10+	S
C 51114 M	1	10+	S
C 19054 M	1	2	I
C 19061 M	1	4	I
C 19059 M	1	1	I
C 19062 M	1	0	R
C 19060 M	2	10+	S
I 19208 M	5	10+	S
I 19120	2	10+	S
C 19118	1	0	R
C 19117	1	14	S
I 19209	5	2	I
C 19113	1	2	I
C 19111	1	1	I
C 19110	1	0	R
I 56001	5	1	R
C 19109	1	Virus 0	
C 19108	1	Virus 1	
I 56002	5	3	I
C 19105	1	1	I
C 19102	1	0	R
C 19101	1	2	I
I 58001	1	0	R
I 57001	5	50+	VS
I 58004	1	10+	S
I 58012	1	0	R
I 58011	1	10+	S
I 58010	1	6	S
I 56006 M	1	0	R
C 19138	1	10+	S
C 19121	1	0	R
C 19122	1	0	R
C 19139	1	0	R

Acc. No.	Hills	Spikes	Rating
C 19040	1	1	I
C 19023	1	0	R
C 19124	1	0	R
C 19142	1	2	I
C 19125	1	0	R
C 19143	1	0	R
C 19145	1	0	R
C 19127	1	0	R
C 19129	2	1	I
C 19130	1	1	I
C 19147	1	0	R
C 19148	1	0	R
C 19132	1	4	I
C 19149	1	1	I
C 19134	1	10+	S
C 19135	1	1	I
C 19152	2	0	R
C 19136	1	2	I
I 19137	1	1	I
C 19183 M	1	0	R
C 19182 M	1	0	R
C 19166	2	3	I
C 19164	1	0	R
I 19162	1	0	R
I 19179 M	1	2	I
C 19178 M	1	0	R
C 19159	1	2	I
C 19176 M	1	0	R
C 19175 M	1	0	R
C 19173 M	1	10+	S
C 19156	1	0	R
C 19155	1	10+	S
C 19172 M	1	2	I
C 19170	1	2	I
I 61-Weed,Jap58	1	0	R
I 58015 M	1	0	R
I 60 (maybe seedling)	1	0	R
I 58016	1	0	R
C 19185 M	1	1	I
C 19188 M	1	0	R
C 19190 M	1	0	R
C 19196	2	0	R
C 19197	1	0	R
C 19200	1	1	I
C 19199	1	9	S

46 Susceptible
59 Intermediate
82 Resistant

128 Females
59 Males
187 Total lines

R Resistant
S Susceptible
I Intermediate

Downy Mildew -- Field Infection on Wild Americans, June 8, 1962.(C.E.H.)

Collection & Clone No.		Downy Mildew Reaction	Collection & Clone No.		Downy Mildew Reaction
Ariz.	1-1	Susc.	Colo.	2-3	Susc.
	1-2	"		3-1	"
	1-3	"		3-2	"
	1-4	"		4-1	"
N.M.	1-1	"		5-1	Res. 4 hills 1 spike
	2-1	"			
	2-2	"		6-1	Susc.
	2-3	"		7-1	"
	2-4	"		7-2	"
	3-1	"	Wyo.	2-1	"
	3-2	"		3-1	"
	3-3	"	Mont.	1-1	"
Colo.	1-1	"	I 58006 M		"
	1-2	"	I 58008		Too small
	1-3	"	I 58004		Susc.
	2-1	"	I 58001		"
	2-2	"	I 59001		"

1962 Downy Mildew Readings -- Male Lines, June 7, 1962. (C.E.H.)

Plot No.	Mildew Rating	Plot No.	Mildew Rating
ML 101	S	ML 311	I
102	R	312	R
103	R	313	R
104	I	314	S
105	-	315	I
106	R	316	R
107	I	317	S
108	-	318	I
109	S	319	S
110	R	320	I
111	S	401	R
112	S	402	I
113	R	403	R
114	I	404	R
115	I	405	I
116	I	406	R
117	I	407	S
118	S	408	S
119	R	409	I
120	I	410	S
201	S	411	I
202	R	412	I
203	I	413	I
204	R	414	I
205	I	415	-
206	R	416	S
207	I	417	-
208	I	418	I
209	R	419	I
210	S	420	I
211	R	501	I
212	I	502	R
213	R	503	R
214	I	504	I
215	S	505	S
216	R	506	I
217	R	507	R
218	S	508	R
219	R	509	R
220	I	510	R
301	I	511	R
302	S	512	I
303	R	513	I
304	S	514	S
305	I	515	R
306	R	516	I
307	I	517	I
308	R	518	R
309	I	519	R
310	-	520	R

R Resistant I Intermediate S Susceptible

1962 Downy Mildew Records on 1959 Nursery

Rating Scale: R Resistant
S Susceptible
VS Very susceptible
I Intermediate
I_1 Spikes w/o sporulation
I_2 Spikes with sporulation

Row & Hill	DM Rating	Row & Hill	DM Rating	Row & Hill	DM Rating
		Cross # 29 (BC 311 x 121-2)			
5-1	S	5-18	VS	5-35	S
5-3	S	5-19	S	5-37	VS
5-4	S	5-20	R	5-38	S
5-6	I	5-21	S	5-40	VS
5-7	VS	5-23	S	5-41	S
5-8	VS	5-24	VS	5-42	I
5-9	S	5-26	I	5-43	S
5-10	VS	5-28	S	5-44	I
5-11	S	5-29	VS	5-46	VS
5-12	S	5-30	S	5-47	R
5-13	VS	5-32	VS	5-48	I
5-15	VS	5-33	I	5-49	R
5-17	S	5-34	VS	5-50	R
		Cross # 41 (422 I x 123 S)			
6-1	S	6-15	VS	6-26	VS
6-5	S	6-16	VS	6-27	VS
6-7	VS	6-17	VS	6-31	VS
6-8	VS	6-20	S	6-32	VS
6-9	VS	6-21	I_2	6-33	VS
6-12	VS	6-22	VS	6-34	VS
6-13	VS	6-23	VS	6-35	S(Dwarf 311
6-14	VS	6-25	VS		x 421-1,2)
		Cross # 59 (Late Cluster x Unknown Male (Reverted))			
7-1	I_2	7-20	VS	7-30	I_1
7-2	S	7-21	VS	7-31	I
7-6	S	7-22	I	7-32	R
7-8	VS	7-24	I	7-35	VS
7-10	VS	7-25	S	7-36	VS
7-12	I	7-26	VS	7-37	S
7-13	S	7-27	S	7-38	VS
7-16	VS	7-28	VS	7-39	VS
7-18	S	7-29	VS	7-41	VS
7-19	VS				
		Cross # 55 (128 I x OP)			
7-42	VS	7-44	VS	7-47	VS
7-43	VS	7-45	VS	7-51	I

1962 Downy Mildew Records on 1959 Nursery. (cont.)

Row & Hill	DM Rating	Row & Hill	DM Rating	Row & Hill	DM Rating
		Cross # 59037 (322 I x 421-1,2)			
8-2	R	8-37	S	9-7	VS
8-3	R	8-38	R	9-8	VS
8-4	S	8-39	VS	9-9	S
8-5	S	8-40	VS	9-10	VS
8-6	S	8-41	S	9-11	I
8-7	I	8-44	R	9-13	I
8-8	I	8-45	R	9-14	S
8-12	VS	8-46	R	9-16	S
8-17	S	8-47	R	9-17	S
8-18	VS	8-48	VS	9-18	I
8-19	VS	8-49	R	9-19	S
8-21	VS	8-50	I	9-20	S
8-25	VS	8-51	R	9-24	S
8-26	VS	9-1	R	9-26	I
8-29	I	9-2	I	9-27	R
8-33	S	9-3	I	9-28	VS
8-35	S	9-5	S	9-29	VS
8-36	S	9-6	VS	9-31	VS
		Cross # 59004 (106 x 317-1,2)			
10-1	R	10-24	S	10-45	I
10-2	I	10-25	VS	10-46	S
10-3	S	10-26	I	10-47	S
10-4	S	10-27	VS	10-48	R
10-5	S	10-28	S	10-50	I
10-6	S	10-29	S	10-51	R
10-7	VS	10-30	S	10-52	R
10-10	VS	10-31	VS	11-1	R
10-11	S	10-32	I	11-2	R
10-15	S	10-33	VS	11-4	S
10-16	VS	10-34	I	11-6	R
10-17	VS	10-35	S	11-9	I
10-18	I	10-36	VS	11-11	I
10-19	S	10-38	I	11-12	S
10-20	VS	10-39	I	11-13	S
10-21	VS	10-40	I	11-16	R
10-22	VS	10-42	I	11-22	R
10-23	VS	10-43	S	11-26	VS
		Cross # 59005 (106 x 321-1)			
11-31	S	11-39	R	11-46	S
11-32	S	11-40	I	11-47	R
11-34	R	11-42	I	11-48	R
11-35	VS	11-44	R	11-50	I
11-37	R				

1962 Downy Mildew Records on 1959 Nursery. (cont.)

Row & Hill	DM Rating	Row & Hill	DM Rating	Row & Hill	DM Rating
		Cross # 59006 (106 x 421-1,2)			
12-1	R	12-5	R	12-10	S (dwarf)
12-3	I	12-7	VS	12-12	S
12-4	R	12-9	R	12-13	S
		Cross # 59019 (212 x 317-1,2)			
12-16	S	12-23	S	12-29	S
12-18	R	12-24	S	12-30	VS
12-19	I	12-26	I	12-31	I
12-20	I	12-27	VS	12-33	R
12-22	R	12-28	I	12-35	I
		Cross # 59029 (314 x 121-2)			
12-39	S	12-42	S	12-45	VS
12-40	R	12-43	I	12-47	R
12-41	I	12-44	R		
		Cross # 59031 (314 x 321-1)			
13-1	R	13-4	R	13-7	I
13-3	S	13-6	S	13-8	S
		Cross # 59042 (409-2 x 317-1,2)			
13-9	R	13-11	R		
		Cross # 59068 (25-S x 317-1, 2)			
13-15	S	13-27	S	13-40	I
13-16	R	13-28	I	13-41	R
13-17	VS	13-29	R	13-42	VS
13-18	VS	13-30	S	13-43	VS
13-19	VS	13-31	VS	13-44	R
13-21	S	13-32	I	13-45	R
13-23	VS	13-34	R	13-46	R
13-25	R	13-36	S	13-49	I
13-26	R	13-39	R		
		Cross # 59069 (25-S x 321-1)			
14-2	S	14-5	I	14-9	S
14-3	S	14-6	I	14-10	R
14-4	I	14-7	S		

1962 Downy Mildew Records on 1959 Nursery. (cont.)

Row & Hill	DM Rating	Row & Hill	DM Rating	Row & Hill	DM Rating
		Cross # 59070 (25-S x 421-1,2)			
14-11	R	14-16	R	14-20	R
14-13	R	14-17	I	14-21	I
14-14	R	14-18	I_1	14-22	I_1
14-15	R				
		Cross # 59075 (Comp Wild A x OP)			
13-50	S	13-51	I	13-52	S

1962 Observation Block - Hop Downy Mildew [1] June 20, 1962 (C.E.H.)

Line No.	Hill Number [2] 1		2		3		4	
OB801	1	R	10+	S	10+	S	10+	S
802	3	I	1/1	B	0	B	0	B
803	-	-	-	-	-	-	-	-
804	-	-	-	-	-	-	-	-
805	-	-	-	-	-	-	-	-
806	-	-	-	-	-	-	-	-
807	-	-	-	-	-	-	-	-
808	10+	S	7	S	10+	S	0	R
809	-	-	-	-	-	-	-	-
810	7	S	2	I	7	S	6	I
811	0	R	0	R	2	I_1	10+	I_2
812	0	R	0	R	0	R	0	R
813	7	S	3	I	3	I	5	I
814	10	S	6	S	10+	S	10+	S
815	10+	VS	10+	VS	10+	VS	10	S
816	0	R	0	R	2	I	4	I
817	10+	S	10+	S	10+	S	10+	S
818	2	I	6	I	3	I	10+	S
819	10+	S	8	S	10+	S	9	S
820	10+	VS	2	I_2	10+	VS	10+	VS
821	9	S	10+	VS	10+	VS	10+	VS
822	10+	VS	10+	VS	8	VS	5	S
3/ 823	Unk.due to drag				7	S	Unk.	

Line No.	Hill Number [2] 1		2		3		4	
OB								
3/ 824	10+	VS	10+	VS	Unk.due to drag			
3/ 825	10+	VS	drag		10+	VS	10	VS
3/ 826	4	S	0	R	0	R	0	R
3/ 827	0	R	3	I	0	R	0	R
3/ 828	4	I	7	S	8	S	3	I
3/ 829	0	R	0	R	0	R	0	RB
3/ 830	0	R	1	R	3	I	1	R
831	10+	S	10+	S	10+	S	10+	S
832	-	-	-	-	-	-	-	-
833	9	S	1	R	0	B	-	-
834	-	-	-	-	-	-	-	-
835	10+	S	6	S	10	S	10+	S
836	10+	VS	-	-	-	-	-	-
837	10+	S	10+	S	10	S	10+	S
838	-	-	-	-	-	-	-	-
839	2	I	0	R	8	S	5	I
840	2	I_2	1	I_2	0	R	0	R
841	1	R	-	-	-	-	-	-
842	0	RB	0	RB	0	RB	0	RB
843	-	-	-	-	-	-	-	-
844	0	RB	0	RB	0	RB	0	RB
845	0	RB	0	RB	0	RB	0	RB

1/ Ratings: R Resistant, S Susceptible, I Intermediate, VS Very susceptible, B Baby, I_1 Spike no sporulation, I_2 Spike light sporulation.

2/ No. before letter represents No. of Spikes.

3/ Cultivation and drag limited reading.

1962 Report on New Hop Varieties at the Irrigation Experiment Station, Prosser, Washington

C. E. Nelson

Planted in spring, 1961

No.	Vigor 0-9*	Cone size 0-9**	(1) Mat.	Aroma 0-9*	No.	Vigor 0-9*	Cone size 0-9**	(1) Mat.	Aroma 0-9*
0-801	5	8	ME	4	0-806	6	5	L	2
0-802	2	2	L	4	0-807	2	4	L	2
0-803	5	5	M	4	0-808	2	2	L	5
0-804	2	2	L	4	0-809	7	5	ME	3
0-805	5	2	ME	5	0-810	6	9	E	2
59-1-34	8	5	ME	2	59-2-5	Missing			
59-1-35	8	4	ME	5	59-2-7	7	2	E	5
59-1-39	3	2	L	2	59-2-15	8	2	L	1
59-1-43	Missing				59-2-19	Missing			
59-2-1	6	8	ME	3	59-2-21	3	2	ML	2
59-5-38	7	6	E	8	59-6-10	3	3	E	4
59-5-44	7	7	ME	8	59-6-12	3	3	E	2
59-6-1 1/	9	8	ME	6	59-6-13	3	3	ME	6
59-6-5	8	7	ME	7	59-6-15	7	5	ME	3
59-6-7	5	5	E	6	59-6-17	7	4	E	5
0-811	3	2	E	3	59-2-31	7	7	E	6
0-812	3	2	ME	4	59-2-33	7	6	E	5
0-813	4	2	M	4	59-2-36	5	4	ML	7
0-814	4	5	M	2	59-2-37	Missing			
0-815	2	2	M	3	59-2-38	3	2	L	2
59-2-25	Missing				59-6-30	6	5	M	7
59-2-26	8	6	E	7	59-6-31	7	6	L	3
59-2-27	7	8	E	5	59-6-32	7	8	ML	5
59-2-29	8	5	ML	3	59-6-33	9	4	E	8
59-2-30	4	1	L	1	59-6-34 1/	8	7	E	8
59-6-19	8	8	ME	7	0-821	3	2	ME	4
59-6-20	7	8	M	5	0-822	5	2	L	2
59-6-22	3	4	L	2	0-823	6	3	ML	5
59-6-25	8	7	M	7	0-824	6	3	ME	4
59-6-27	9	8	M	7	0-825	7	1	L	0
0-816	2	2	E	4	59-2-39	2	2	E	1
0-817	5	3	ML	2	59-2-40	3	2	E	3
0-818	2	2	M	3	59-2-41	8	2	M	9
0-819	Missing				59-2-42 1/	9	8	ME	8
0-820	5	4	M	5	59-3-1	7	7	E	5

* = 0 poor 9 good

** = 0 small 9 large

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

1962 Report on New Hop Varieties at the Irrigation Expt. Stn. (cont.)

No.	Vigor 0-9*	Cone size 0-9**	(1) Mat.	Aroma 0-9*
59-7-2	6	1	VL	0
59-7-6	9	5	ME	5
59-7-10	8	5	E	3
59-7-16	8	5	E	7
59-7-19	6	4	E	4
0-826	6	3	ML	7
0-827	6	3	ME	7
0-828	6	7	M	7
0-829	7	5	M	6
0-830 1/	8	5	M	5
59-3-7	8	9	E	7
59-3-8 1/	8	8	E	6
59-3-9	3	4	M	5
59-3-11	5	9	E	5
59-3-14	7	0	L	0
59-7-20	7	5	E	8
59-7-24	2	1	L	0
59-7-25	8	1	L	6
59-7-28	8	4	E	2
59-7-29	8	5	E	5
59-3-32 #	1	6	E	8
59-3-33	2	1	E	1
59-3-34	5	5	M	5
59-3-40	4	5	L	5
59-3-41 1/	8	8	M	5
523-2	Missing			
523-3	2	6	M	5
526-1	5	2	L	0
526-3	Missing			
526-5	3	2	L	1
59-3-42	4	5	M	7
59-4-1	4	8	M	0
59-4-4	5	1	L	0
59-4-5	6	5	M	3
59-4-6	3	8	E	5
322	2	4	E	3
513-2	3	3	E	2
519-5	5	5	ME	7
8-S	4	4	E	8
15-S	4	8	E	7

No.	Vigor 0-9*	Cone size 0-9**	(1) Mat.	Aroma 0-9*
0-831	5	3	ML	5
0-832	4	5	E	3
0-833	5	5	M	5
0-834	4	2	ML	5
0-835	3	4	M	5
59-3-16	6	7	M	5
59-3-23	Missing			
59-3-25	3	3	E	2
59-3-26	2	2	E	1
59-3-27	Missing			
59-7-31	5	3	E	2
59-7-32	2	4	E	5
59-7-33	5	6	E	6
59-7-36	8	5	ML	5
59-7-40	7	4	E	7
0-836	Missing			
0-837	2	3	E	5
0-838	5	2	E	0
0-839	7	7	E	7
523-1	7	5	L	5
59-4-7	Missing			
59-4-8	Missing			
59-4-9	5	5	M	5
59-4-10 1/	8	7	E	5
59-4-11 1/	8	8	M	7
24-S	3	3	E	6
40-S	1	4	E	6
50-S	4	5	ML	6
95-S	6	6	M	5
# 142-S	Missing			
59-4-14	2	2	L	0
59-4-15	Missing			
59-4-16	5	5	M	5
59-4-18	6	2	ML	5
59-4-19	4	2	L	0
59-1-1	3	5	L	7
59-1-2	1	2	M	7
59-1-4	6	1	L	1
59-1-6	1	2	M	0
59-1-12	4	6	E	6

1962 Report on New Hop Varieties at the Irrigation Expt. Stn. (cont.)

No.	Vigor 0-9*	Cone size 0-9**	(1) Mat.	Aroma 0-9*	No.	Vigor 0-9*	Cone size 0-9**	(1) Mat.	Aroma 0-9*
59-4-21	7	0	L	0	59-4-34	7	4	ME	5
59-4-22	Missing				59-4-35	7	5	M	5
59-4-23	4	1	L	0	59-4-36	7	5	E	7
59-4-24	3	3	M	0	59-5-6	6	3	E	5
59-4-25	Missing				59-5-7	6	3	ME	6
59-1-13	6	5	L	2	59-1-27	1	2	L	0
59-1-15	3	3	E	3	59-1-28	1	2	L	0
59-1-17	7	5	E	1	59-1-29	4	3	M	4
59-1-19	1	3	M	0	59-1-30	3	2	M	6
59-1-20	1	1	L	0	59-1-33	3	3	ME	5
59-4-27	2	3	M	7	59-5-8	2	5	E	5
59-4-29	2	3	M	6	59-5-15	5	4	E	6
59-4-30	Missing				59-2-17	2	4	E	7
59-4-31	1/8	5	M	5	#59-5-21	2	3	ME	1
59-4-33	7	8	M	5	59-2-23	4	3	M	1
59-1-21	3	5	E	7	7-44	7	6	M	5
59-1-22	1	3	M	0					
59-1-23	1	1	L	0	128-I	3	3	ML	7
59-1-24	1	3	E	5					
# 59-1-25	7	7	E	7					
					Planted on Apr. 13, 1962				
524-5 WA	Missing				10-11	7	5	E	5
# 525-3 WA	"				10-10	No data - weak			
523-4 WA	"				10-6	Weak			
OB-843	"				10-5	6	7	M	1
OB-842	"				10-4	6	5	M	2
11-46	6	8	E	7	8-51	2	4	E	3
11-42	5	7	E	8	8-46	Missing			
11-40	Missing				10-3	2	7	E	1
11-32	6	8	E	7	10-2	1	2	M	0
OB-840	6	5	E	8	10-1	2	5	M	5
11-26	7	9	ME	7	8-40	1	5	M	5
11-22	Male				8-39	1	4	M	5
11-16	7	9	E	8	8-38	Missing			
11-6	Male				8-37	2	5	L	5
#525-4 WA	3	1	1	0	8-35	Missing			
10-51	Missing				8-33	6	7	M	6
10-47	5	5	ML	3	8-29	Missing			
11-11	7	7	E	9	8-26	Missing			
11-4	6	7	E	8	8-25	2	4	E	0
11-1	6	8	E	8	8-21	3	4	M	0

1962 Report on New Hop Varieties at the Irrigation Expt. Stn. (cont.)

No.	Vigor 0-9*	Cone size 0-9**	(1) Mat.	Aroma 0-9*
10-45	6	7	E	4
10-43	6	5	ML	1
10-41	Missing			
10-40	3	7	E	1
10-38	Missing			
10-37	2	0	L	0
10-33	Missing			
10-32	Missing			
10-28	Missing			
10-26	Male			
10-24	Missing			
10-23	1	5	M	7
10-21	2	1	L	0
10-20	4	9	M	7
10-15#	2	8	ML	5
13-32	Missing			
13-36	1	8	E	7
13-29	Weak			
13-28	Weak			
13-27	1	7	E	6
13-25	Weak			
13-24	Old plant apparently			
13-23	Missing			
13-19	Missing			
13-18	5	8	M	5
13-17	Old plant?			
13-39	Weak			
13-42	1	4	E	5
13-43	1	6	E	2
13-44	1	4	E	5
13-45	8	8	M	8
13-49	2	7	M	8
13-34	Missing			
13-10	2	5	M	8
13-9	5	2	E	0

No.	Vigor 0-9*	Cone size 0-9**	(1) Mat.	Aroma 0-9*
8-19	7	8	E	7
8-18	Missing			
8-17	Missing			
#8-3	1	6	E	1
8-12	7	4	E	1
8-6	2	2	L	7
8-8	3	4	M	4
8-5	Male			
8-4	5	5	M	0
8-2	2	3	M	7

1962 planting

No.	Vigor 0-9*	Cone size 0-9**	(1) Mat.	Aroma 0-9*
13-8	1	5	E	7
13-6	Missing			
13-3	1	7	E	5
13-1	4	8	E	8
G2071-3	5	4	E	4
12-12	6	3	M	1
12-7	4	4	E	7
12-4	8	8	M	5
12-3	7	6	E	5
12-33	7	3	M	8
12-28	Missing			
12-27	2	7	E	5
12-26	Male			
12-22	2	6	M	1
11-48	1	7	M	7

Numbers checked with original listings and corrected.

1/ Recommended for increase into observation plots in 1963.

Notes on Crosses when Picked

29-9 Ariz. 1-4 x 29-1 Ariz. 1-1-5Ps 1 no good 4 real good, seed very light colored ripe?
422 x 526-4-5Ps 1 died, 1 good 3-few scattered hops.
Storage 312 x 120-5-3Ps 2 died 1 few hops.
523-1 x 30-11-5Ps 1 died, 1-4 hops 3 wonderful huge hops
311 x 421-1,2-8Ps hops on 6 fair 2 died
30-13 x 30-10-5Ps all wonderful, but when thrashed seed real light -- up in blower, just a few seed not ripe.
Storage 401 x 123-S (2 yr old pollen) 3Ps all fair
29-18 x 525-2-5Ps 2 real good 2 fair 1 dry very lousey, seed small and sticky.
122I x 421-1.2 7Ps 1 dead-dry, 3 green not a thing 1-3 hops 1-2 hops 1-7 hops.
311 x 123-S (made 12Ps) 4Ps 2 yr old S. few hops on each not good 8 Ps fair 2Ps just knobs. Very few seed when finished, very perfect when pollinated. Gave up
422 x 123-S 5Ps 1 nothing 2-4 hops 1 fair 1 good
311 x 526-4-5Ps 1 died 3 fair 1 good
29-21 x 29-23-6Ps 5 good, 1 undeveloped
122 x 526-4-6Ps 2 nothing 2 few hops 2 good
29-10 x 525.2 - 6 Ps 2 nothing 2 real good 2 just small knobs
422 x 421-1,2-5Ps 3 vines leaves and stem green no sign of hops 1 with a few good cones, 1 dead
122 x 123-S-6Ps, 1 dead, 2 nothing 3 just a few hops
523-1 x 29-1-5Ps 3 real good, 1 dead, 1 few cones
311 x 5-29-4-8Ps 3 few hops mostly knobs 5 good
422 x 121-2 5 Ps 2 dead, 1 fair 2 few hops
30-12 x 525-2 6 Ps 5 real good, 1 fair, not much left when thrashed
29-21 x 30-10 4 Ps 1 fair 3 with undeveloped hops
29-6 x 29-23 5 Ps 2 dead, 2 few fair hops, 1 knobs - not any seed left
206 x 119-1, 2 S- 3Ps 2 dry and dead, 1 few hops
This is a hard one to x on -- just 2 yr. old storage used 40 seed
412 x 221-2 Storage 2 dead, 1 few hops
401 x 317-1 3 Ps 2 no good, 1 few hops
401 x 119-1,2 3 Ps 1 dead, 2-9 small hops.

Male Line -- Flowering Experiment -- 1962.

Entry	Rep.	Spring Growth	1st Train	1st Flower	2nd Train	2nd Flower
1	I	C	5/16	6/29	6/11	7/20
106-S	II	C	5/16	6/29	6/11	7/23,25
	III	C	5/16	6/30	6/11	7/20
	IV	C	5/16	6/30	6/11	7/18,27
	V	C	5/16	6/12	7/2	7/23
2	I	C	5/16	7/16,18	6/11	7/25
110-S	II	B	5/16	7/16,20	6/15	8/1
	III	C	5/16	7/16,18	6/11	7/30
	IV	A	5/16	7/16,20	6/11	7/30,8/3
	V	C	5/16	7/16,23	6/18	-
3	I	C	5/24	7/9,12	6/15	7/25
123	II	C	5/16	7/9,16	6/11	7/23
	III	B	5/24	7/9,16	6/18	7/23,27
	IV	B	5/21	7/9,12	6/18	7/23
	V	C	5/24	7/5,10	6/18	7/23,25
4	I	D	5/16	7/12,16	6/11	7/23
217	II	D	5/21	7/18,23	6/11	7/27
	III	D	5/16	7/20,23	6/11	7/25,30
	IV	B	5/18	7/12,16	6/11	-
	V	C	5/29	7/18	6/18	7/23
5	I	D	5/16	7/27	6/11	8/3,8
125	II	D	5/16	7/27	6/11	7/30,8/6
	III	D	5/16	7/27,30	6/11	8/6
	IV	D	5/16	7/27,30	6/11	-
	V	D	5/16	7/27,30	6/12	8/10
6	I	B	5/16	7/16,20	6/11	7/25,27
221	II	A	5/29	7/20,23	6/15	7/27
	III	A	5/16	7/18,23	6/11	-
	IV	B	5/21	7/18,23	6/15	-
	V	C	5/24	7/16,23	6/15	-
7	I	A	5/16	7/16,20	6/11	7/27
324	II	A	5/16	7/16,18	6/11	7/25,30
	III	A	5/16	7/23	6/11	8/8
	IV	A	5/24	7/23	6/15	8/3
	V	A	5/16	7/16,23	6/12	7/27
8	I	-	--	--	--	--
224	II	A	5/16	7/23	6/11	7/27
	III	A	5/16	7/18,20	6/11	7/25
	IV	A	5/16	7/16,18	6/11	7/23,25
	V	A	5/16	7/23	6/11	7/30,8/3

Male Line -- Flowering Expt. 1962 (cont.)

Entry	Rep.	Spring Growth	1st Train	1st Flower	2nd Train	2nd Flower
9	I	A	5/16	7/25,27	6/11	7/27-8/1
317	II	A	5/16	7/25,27	6/11	--
	III	--	--	--	--	--
	IV	A	5/16	7/20,23	6/11	7/25,27
	V	A	5/16	7/20,23	6/11	7/23,27
10	I	B	5/16	7/23	6/11	8/1
319	II	B	5/29	7/24,27	6/18	8/1
	III	A	5/24	7/27,30	6/15	8/3,6
	IV	--	--	--	--	--
	V	C	5/16	7/16,20	6/11	--
11	I	B	5/18	7/27	6/11	--
322	II	C	5/18	7/23	6/11	--
	III	C	5/16	7/27,30	6/11	8/1
	IV	B	5/16	7/20,25	6/11	--
	V	A	5/16	7/27	6/11	
12	I	A	--	died		
320	II	A	5/24	7/23,25	6/15	7/27
	III	A	5/16	7/20,23	6/11	7/30,8/1
	IV	--	--	--	--	--
	V	A	5/29	7/23,27	--	8/10
13	I	D	5/16	7/16,20	6/11	7/27
323	II	B	5/16	7/18,23	6/11	8/1
	III	C	5/16	7/12,16	6/11	7/27
	IV	C	5/16	7/12,16	6/11	7/25
	V	C	5/16	7/20,23,	6/11	--
14	I	C	5/16	7/20,23	6/11	7/20,23
424	II	B	5/16	7/18,23	6/11	7/27,30
	III	B	5/16	7/18,20	6/11	7/30
	IV	B	5/18	7/18,23	6/15	7/27
	V	B	5/16	7/16,20	6/11	7/30,8/1
15	I	C	5/16	7/16,18	6/11	7/25
518	II	C	5/16	7/20,23	6/11	7/23
	III	C	5/16	7/23,25	6/11	8/1
	IV	C	5/18	7/23,25	6/11	7/30
	V	C	5/18	7/20,23	6/15	7/27
16	I	--	--	--	--	--
425-1	II	B	5/16	7/27,30	6/11	8/8,10
	III	C	5/16	7/30	6/11	8/1,3
	IV	A	5/16	7/30	6/11	8/6
	V	B	5/16	7/23,27	6/12	--

Male Line -- Flowering Expt. 1962 (cont.)

Entry	Rep.	Spring Growth	1st Train	1st Flower	2nd Train	2nd Flower
17	I	A	5/29	7/27,30	6/15	7/27,8/3
521	II	A	5/21	7/27,30	6/15	7/27,30
	III	B	5/16	7/23,25	6/11	7/27
	IV	A	5/18	7/27,30	6/11	8/1,3
	V	A	5/16	7/27,30,	6/11	8/1,3
18	I	A	5/21	7/16,20	6/15	--
523	II	A	5/16	7/16,18	6/11	7/27
	III	B	5/24	7/23	6/11	7/25
	IV	A	5/24	7/18,20	6/18	7/27
	V	A	5/21	7/16,20	6/15	--
19	I	A	5/16	7/20,23	6/11	7/27
417	II	A	5/16	7/23,30	6/11	--
	III	D	5/24	7/27,27	6/15	--
	IV	A	5/16	7/23,27	6/11	--
	V	B	5/16	7/18,20	6/12	--
20	I	C	5/16	7/12,16	6/11	7/25
524	II	C	5/29	7/16,20	6/15	7/27
	III	B	5/16	7/12,16	6/11	--
	IV	D	5/29	7/27	6/22	--
	V	C	5/16	7/12,18	6/11	--

Spring Growth Measurements

All entries were pruned on 4/16 and 17, at which time the average length of growth was recorded as:

A	0-6 inches	Late
B	6-18 "	Medium
C	18-30 "	Early
D	30 inches & above	Very Early

Inheritance Study -- Downy Mildew 1962 -- June 19, 1962. (C.E.H.)

Line	Hill No. 1	2	3
1001	I_2	IB	--
1002	R	S	R
1003	VS	S	I_1
1004	R	I_2	R
1005	--	S	VS
1006	VS	S	S
1007	RB	R	I_2
1008	--	S	VS
1009	ID	S	I_2
1010	I	I_1	I_1
1011	S	S	--
1012	R	I	--
1013	VS	VS	I
1014	R	I	I
1015	I	S	VS
1016	S	I	S
1017	I_2	R*	I_1
1018	S	S	S
1019	S	S	I
1020	VS	VS	VS
1021	VS	VS	VS
1022	S	S	S
1023	I	S	I,G
1024	I_1	S	I_2
1025	S	S	VS
1026	VS	VS	VS
1027	S	S	VS
1028	VS	VS	VS
1029	I_2	I_2	S
1030	S	R	VS
1031	VS	VS	VS
1032	S	VS	RG
1033	VS	VS	VS
1034	S	I_1	VS
1035	VS	VS	VS
1036	VS	VS	VS
1037	VS	VS	VS
1038	S	VS	VS
1039	ID	I	VS
1040	S	S	VS
1041	VS	S	S
1042	I_2	I_2	S
1043	VS	VS	S
1044	VS	VS	VS
1045	VS	VS	VS
1046	VS	VS	S
1047	VS	VS	VS
1048	VS	S	S
1049	VS	VS	VS
1050	VS	VS	VS

Line	Hill No. 1	2	3
1051	VS	I	I
1052	VS	VS	VS
1053	S	S	I_2
1054	VS	VS	VS
1055	S	R*	S
1056	VS	VS	S
1057	VS	VS	VS
1058	--	I_2	S
1059	S	S	S
1060	S	VS	VS
1061	VS	--	VS
1062	VS	I	S
1063	I_1	I_1	I_2
1064	RB	S	R*
1065	S	--	I_2
1066	--	VS	VS
1067	VS	VS	VS
1068	VS	VS	VS
1069	S	I_2	VS
1070	VS	VS	VS
1071	I_1,B	S	R
1072	VS	VS	VS
1073	S	R*	S
1074	VS	VS	--
1075	VS	VS	VS
1076	VS	VS	VS
1077	I_1	--	VS
1078	VS	VS	--
1079	--	VS	VS
1080	I_1	I_2	I_2
1081	S	VS	S
1082	VS	VS	VS
1083	S	S	R
1084	I_1	S	VS
1085	RB	VS	VS
1086	VS	VS	S
1087	I_2	S	VS
1088	S	VS	VS
1089	VS	VS	VS
1090	--	I	S
1091	--	S	--
1092	VS	VS	VS
1093	I_1	VS	VS
1094	S	VS	S
1095	VS	VS	VS
1096	VS	VS	VS
1097	VS	VS	S
1098	VS	VS	VS
1099	VS	VS	VS
1100	VS	S	VS

Line	Hill No. 1	2	3
2001	VS	VS	VS
2002	S	VS	VS
2003	I	S	S
2004	VS	VS	VS
2005	VS	I_2	--
2006	S	S	S
2007	I	S	S
2008	S	VS	S
2009	VS	VS	VS
2010	VS	VS	--
2011	S	S	I
2012	VS	VS	VS
2013	I_2	S	I
2014	VS	VS	--
2015	VS	VS	S
2016	S	VS	I_2
2017	VS	VS	VS
2018	VS	I	VS
2019	VS	S	S
2020	VS	VS	S
2021	VS	--	S
2022	S	S	S
2023	I	I	S
2024	S	S	VS
2025	I_2	--	VS
2026	I	S	S
2027	R	I	I
2028	S	S	S
2029	VS	S	VS
2030	VS	VS	VS
2031	VS	VS	VS
2032	S	I	R
2033	I	S	S
2034	I	I	I
2035	S	S	S
2036	R	R	I_1
2037	S	S	VS
2038	VS	I	S
2039	R	VS	--
2040	VS	VS	S
2041	S	R	VS
2042	VS	VS	VS
2043	VS	VS	VS
2044	I	VS	VS
2045	VS	S	VS
2046	I_2	I_2	I_2
2047	VS	VS	VS
2048	I	VS	--
2049	VS	S	S
2050	I	I_2	I_1^*

Line	Hill No. 1	2	3
2051	S	I	I_1
2052	VS	R	I
2053	VS	--	S
2054	VS	VS	VS
2055	S	I_1	I_2
2056	VS	S	S
2057	VS	R*	VS
2058	--	VS	VS
2059	VS	VS	VS
2060	I_1	I_1	I_2
2061	VS	VS	VS
2062	VS	VS	VS
2063	--	VS	VS
2064	S	I	I
2065	S	I_1	S
2066	S	IV	S
2067	S	VS	VS
2068	S	I	I
2069	S	VS	VS
2070	S	VS	VS
2071	VS	--	VS
2072	I_1	R	R
2073	VS	VS	VS
2074	S	I	R
2075	S	S	S
2076	VS	VS	S
2077	I_1	S	S
2078	S	S	S
2079	VS	VS	VS
2080	S	S	S
2081	VS	VS	VS
2082	I	I	R*
2083	VS	S	VS
2084	VS	VS	VS
2085	VS	VS	S
2086	S	I_1	S
2087	VS	S	I
2088	VS	VS	VS
2089	VS	VS	IG
2090	VS	VS	VS
2091	S	S	S
2092	VS	VS	--
2093	VS	VS	--
2094	VS	VS	VS
2095	VS	VS	VS
2096	I_1	I	I
2097	VS	S	S
2098	VS	VS	S
2099	S	S	VS
2100	S	VS	VS

Inheritance Study, Downy Mildew 1962 (cont.)

Line	Hill No. 1	2	3
3001	VS	VS	VS
3002	I_1	I_1	VS
3003	S	--	I_1
3004	VS	I_2	S
3005	S	I_2	RG
3006	RV	I_2	R
3007	VS	VS	S
3008	S	VS	I
3009	I_1	I_1	I_1
3010	VS	S	VS
3011	S	S	I_2
3012	S	VS	VS
3013	VS	VS	S
3014	I_1	VS	VS
3015	VS	VS	S
3016	I_2	I_2	I_1
3017	S	S	SB
3018	VS	VS	VS
3019	VS	S	VS
3020	R	I	RB
3021	R	VS	I
3022	VS	VS	VS
3023	VS	VS	VS
3024	VS	I	S
3025	--	S	VS
3026	S	I	S
3027	S	VS	VS
3028	VS	VS	VS
3029	SD	VS	SD
3030	I_2	I_2	I_2
3031	S	S	VS
3032	S	VS	I_2D
3033	S	I	I
3034	I	I_2	I_2
3035	S	S	S
3036	--	VS	I_1
3037	VS	VS	VS
3038	VS	VS	VS
3039	VS	VS	VS
3040	--	VS	--
3041	--	VS	S
3042	VS	I_1	VS
3043	I_2	VS	--
3044	VS	VS	S
3045	I	SB	VS
3046	S	I_1	S
3047	S	S	S
3048	I	I_1	S
3049	S	I_2	S
3050	VS	S	VS

Line	Hill No. 1	2	3
3051	VS	VS	--
3052	S	VS	VS
3053	I_1	I_1	I_2
3054	VS	VS	I_1
3055	VS	S	S
3056	S	R	I
3057	S	S	S
3058	S	VS	S
3059	I	I_1	S
3060	VS	VS	VS
3061	VS	VS	S
3062	--	--	VS
3063	I	VS	VS
3064	S	VS	VS
3065	VS	VS	VS
3066	S	VS	S
3067	VS	S	S
3068	S	VS	S
3069	--	--	--
3070	I_2	S	I_1
3071	VS	VS	VS
3072	S	VS	--
3073	VS	VS	VS
3074	VS	VS	VS
3075	VS	I_2	S
3076	S	S	S
3077	S	VS	S
3078	S	--	--
3079	VS	VS	VS
3080	I_1	I_1	R
3081	I_2	S	I
3082	I_1	I_1B	S
3083	VS	VS	I_2
3084	VS	VS	VS
3085	VS	VS	VS
3086	S	VS	VS
3087	VS	S	VS
3088	S	VS	VS
3089	A	S	VS
3090	S	VS	S
3091	I	I	VS
3092	VS	VS	VS
3093	I	I	S
3094	I	VS	VS
3095	VS	VS	VS
3096	VS	VS	VS
3097	VS	S	VS
3098	S	VS	S
3099	VS	VS	S
3100	VS	VS	--

Line	Hill No. 1	2	3
4001	VS	S	VS
4002	I_2	VS	S
4003	--	--	--
4004	VS	S	VS
4005	I_1	VS	VS
4006	VS	-B	S
4007	VS	VS	S
4008	VS	VS	VS
4009	VS	VS	VS
4010	VS	VS	VS
4011	VS	VS	VS
4012	VS	VS	VS
4013	I_2	I_1	R
4014	VS	VS	S
4015	S	--	S
4016	I	VS	S
4017	VS	VS	VS
4018	VS	VS	VS
4019	--	--	VS
4020	S	VS	VS
4021	S	VS	VS
4022	I_1	I_1	I_1
4023	S	--	VS
4024	VS	VS	VS
4025	I_2	VS	I_2
4026	S	VS	VS
4027	S	VS	VS
4028	VS	VS	VS
4029	S	S	S
4030	S	VS	VS
4031	--	VS	VS
4032	VS	VS	VS
4033	VS	S	S
4034	VS	S	S
4035	S	S	S
4036	VS	VS	--
4037	VS	VS	VS
4038	--	--	--
4039	R	S	VS
4040	I_1	I_2	S
4041	VS	I_1	VS
4042	VS	VS	VS
4043	VS	VS	VS
4044	VS	--	--
4045	I_1	I	I_1
4046	VS	IG	VS
4047	VS	VS	VS
4048	S	VS	VS
4049	VS	S	S
4050	VS	--	VS

Line	Hill No. 1	2	3
4051	VS	VS	VS
4052	I	S	S
4053	S	I	--
4054	VS	VS	VS
4055	VS	VS	S
4056	VS	VS	--
4057	I_1	S	--
4058	S	VS	VS
4059	I_2	I	I
4060	VS	--	S
5001	S	VS	VS
5002	VS	VS	VS
5003	--	--	--
5004	S	--	VS
5005	S	VS	VS
5006	VS	VS	VS
5007	VS	VS	VS
5008	S	S	VS
5009	SB	VSB	--
5010	VS	VS	--
5011	S	S	S
5012	VS	S	VS
5013	I	S	S
5014	I	S	VS
5015	I	--	S
5016	S	VS	S
5017	I_2	I_1	I_1
5018	I_2	VS	--
5019	VS	VS	VS
5020	VS	VS	S
5021	S	VS	I
5022	VS	--	VS
5023	VS	I_1	VS
5024	S	I_1	R
5025	S	S	S
5026	S	VS	S
5027	R	S	I
5028	S	R	S
5029	VS	VS	VS
5030	--	VS	S
5031	VS	VS	VS
5032	VS	VS	VS
5033	--	S	R
5034	S	S	VS
5035	S	VS	VS
5036	VS	VS	VS
5037	VS	VS	S
5038	R*	S	S
5039	VS	VS	S
5040	--	VS	--

Inheritance Study, Downy Mildew 1962 (cont.)

Line	Hill No. 1	2	3
5041	VS	VS	VS
5042	VS	VS	VS
5043	S	VS	VS
5044	I	R	I
5045	S	VS	VS
5046	VS	S	VS
5047	S	VS	S
5048	VS	VS	S
5049	VS	VS	--
5050	VS	VS	S
5051	VS	S	S
5052	VS	I	S
5053	R	R	S
5054	VS	I_1	VS
5055	VS	S	VS
5056	VS	VS	VS
5057	VS	VS	--
5058	S	I	VS
5059	I	I	I
5060	S	I	I
6001	VS	VS	VS
6002	VS	VS	VS
6003	VS	VS	VS
6004	VS	S	VS
6005	S	VS	VS
6006	S	S	S
6007	S	VS	VS
6008	VS	VS	S
6009	VS	VS	--
6010	I	R	VS
6011	S	VS	VS
6012	I_2	I_2	I_2
6013	S	VS	VS
6014	--	VS	VS
6015	S	I_2	I_1
6016	VS	VS	VS
6017	VS	--	I
6018	VS	VS	VS
6019	VS	VS	VS
6020	VS	VS	VS
6021	VS	VS	VS
6022	--	S	VS
6023	VS	VS	VS
6024	VS	VS	VS
6025	S	--	VS
6026	2B	VS	VS
6027	S	S	S
6028	S	S	SB
6029	VS	--	VS
6030	VS	VS	VS
6031	I	I_2	RB

Line	Hill No. 1	2	3
6032	--	--	--
6033	VS	--	--
6034	VS	VS	VS
6035	I_1	I	I
6036	S	I_2	S
6037	--	--	--
6038	S	S	VS
6039	I	I	VS
6040	I	I	I
6041	I	S	S
6042	VS	VS	--
6043	VS	VS	VS
6044	RG	S	I_1
6045	I_2	S	VS
6046	VS	VS	VS
6047	S	VS	VS
6048	VS	S	S
6049	--	VS	SB
6050	R	S	VS
6051	VS	VS	VS
6052	S	VS	VS
6053	VS	VS	VS
6054	--	VS	VS
6055	--	VS	VS
6056	VS	VS	VS
6057	VS	VS	I
6058	--	S	VS
6059	-B	-B	--
6060	S	VS	I

Resistance Rating

S Susceptible
R Resistant
I Intermediate

Spike Type Classification

I_1 non sporulating early dying spikes.
I_2 Light sporulation.
* Very resistant
G Genetic abnormality
B Baby hop

			Hill No. 1	2	3	4	5
R-17-1	A x S		S	VS	S	VS	R*
R-17-2	A x T		VS	RB	VS	R	--
R-17-3	A x T		S	S	VS	I	S
R-17-4	A x R		S	S	VS	VS	S
R-17-5	A x R		VS	VS	S	VS	VS
R-17-6			--	--	--	--	--
R-17-7	A x X		I_2	I_1	S	--	VS
R-17-8	A x Y		I	I_1	S	--	--
R-17-9	A x Y		I	I	I	I_2	S
R-17-10	G x Z		VS	RB	S	S	--
R-16	A x S		S	VS	VS		
R-15	A x S		VS	VS	VS		
--							
R-13	A x Z		VS	VS	VS		
R-12	Z		I	I	S		
--							
R-10	X		--	I_2	I_2		
R-9	T		S	VS	VS		
R-8	S		VS	VS	VS		
--							
R-6	G		S	S	S		
R-5	F		VS	VS	VS		
R-4	E		VS	VS	VS		
R-3	D		I_1	I_1	I_1		
R-2	C		I_1	I_1	I_1		
R-1	A		S	S	S		
--							
R-17-11			R*	VS	VS	I	S
R-17-12			S	S	VS	S	VS
R-17-13			R	I	I	I_2	I
R-17-14			I_2	VS	--	S	S
R-17-15			S	S	--	VS	R
R-17-16			--	VS	VS	--	S
R-17-17			--	--	--	VS	--
R-17-18			--	--	--	--	--
R-17-19			VS	VS	VS	VS	VS
R-17-20			I	S	--	S	I
R-17-21			R*	I	S	--	I
R-17-22			--	--	--	--	--
R-17-23			VS	VS	VS	VS	VS
R-17-24			VS	VS	VS	VS	VS
R-17-25			VS	VS	VS	VS	VS
R-17-26			S	--	--	--	--
R-17-27			--	--	--	--	--
R-17-28			--	--	--	--	--
R-17-29			--	--	--	--	--
R-17-30			S	S	I_1	S	R
R-17-31			--	I	I	R*	--

Harvest Weights in the Gibberellic Acid Trial on Fuggle in 1962.
Harvest weight by reps. (not adj. for moisture)

Entry	Replication I	II	III	IV	V	VI	Total	Avg.
1	38.0	47.3	46.1	44.7	50.4	55.1	281.6	43.6
2	41.2	41.7	43.0	45.7	38.3	47.9	257.8	43.0
3	45.3	33.9	41.5	46.2	50.8	47.5	265.2	44.2
4	39.1	38.9	42.6	44.0	53.3	42.4	260.3	43.4
5	43.8	46.1	42.7	46.8	44.9	46.8	271.1	45.2
6	37.2	33.8	43.0	52.3	49.7	49.4	265.4	44.2
7	38.1	36.8	44.7	42.4	52.8	51.1	265.9	44.3
8	35.3	38.7	43.9	35.1	42.3	50.4	245.7	41.0
9	39.1	37.4	43.0	47.8	52.2	60.4	279.9	46.6
10	40.7	41.2	43.6	47.7	39.2	49.8	262.2	43.7
Total	397.8	395.8	434.1	452.7	473.9	500.8	2655.1	

S_y = 2,655.10
S_{y^2} = 119,341.11
$S_y{}^2T^2$ = 705,943.05
$S_y{}^2R^2$ = 1,183,664.43

Analysis of Variance

Source	DF	SS	MS	F	
Treatment	9	164.575	18.286	1.02	N.S.
Replication	5	873.843	174.769	9.71	**
Error	45	810.092	18.002		
Total	59	1,848.510			

Moisture dry-down percentages from the gibberellic acid trial on Fuggle are given on page 125.

Gibberellic Acid on Fuggle - East Farm

% α -acid (dry weight basis)

Entry	Replication I	II	III	IV	Total	Ave.
1	6.39	7.05	5.21	5.97	24.62	6.13
2	6.67	6.70	6.83	7.17	27.37	6.84
3	6.83	6.33	5.15	5.90	24.21	6.05
4	6.39	6.02	5.73	5.39	23.53	5.88
5	6.24	7.05	5.74	6.10	25.13	6.28
6	6.55	5.72	5.41	6.49	24.17	6.04
7	6.40	5.69	7.55	5.17	24.81	6.21
8	4.67	6.83	6.45	5.83	23.78	5.95
9	5.98	6.55	5.32	6.63	24.48	6.12
10	5.90	7.26	6.39	7.17	26.72	6.68
Total	62.02	65.20	59.78	61.82	248.82	6.22

$Sy = 248.82$
$Sy^2 = 1,565.3684$
$Sy^2T^2 = 6,205.0054$
$Sy^2R^2 = 15,492.8812$

Analysis of Variance

Source	DF	SS	MS	F	
Treatment	9	3.4665	0.3852	0.82	N.S.
Replication	3	1.5033	0.5011	1.07	N.S.
Error	27	12.6138	0.4672		
Total	39	17.5836			

% β -acid (dry weight basis)

Entry	Replication I	II	III	IV	Total	Ave.
1	2.36	2.15	2.40	2.29	9.20	2.30
2	2.40	2.17	2.13	1.56	8.26	2.06
3	2.19	2.60	2.47	2.36	9.62	2.41
4	2.40	2.61	2.64	2.46	10.11	2.53
5	2.57	2.17	2.88	2.32	9.94	2.43
6	2.27	2.50	2.88	1.63	9.28	2.32
7	2.81	2.27	2.42	2.20	9.70	2.42
8	2.94	2.49	2.25	2.46	10.14	2.53
9	2.46	2.11	2.79	2.25	9.61	2.40
10	2.25	2.52	2.15	1.58	8.50	2.12
Total	24.65	23.59	25.01	21.11	94.36	2.36

$Sy = 94.36$
$Sy^2 = 226.3856$
$Sy^2T^2 = 894.0578$
$Sy^2R^2 = 2,235.2428$

Analysis of Variance

Source	DF	SS	MS	F	
Treatment	9	.91927	.10213	1.42	N.S.
Replication	3	.92904	.30968	4.31	*
Error	27	1.94211	.07193		
Total	39	3.79036			

Gibberellic Acid on Fuggle - East Farm

Oil content (ml/100g dry matter)

Entry	Replication I	II	III	IV	Total	Ave.
1	0.98	0.91	1.09	0.95	3.93	.98
2	0.86	1.03	0.97	1.03	3.89	.97
3	1.03	0.92	0.92	0.92	3.79	.95
4	1.08	0.97	0.92	0.89	3.86	.97
5	1.02	1.07	0.86	0.81	3.76	.94
6	1.06	0.87	0.92	1.03	3.88	.97
7	1.03	1.08	0.95	0.76	3.82	.95
8	0.92	1.03	0.92	0.81	3.68	.92
9	1.00	1.08	0.92	1.00	4.00	1.00
10	0.79	1.02	0.87	1.09	3.77	.94
Total	9.77	9.98	9.34	9.29	38.38	.96

Sy = 38.38
Sy^2 = 37.1356
Sy^2T^2 = 147.3804
Sy^2R^2 = 368.5930

Analysis of Variance

Source	DF	SS	MS	F
Treatment	9	.021949	.002439	0.23 N.S.
Replication	3	.033369	.011123	1.18 N.S.
Error	27	.25681	.0095115	
Total	39	.30999		

Cone Weight (mg) on Gibberellic Acid Trial on Fuggle, 1962

Entry	Replication I	II	III	IV	Total	Ave.
1	155	160	163	165	643	161 abc
2	117	135	138	136	526	132 de
3	116	134	145	132	527	132 de
4	161	165	146	152	624	156 bc
5	140	133	146	153	572	143 cd
6	111	133	109	120	473	118 e
7	171	161	170	186	688	172 ab
8	152	156	148	156	612	153 bcd
9	130	141	132	152	555	139 cde
10	135	165	176	236	712	178 a
Total	1388	1483	1473	1588	5932	

S_{y_2} = 5,932
S_{y^2} = 900,374
$S_{y^2T^2}$ = 3,571,000
$S_{y^2R^2}$ = 8,817,306

Analysis of Variance

Source	DF	SS	MS	F
Treatment	9	13,034.4	1,448.3	6.97 **
Replication	3	2,015.0	671.7	3.23 *
Error	27	5,609.0	207.7	
Total	39	20,658.4		

Cone Length (mm) on Gibberellic Acid Trial on Fuggle, 1962

Entry	Replication I	II	III	IV	Total	Ave.
1	32	33	33	29	127	32 ab
2	28	28	29	29	114	28 cd
3	28	30	28	29	115	29 bcd
4	31	30	29	29	119	30 bc
5	30	26	31	29	116	29 bcd
6	24	26	28	26	104	26 d
7	34	32	33	34	133	33 a
8	30	30	30	30	120	30 bc
9	26	31	32	29	118	30 bc
10	30	31	33	36	130	32 ab
Total	293	297	306	300	1196	

S_{y_2} = 1,196
S_{y^2} = 36,008
$S_{y^2T^2}$ = 143,696
$S_{y^2R^2}$ = 357,694

Analysis of Variance

Source	DF	SS	MS	F
Treatment	9	163.6	18.2	6.50 **
Replication	3	9.0	3.0	1.07 N.S.
Error	27	75.0	2.8	
Total	39	247.6		

Height of Trellis Experiment — Harvest Weights (adj. for moisture) 1962.

		Fuggle	LC	BG	144I	135I	128I	Total
	16'	25.4	35.0	29.6	45.8	15.5	35.4	186.7
I	18'	18.6	22.7	29.4	40.0	27.2	26.1	164.0
	20'	(25.8)	39.9	26.1	36.7	24.1	45.4	(198.0)
	Sub.	(69.8)	97.6	85.1	122.5	66.8	106.9	(548.7)
	16'	27.4	27.9	35.2	30.0	20.0	43.6	184.1
II	18'	25.3	20.0	34.8	49.9	27.8	42.7	200.5
	20'	24.7	18.8	30.8	38.8	31.3	59.7	204.1
	Sub.	77.4	66.7	100.8	118.7	79.1	146.0	588.7
	16'	25.1	15.5	43.7	33.3	33.6	39.6	190.8
III	18'	27.8	28.8	35.4	51.1	26.6	60.5	230.2
	20'	37.3	19.3	27.3	46.1	37.0	62.8	229.8
	Sub.	90.2	63.6	106.4	130.5	97.2	162.9	650.8
	Total	237.4	227.9	292.3	371.1	243.1	415.8	1788.2

Sy^2 = 65,647.12
Sy_2T^2 = 563,884.60
Sy_2R^2 = 1,071,180.02
Sy_2H^2 = 1,068,360.26
Sy^2RT = 358,911.48
Sy^2TH = 190,559.36

CF = 59,215.912

	Fug.	LC	BG	144I	135I	128I	Total
16'	77.9	78.4	108.5	109.1	69.1	117.6	561.6
18'	73.7	71.5	99.6	141.0	81.6	129.3	594.7
20'	87.8	78.0	84.2	121.6	92.4	167.9	631.9

Analysis of Variance

Source	DF	SS	MS	F
Heights	2	137.436	68.718	1.61 N.S.
Replication	2	294.089	147.044	3.40 N.S.
Error a	4	172.931	43.233	
Subtotal a	8	604.456		
Varieties	5	3,437.932	687.586	12.42 **
V x H	10	728.507	72.851	1.32 N.S.
Error b	30	1,660.313	55.344	
Subtotal b	45	5,826.752		
Grand total	53	6,431.208		

Height of Trellis Experiment - 1962

α-acid (dwb)

Rep.	Height	Variety Fug.	L.C.	B.G.	144-I	135-I	128-I	Sum
I	16'	6.70	8.03	8.26	2.85	2.14	10.30	38.28
	18'	5.85	7.29	7.15	2.99	2.71	9.42	35.41
	20'	(6.06)	8.32	8.18	3.41	2.71	8.56	37.24
		18.61	23.64	23.59	9.25	7.56	28.28	110.93
II	16'	6.02	6.35	8.18	3.34	2.05	11.03	36.97
	18'	5.23	6.20	7.63	2.61	3.32	8.59	33.58
	20'	6.42	6.09	7.69	3.30	2.15	6.70	32.35
		17.67	18.64	23.50	9.25	7.52	26.32	102.90
III	16'	4.70	5.25	6.83	2.93	1.39	7.45	28.55
	18'	5.30	6.01	7.86	2.68	2.23	8.12	32.20
	20'	4.77	4.59	6.40	2.37	5.31	7.83	31.27
		14.77	15.85	21.09	7.98	8.93	23.40	92.02
		Variety x Height Interaction						
	16'	17.42	19.63	23.27	9.12	5.58	28.78	103.80
	18'	16.38	19.50	22.64	8.28	8.26	26.13	101.19
	20'	17.25	19.00	22.27	9.08	10.17	23.09	100.86
		51.05	58.13	68.18	26.48	24.01	78.00	305.85

Sy^2	2,045.2775
Sy^2V^2	17,995.3823
Sy^2R^2	31,361.5553
Sy^2H^2	31,186.5957
Sy^2Sub a	10,476.7193
Sy^2VH	6,027.1111

Analysis of Variance

Source	DF	SS	MS	F
Height	2	0.28823	0.14412	-- N.S.
Replication	2	10.00821	5.00410	5.68 N.S.
Error a	4	3.52302	0.88076	
Subtotal a	8	13.81946		
Varieties	5	267.18650	53.43730	70.59 **
V x H	10	9.26188	0.92619	1.22 N.S.
Error b	30	22.70924	0.75697	
Subtotal b	45	299.15762		
Grand	53	312.97708		

Height of Trellis Experiment - 1962

β-acid (dwb)

Rep.	Height	Variety						
		Fug.	L.C.	B.G.	144-I	135-I	128-I	Sum
I	16'	2.73	5.63	4.08	4.82	5.07	4.42	26.75
	18'	2.31	4.35	3.94	4.93	5.42	4.56	25.51
	20'	(2.47)	3.32	4.12	4.74	5.88	4.56	25.09
		7.51	13.30	12.14	14.49	16.37	13.54	77.35
II	16'	2.32	3.24	4.00	4.32	4.81	4.61	23.30
	18'	2.69	2.43	3.94	5.20	5.47	4.34	24.07
	20'	2.90	2.41	4.33	4.96	5.68	7.27	27.55
		7.91	8.08	12.27	14.48	15.96	16.22	74.92
III	16'	3.41	2.65	4.39	4.68	6.39	5.11	26.63
	18'	3.41	2.33	4.49	4.57	5.55	5.14	25.49
	20'	2.67	2.66	4.14	3.49	4.50	4.80	22.26
		9.49	7.64	13.02	12.74	16.44	15.05	74.38
Variety x Height Interaction								
	16'	8.46	11.52	12.47	13.82	16.27	14.14	76.68
	18'	8.41	9.11	12.37	14.70	16.44	14.04	75.07
	20'	8.04	8.39	12.59	13.19	16.06	16.63	74.90
		24.91	29.02	37.43	41.71	48.77	44.81	226.65

Sy^2 = 1,021.4435
Sy^2V^2 = 8,989.8465
Sy^2R^2 = 17,128.4133
Sy^2H^2 = 17,125.3373
Sy^2Sub a = 5,731.4927
Sy^2VH = 3,007.6485

Analysis of Variance

Source	DF	SS	MS	F
Heights	2	0.10721	0.05360	-- N.S.
Replication	2	0.27810	0.13905	-- N.S.
Error a	4	3.56305	0.89076	
Subtotal a	8	3.94836		
Varieties	5	47.57141	9.51428	18.96 **
V x H	10	3.57046	0.35705	-- N.S.
Error b	30	15.05285	0.50176	
Subtotal b	45	66.19472		
Grand	53	70.14308		

Dry-down Percentages, 1962

Height of Trellis Experiment

		Fuggle	LC	BG	144I	135I	128I	Totals	Avg.
	16'	26.3	24.6	29.5	21.8	29.9	29.8	161.9	27.0
I	18'	26.3	24.2	30.6	23.0	25.9	29.1	159.1	26.5
	20'	(26.3)	26.8	29.9	24.1	28.0	29.4	(164.5)	(27.4)
	Sub.	(78.9)	75.6	90.0	68.9	83.8	88.3	(485.5)	
	Avg.	26.3	25.2	30.0	23.0	27.9	29.4		
	16'	25.7	24.4	28.8	23.0	27.2	28.6	157.7	26.3
II	18'	25.9	24.2	29.1	22.2	27.9	30.2	159.5	26.6
	20'	26.9	25.1	30.2	23.7	29.4	30.3	165.6	27.6
	Sub.	78.5	73.7	88.1	68.9	84.5	89.1	482.8	
	Avg.	26.2	24.6	29.4	23.0	28.2	29.7		
	16'	25.8	24.9	29.0	21.1	26.8	27.5	155.1	25.8
III	18'	25.8	24.1	29.4	23.0	27.4	27.8	157.5	26.2
	20'	26.6	24.9	30.1	21.9	28.0	26.7	158.2	26.4
	Sub.	78.2	73.9	88.5	66.0	82.2	82.0	470.8	
	Avg.	26.1	24.6	29.5	22.0	27.4	27.3		
Overall Avg.		26.2	24.8	29.6	22.7	27.8	28.8		26.6

Harvest Weights in the Date of Pruning and Training Trial on Late Cluster in 1962.
Harvest weight by reps. (not adj. for moisture)

Entry	Replication I	II	III	IV	V	VI	Total	Ave.
1	49.1	54.8	59.2	47.3	46.2	38.3	294.9	49.2
2	45.0	34.5	38.9	47.6	47.2	42.5	255.7	42.6
3	55.4	43.4	36.4	51.5	43.8	43.8	274.3	45.7
4	46.4	53.6	56.4	51.0	47.1	41.9	296.4	49.4
5	53.1	35.0	27.9	53.1	41.4	34.2	244.7	40.8
6	49.4	40.2	44.2	36.6	40.7	45.2	256.3	42.7
Total	298.4	261.5	263.0	287.1	266.4	245.9	1622.3	

Sy = 1,622.30
Sy_2 = 74,909.49
Sy^2T^2 = 441,009.73
Sy^2R^2 = 440,455.99

Analysis of Variance

Source	DF	SS	MS	F
Treatment	5	394.475	78.895	1.78 N.S.
Replication	5	302.185	60.437	1.37 N.S.
Error	25	1105.683	44.227	
Total	35	1802.343		

Prune and Train -- Late Cluster, 1962

% α-acid (dry weight basis)

Entry	Replication I	II	V	VI	Total	Ave.
1	6.02	5.22	5.81	5.87	22.92	5.73
2	6.20	5.49	4.60	5.32	21.61	5.40
3	6.56	5.45	5.17	6.04	23.22	5.81
4	6.22	6.48	7.87	7.29	27.86	6.97
5	6.39	7.16	6.06	7.24	26.85	6.71
6	7.58	6.79	7.45	7.77	29.59	7.40
Total	38.97	36.59	36.96	39.53	152.05	6.33

$Sy = 152.05$
$Sy^2 = 982.1255$
$Sy^2T^2 = 3,904.1571$
$Sy^2R^2 = 5,786.1515$

Analysis of Variance

Source	DF	SS	MS	F
Treatment	5	12.7391	2.5478	7.60 **
Replication	3	1.0584	.3528	1.05 N.S.
Error	15	5.0279	.3352	
Total	23	18.8254		

% β-acid (dry weight basis)

Entry	Replication I	II	V	VI	Total	Ave.
1	3.56	3.93	3.93	3.62	15.04	3.76
2	4.12	3.60	3.94	3.75	15.41	3.85
3	4.23	4.06	3.55	3.23	15.07	3.77
4	4.53	3.58	3.27	4.54	15.92	3.98
5	5.23	3.48	3.63	4.34	16.68	4.17
6	4.14	3.28	3.12	4.52	15.06	3.77
Total	25.81	21.93	21.44	24.00	93.18	3.88

$Sy = 93.18$
$Sy^2 = 367.7806$
$Sy^2T^2 = 1,449.2470$
$SY^2R^2 = 2,182.7546$

Analysis of Variance

Source	DF	SS	MS	F
Treatment	5	.5404	.1081	N.S.
Replication	3	2.0211	.6737	2.81 N.S.
Error	15	3.4478	.2399	
Total	23	6.0093		

Oil content (ml/100g dry matter)

Entry	Replication I	II	V	VI	Total	Ave.
1	.34	.80	.73	.67	2.54	.63
2	.73	.62	.68	.67	2.70	.67
3	.74	.73	.73	.67	2.87	.72
4	.79	.67	.78	.78	3.02	.75
5	.95	.45	.56	.72	2.68	.67
6	.85	.56	.70	.78	2.89	.72
Total	4.40	3.83	4.18	4.29	16.70	.69

Sy = 16.70
Sy^2 = 11.9896
Sy^2T^2 = 46.6334
Sy^2R^2 = 69.9054

Analysis of Variance

Source	DF	SS	MS	F
Treatment	5	0.0379	.00758	N.S.
Replication	3	0.0305	.01016	N.S.
Error	15	0.3008	.02005	
Total	23	0.3692		

Cone Length (mm) on Pruning and Training of Late Cluster, 1962.

Entry	Replication I	II	III	IV	Total	Ave.
1	32	32	32	30	126	32
2	31	36	31	30	128	32
3	32	31	33	31	127	32
4	33	32	31	31	127	32
5	31	31	30	29	121	30
6	31	32	30	30	123	31
Total	190	194	187	181	752	

Sy = 752
Sy^2 = 23,608
Sy^2T^2 = 94,288
Sy^2R^2 = 141,466

Analysis of Variance

Source	DF	SS	MS	F
Treatment	5	9.3	1.9	1.36 N.S.
Replication	3	15.0	5.0	3.57 *
Error	15	21.0	1.4	
Total	23	45.3		

Cone Weight (mg) on Pruning and Training of Late Cluster, 1962

Entry	Replication I	II	III	IV	Total	Ave.
1	141	179	166	158	644	161
2	155	193	151	171	670	168
3	184	142	160	170	656	164
4	162	180	191	167	700	175
5	143	178	162	146	629	157
6	164	184	202	169	719	180
Total	949	1056	1032	981	4018	

Sy = 4,018
Sy^2 = 679,102
Sy^2T^2 = 2,696,574
Sy^2R^2 = 4,043,122

Analysis of Variance

Source	DF	SS	MS	F
Treatment	5	1,463.3	292.7	1.16 N.S.
Replication	3	1,173.5	391.2	1.55 N.S.
Error	15	3,785.0	252.3	
Total	23	6,421.8		

Moisture Dry-down Percentages, 1962

Entry	1	2	5	6	Total	Avg.
Prune and Train on LC - 1962						
1	30.0	27.1	31.4	33.7	122.2	30.6
2	29.0	32.6	31.7	30.3	123.6	30.9
3	30.2	26.3	30.3	32.0	118.8	29.7
4	29.4	28.2	33.0	31.4	122.0	30.5
5	30.0	33.0	32.0	31.7	126.7	31.7
6	29.6	32.0	35.1	32.1	128.8	32.2
					742.1	30.9
Gibberellic Acid on Fuggle - 1962						
1	26.5	26.5	28.1	28.8	109.9	27.5
2	25.5	26.1	26.3	27.1	105.0	26.2
3	26.7	25.9	26.8	27.3	106.7	26.7
4	27.0	26.5	25.9	26.9	106.3	26.6
5	24.8	25.7	25.8	27.2	103.5	25.9
6	26.1	26.9	27.8	28.0	108.8	27.2
7	26.6	26.7	26.1	26.9	106.3	26.6
8	24.8	26.7	27.2	27.6	106.3	26.6
9	25.7	27.2	26.9	28.3	108.1	27.0
10	27.0	26.8	25.9	27.9	107.6	26.9
					1068.5	26.7

Detailed composition of hop oil from hand-picked and machine-picked loose and baled (24 lb./cu.ft.) Fuggle during 164-day storage period at room temperature. *

Time (days)	Hand Picked: Loose Total	Myrcene	Hum.	B-car.	MNK	Others	Hand Picked: Bale Total	Myrcene	Hum.	B-car.	MNK	Others
0	2.030	1.295	0.355	0.108	0.067	0.205	1.730	1.035	0.355	0.096	0.017	0.227
½	2.010	1.246	0.354	0.105	0.018	0.287	1.610	1.006	0.282	0.082	0.016	0.224
1	2.009	1.234	0.227	0.098	0.018	0.432	1.829	1.039	0.351	0.110	0.016	0.313
2	2.129	1.335	0.362	0.109	0.021	0.302	1.979	1.132	0.364	0.099	0.020	0.364
4	2.130	1.297	0.394	0.109	0.019	0.311	1.449	0.780	0.336	0.093	0.017	0.223
7	2.130	1.278	0.411	0.128	0.019	0.294	1.479	0.679	0.327	0.090	0.019	0.364
21	2.130	1.453	0.344	0.096	0.021	0.226	1.169	0.567	0.273	0.078	0.021	0.230
51	1.909	1.155	0.288	0.088	0.015	0.363	1.140	0.536	0.374	0.069	0.014	0.147
77	1.791	0.963	0.281	0.081	0.020	0.446	1.239	0.481	0.374	0.108	0.021	0.255
164	1.340	0.772	0.276	0.072	0.023	0.197	0.749	0.295	0.253	0.063	0.018	0.120

Time (days)	Machine Picked: Loose Total	Myrcene	Hum.	B-car.	MNK	Others	Machine Picked: Bale Total	Myrcene	Hum.	B-car.	MNK	Others
0	1.970	1.235	0.278	0.098	0.018	0.341	1.399	0.865	0.270	0.081	0.014	0.169
½	1.929	1.220	0.316	0.081	0.015	0.297	1.630	0.944	0.308	0.091	0.015	0.272
1	1.860	1.177	0.324	0.085	0.017	0.257	1.649	0.907	0.343	0.104	0.016	0.279
2	1.710	1.048	0.291	0.087	0.012	0.272	1.700	0.932	0.328	0.100	0.017	0.323
4	1.790	0.848	0.455	0.115	0.023	0.349	1.238	0.666	0.315	0.085	0.015	0.157
7	1.870	1.154	0.305	0.087	0.021	0.303	1.300	0.688	0.309	0.087	0.018	0.198
21	1.660	1.057	0.274	0.038	0.017	0.274	1.010	0.491	0.276	0.081	0.016	0.146
51	1.709	1.026	0.248	0.058	0.013	0.364	0.941	0.375	0.240	0.071	0.015	0.240
77	1.540	0.952	0.282	0.086	0.017	0.203	0.859	0.372	0.258	0.071	0.015	0.143
164	1.149	0.613	0.217	0.064	0.018	0.237	0.589	0.192	0.175	0.051	0.014	0.157

* Total and each component expressed in ml./100 g. dry hops.