Problems Relating to Flax Retting and Fiber Quality FINAL REPORT ON STATE PROJECT No. 83*

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INTRODUCTION

The Willamette Valley of Oregon is one of the few areas in the United States where conditions are considered suitable for growing fiber flax. It is the only such area where fiber flax is grown commercially. Under the stimulus of federal support brought about by lack of imports during World War II, production was expanded rapidly in Western Oregon. At the industry's height in the early 1940's 37,000 tons of flax straw were grown in the Willamette Valley, which produced about 3,300 tons of flax fiber, and 14 processing plants were in operation. With the withdrawal of subsidies following the war production declined until at present only one or two plants continue to operate.

During the war period spinners readily took all the fiber that was produced. After the war when imported fiber was again available, certain objections to domestic fiber were raised. These included unsatisfactory grading of flax straw and flax fiber and the presence of excessive wax in the fiber which was blamed for frequent costly shut-downs of spinning plants to remove wax deposits from the machinery.

In an effort to solve some of the problems encountered by the Oregon flax industry during this period the Oregon Agricultural Experiment Station late in 1946 inaugurated a co-operative research project involving several areas of investigation. The Department of Agricultural Chemistry conducted work on chemical degumming, wax solvents, relationship of maturity and variety to wax content, relationship of maturity to moisture and oil content of flax seed and miscellaneous chemical analyses for other departments involved in the program. The Bacteriology Department studied the retting process from various angles such as fermentation by-products, nutrition of retting organisms, aerobic retting, retting water and other factors related to retting. The Department of Agricultural Engineering and the Division of Agricultural Engineering of the Bureau of Plant Industry, Soils and Agricultural Engineering were responsible for development of flax processing machinery, determining the point at which natural tank retting was complete, design and construction of an artificial drier for flax straw and for conducting experimental retting studies. The Division of Cotton and Other Fiber Crops and Diseases, Bureau of Plant Industry, Soils and Agricultural Engineering supplied flax straw and fiber for the project as well as growing the varietal samples and the maturity samples.

This report deals with that portion of the project for which the Department of Agricultural Chemistry was responsible and covers the period from late 1946 to 1955. However, only minor service work on the project for other departments was done in 1946, 1954 and 1955. The work will be reported by subject rather than chronologically.

INVESTIGATION RESULTS

Ret Water

A series of retting experiments was conducted by the Agricultural Engineering Division of B.P.I.S. and A.E. at a Lane

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County flax plant. Two retting tanks were used in which factors of temperature and water replacement were varied; in one tank manually and in the other automatically. Development of acidity in the retting water was used as a measure of the effect of the variables employed. Ret water samples were taken at approximately 24 hour intervals over the duration of the ret (5 to 6 days). Total acidity, permanent acidity and pH were determined on each sample. Total acidity increased for about 4 days after which it remained fairly constant. pH decreased for about 3 days after which it did not change. Permanent acidity was more erratic but in general tended to increase throughout the whole retting period. The effects of the several variables employed were not large enough to be significant nor was the rate of acid development exact enough to be used as a measure of the completeness of retting.

Soluble solids in the water used for retting at this plant were 100–125 parts per million. The tank water after retting contained 3,000—4,000 ppm of dissolved material.

Solvent for Flax Wax

The solubility of flax wax was determined in nine different solvents which are readily available in most chemical laboratories. The tabulation below lists the solvents tested in order of their effectiveness in dissolving flax wax. The solubilities are listed as parts of wax in 100 parts of solution at 25°C.

Methyl alcohol ..	.086	Ethyl ether ..	.490
Petroleum ether	.222	Acetone ..	.494
Ethyl alcohol ..	.246	Benzene ..	1.020
Kerosene ..	.288	Chloroform ..	1.614
Stoddard solvent	.386		

Although ethyl ether was not the most effective of those tested it was quite satisfactory as a wax solvent and was used for all laboratory extractions.

Wax Deposits from Spinning Machinery

Wax deposits were collected from several machines at the Salem linen mill and samples of the deposits were extracted. It was found that the extractible material varied from t0% to 40% by weight. The remaining 60% 2o 80% of the deposit was made up of dirt and particles of flax fiber and similar material which became imbedded in the sticky wax. Inasmuch as there is usually a considerable amount of such dust in the atmosphere of a spinning mill deposits on machines may build up rapidly if the flax fiber being processed carries much wax.

Wax Content of Domestic and Foreign Flax Fiber Samples

A comparison of wax content of 11 foreign and 68 domestic flax fibers was made. The foreign lots were mostly from Belgium with single samples from Ireland, Japan and Canada. The domestic lots came from the Molalla, Washington County, Mt. Angel, Santiam and Springfield plants of the Willamette Valley.

WAX CONTENT OF FOREIGN AND DOMESTIC FLAX FIBER IN PERCENT

	Foreign 11 samples	Foreign 9 samples*	Domestic 68 samples
Minimum ..	1.42	1.42	2.17
Maximum ..	3.49	2.65	4.80
Range ..	2.07	1.23	2.63
Mean ..	2.12	1.85	3.47
Standard deviation ..	.669	.364	.497

*Same as column 1 but with 2 high wax samples omitted.

Although each group of samples contains some individuals that depart markedly from their respective mean values, it is evident for the lots examined that the foreign fibers have a considerably lower wax content than the domestic fibers.

Relationship of Turning Flax Bundles to Wax in Resulting Fiber

After retting is completed the bundles of flax straw are set up in the form of "wigwams" to dry. If the lot consists of large bundles or if drying is slowed down by adverse weather conditions it is a standard practice to cut the ties and turn the bundles inside out to facilitate drying. Some spinners and processors claim that straw "turned" during drying will yield a fiber which gives less wax accummulation on spinning machinery. Some tests were made to check the validity of this contention. The data are summarized below.

WAX CONTENT OF FIBER FROM UNTURNED AND TURNED FLAX STRAW IN PERCENT

	Unturned 44 lots	Turned 46 lots
Minimum ..	2.46	1.81
Maximum ..	3.54	3.81
Range ..	1.08	2.00
Mean ..	2.91	2.89

In most cases unturned and turned samples were duplicates from the same lots of flax straw. Wide differences in wax content, but without definite trends, indicate that the pairs of samples were not uniform material. The mean values for the two treatments show that there is no difference in wax content of the two groups of samples.

There being no apparent difference in the amount of wax in the fiber from unturned and turned straw, the idea was explored that turning may bring about some oxidation and hence result in a less sticky or gummy wax.

To test this theory six lots of flax straw were sampled in duplicate. One sample of each pair was dried without turning ; the other was turned repeatedly over a much longer time than is normally required for drying. This treatment provided ample opportunity for oxidation to take place. The samples were then scutched and the iodine number or wax from each of the 12 samples was determined. This is a measure of the saturation (oxidation) of the double bonds in a fat of wax. The following table gives the results.

IODINE NUMBERS OF FLAX FIBER WAX FROM UNTURNED AND TURNED FLAX STRAW

Sample	Unturned	Sample	Turned
1	72.03	7	67.89
2	69.71	8	65.11
3	72.04	9	62.12
4	70.84	10	65.88
5	76.24	11	64.69
6	80.45	12	64.53
Mean ..	73.55	—	65.04

These data confirm the idea that some oxidation of the wax does take place as a result of turning the straw during drying. Whether this oxidation is sufficient to form a less sticky wax could only be determined by a test of sufficient size to yield several tons of fiber for full scale spinning mill trials. Unfortunately such a test was beyond the scope of our experimental set-up.

Chemical Degumming of Flax Fiber

The process of removing fiber from flax straw by mechanical means without previous retting is termed decortication. Fiber prepared in this manner retains considerable woody material which is not readily removed by the scutchers. However if such fiber is digested with certain chemicals the extraneous matter is loosened so that scutching will yield a fiber that compares favourably with that prepared from retted straw.

Natural retting can be done only when weather conditions are favourable for drying. On the other hand, decortication and chemical degumming can be done the year around. It is obvious that a plant can be operated more economically on a continuous basis than one which can be used only a few months each season. With this idea in mind a number of chemical degumming experiments on decorticated flax straw were conducted to see if a satisfactory fiber could be prepared by this means.

Chemical degumming is not a new process and it has been tried on many kinds of fiber. Most processes involve digestion of the straw or decorticated fiber with an alkali such as sodium hydroxide, sodium carbonate, sodium phosphate or sodium sulfide either alone or in combination with or followed by other materials. The latter are to restore to the fiber some of the oiliness or softness that has been removed by the alkali and in some cases to bleach the fiber.

The sample weight loss from the various treatments varied from 27% to 41% depending on the effectiveness of decortication and the type of degumming treatment. Most samples lost about 30% to 35%. The material removed by the treatment is mostly cortex and woody substance and some pectin and gums which cement the fiber bundles together.

Many degumming combinations were tested the details of which will not be related here. Our tests indicate that while a single digestion treatment may yield a clean, white fiber it will be too brittle and harsh for spinning. A second treatment is required to restore the necessary softness and flexibility to the fiber so that it can be spun. Effective primary treatments were boiling for 1 hour in 1% to 2% sodium hydroxide or in 1% sodium carbonate plus sodium sulfide solution. The secondary treatment involved acidification by hydrochloric acid with addition of a bleach such as hydrogen peroxide and a substance such as the higher molecular weight polyethylene glycols to restore softness to the fiber. Another effective primary treatment was a 1 hour boil in 4% sodium sulfite. With this chemical no bleach was required in the secondary treatment but acidification and a fiber softening agent were necessary as with the other primary treatments.

No strength tests were made on fiber prepared by decortication and chemical degumming although subjective tests by experienced spinning mill men indicated that it was as strong as fiber prepared by natural retting. Quantities large enough for actual spinning trials were not prepared in these experiments nor were comparative cost studies made. No doubt chemical degumming would be somewhat more expensive than natural retting.

Relation of Maturity of Flax to Wax Content of Fiber

Early in the flax fiber investigations it was noted that the wax content seemed to increase as the flax matured. On the basis of these observations plots were seeded in 1948, 1949 and 1950 from which samples were harvested at weekly intervals beginning in late June and continuing for eleven weeks. Triplicate lots of each harvest were retted and scutched and the resulting fibers were tested for wax content (ethyl ether extract). The data were statistically analyzed by the experiment station statistical service. The 1948 test was on only one variety of flax; the 1949 and 1950 tests included three varieties. The analytical and statistical data for the three seasons' samples are tabulated in Tables I, II and III.

Except for the 1st and 10th harvests (possibly poor samples) there appears to be an increase in wax content of the fiber until late in the season. B.P.I., S. and A. E. co-operators' work on these samples shows that the optimum yield and quality occurred between 78 and 85 days after planting (Aug. 7 to Aug. 20 harvests). Likewise flax seed from these harvests had reached a maximum germination percentage and oil content. These figures and observations would indicate that for best quality harvesting should be done two or three weeks earlier than is now common practice (105 to 110 days after planting in Willamette Valley).

The analysis of variance in Table I indicates a high degree of significance in the relationship of maturity to wax content.

Differences in wax content with maturity were not as evident in the 1949 lots as they were in the previous year. Nor did the statistical analysis indicate that the three varieties, Liral Prince, Concurrent and Cascade, were significantly different in wax content.

The seed from these lots had reached a maximum oil content by the July 18 harvest date or about 95 days after planting or about 10 days longer than for the 1948 samples. It is probable that year to year weather variations have a definite bearing on the time required for a crop to mature. For example, wax content of 1946 crop flax from a number of Willamette Valley plants was higher than for lots from either 1945 or 1947 crops from the same plants.

There was more of a trend in wax content in the 1950 lots than was shown in the 1949 samples but not as much as in the 1948 experiments. Here too, a very significant varietal difference in wax content showed up in contrast to none in the 1949 samples from the same varieties. Liral Prince variety was considerably lower in wax than Concurrent or Cascade which confirmed some earlier tests on 1947 crop samples but which did not show up in the 1949 tests.

Again maximum oil content of the flax seed from the 1950 samples was reached at 87 to 94 days after planting. (July 17 to July 24 harvests) well before the normal commercial harvest time. The data in Table IV represent a slightly different approach to the maturity effect than do those in Tables I, II and III. In this case the planting dates were varied rather than the harvest dates. The first two replicates in each lot were harvested two weeks earlier than the last three, but in only three instances, Cascade planted 3–30–51 and both varieties planted 4–20–51 do the wax contents of the earlier harvested replicates differ significantly from the later harvested ones. These may be due to sample variation as it is evident that the range in some of the other sets of five replicates is rather wide. The trend of the averages, however, points towards lower wax contents for the earlier planted lots.

To summarise the investigation of the relationship of flax fiber wax to maturity it may be said that (1) there is a poorly defined trend indicating increase of wax with maturity, (2) there appear to be wax differences due to variety, (3) seasonal weather variations may affect wax content and (4) seed maturity increased fiber yield and quality and lower wax content of fiber suggest that earlier harvesting may be advantageous.

Wax Content of Flax Fiber as Related to Flax Variety

Some preliminary observations on flax from the 1947 and 1950 crops suggested the possibility that wax content of the fiber was to some extent a varietal characteristic. A more extensive test of possible varietal effects was set up in 1952. Ten varieties were grown at three locations and at one of these early and late plantings were made. The pertinent data are given below in Table V and furnish some very interesting information.

The fiber from some varieties such as Norfolk Queen, Liral Prince and Tallmune has less wax than the commercial varieties Cascade and Concurrent. There are, however, some exceptions which seem to be related to the location where the flax was grown. For example, these three varieties from the Granger Experiment Station Farm have as high or higher wax than the commercial types. Without exception the Granger Farm lots have definitely higher wax than corresponding lots grown either at the East Farm or near the Santiam Flax plant in the Jefferson area.

It is obvious also that the time of seeding may be an influencing factor in the wax content of the fiber. The late-planted plots on the East Farm were definitely higher in wax than the plots planted two weeks earlier although both lots were harvested about the same number of days after planting. It thus appears that the wax content of fiber may be affected by time of seeding and location where grown as well as by variety. Since climatic conditions are practically identical in the three locations where these plots were grown variations in wax content of any one variety must be attributed to other causes such as soil or fertilizer differences.

Miscellaneous Services

A great many flax fiber samples have been tested for wax content for other departments co-operating on this project. These include miscellaneous commercial lots of fiber, lots that were unturned and turned during drying, lots from various tank retting treatments, a series in which retting time was varied from 68 to 164 hours, a series representing different seed treatments for disease control, a series from fertilizer trial plots, two series in which moisture content was varied at the time of scutching and several lots from experimental retting trials for the Bacteriology Department. Some decorticated lots were chemically degummed for project co-operators.

SUMMARY

This terminal report covers all research and service work done by the Department of Agricultural Chemistry on State Project 83. Problems Relating to Flax Retting and Fiber Quality.

The investigations include :—

1. Acidity of ret water as an indicator of retting completion.
2. Solvents for dissolving wax from flax fiber.
3. Nature of wax deposits from flax spinning machinery.
4. Comparison of wax content of some domestic and foreign flax fiber samples.
5. The relationship of turning straw during drying to amount and nature of wax in the resulting fiber.
6. Preparation of flax fiber by chemical treatments as a substitute for tank retting.
7. The relationship of maturity to the wax content of the fiber prepared from flax straw.
8. Wax content of flax fiber as a varietal characteristic.
9. Miscellaneous tests and analyses for other departments co-operating on flax investigations.

CONCLUSIONS

1. The increase of ret water acidity is not a suitable measure of retting end-point for Oregon flax as it is processed at Willamette Valley plants.
2. Most common organic solvents will dissolve the wax from flax fiber. Ether, acetone, benzene and chloroform are among the better ones tested.
3. Wax deposits on spinning machinery are composed of 20–40% wax and 60–80% of dirt and flax fiber particles which became imbedded in the wax.
4. For the lots tested foreign flax fiber had a lower wax content than domestic flax.
5. Turning flax straw to facilitate drying did not affect the wax content but did appear to result in some oxidation of the wax.
6. Flax fiber can be prepared by mechanical decortication followed by chemical degumming. This fiber is not as good as that prepared from retted flax and no doubt is more costly to produce.
7. Wax content of flax fiber appears in some seasons to increase with maturity of the flax from which it was prepared but this relationship was not consistent for the three seasons in which the correlation was studied. This relationship may at times be complicated by other factors such as soil or seasonal weather conditions. These investigations indicate that by harvesting flax ten days or two weeks earlier than the prevailing practice will yield a fiber of lower wax content without any sacrifice in yield or quality of fiber or seed.
8. Wax content of flax fiber was shown definitely to be related to variety. This may explain at least partially, the lower wax content of European fiber.

(*Continued on Page 182.*)

TABLE I.

FIBER FLAX MATURITY STUDIES—1948 CROP.
PLANTED MAY 19, 1948.

Sample Number	Harvest Date	Percent Wax in Fiber		Percent Oil in Seed	
1A	7— 9—48	3.18		—	
1B		3.22	3.26 ave.	—	
1C		3.38		—	
2A	7—16—48	2.50		—	
2B		2.90	2.66 ave.	—	
2C		2.58		—	
3A	7—23—48	2.91		—	
3B		2.82	2.79 ave.	—	
3C		2.63		—	
4A	7—30—48	2.67		28.84	
4B		3.01	2.84 ave.	21.81	22.78 ave.
4C		2.85		21.68	
5A	8— 7—48	2.86		34.81	
5B		2.79	2.77 ave.	34.74	34.85 ave.
5C		2.65		35.02	
6A	8—14—48	3.23		35.67	
6B		2.67	2.85 ave.	36.45	36.10 ave.
6C		2.66		36.19	
7A	8—20—48	3.22		35.85	
7B		3.21	3.20 ave.	36.25	36.11 ave.
7C		3.17		36.24	
8A	8—27—48	3.10		36.65	
8B		3.15	3.24 ave.	36.61	36.54 ave.
8C		3.47		36.36	
9A	9— 3—48	3.60		36.57	
9B		3.53	3.48 ave.	36.87	36.79 ave.
9C		3.31		36.94	
10A	9—17—48	3.13		36.31	
10B		3.13	3.13 ave.	35.97	36.07 ave.
10C		3.14		35.92	
11A	9—24—48	——		36.08	
11B		3.66	3.55 ave.	36.48	36.36 ave.
11C		3.43		36.53	

ANALYSIS OF VARIANCE.

Variation Due to:	Sum of Squares	Degrees of Freedom	Mean Square	F	Remarks
Total	3.7671	32	——	——	—
Dates	3.0959	10	.3096	10.15**	—
Error	.6712	22	.0305	——	—

Sx = .1008

L.SD. = .2958 at 5% level.
= .4020 at 1% level.

**Significant at the 1% level.

TABLE II.

FIBER FLAX MATURITY STUDIES—1949 CROP.

VARIETY : LIRAL PRINCE. PLANTED APRIL 15, 1949.

Sample	Harvest Date	% Wax		% Oil	
1501	6—20—49	4.24		No Sample	
1502		3.69	3.94 ave.		
1503		3.89			
1518	6—30—49	3.34		26.37	
1519		3.19	3.36 ave.	23.77	25.17 ave.
1520		3.56		25.36	
1527	7— 5—49	3.85		29.47	
1528		3.14	3.47 ave.	26.18	28.21 ave.
1529		3.41		28.98	
1536	7—11—49	4.18		33.34	
1537		3.71	3.94 ave.	32.66	33.56 ave.
1538		3.94		34.69	
1545	7—18—49	3.37		34.31	
1546		3.30	3.39 ave.	36.23	35.32 ave.
1547		3.51		35.43	
1554	7—25—49	3.58		34.88	
1555		3.31	3.32 ave.	35.74	35.41 ave.
1556		3.07		35.61	
1563	8— 2—49	3.27		34.44	
1564		3.29	3.29 ave.	35.91	35.31 ave.
1565		3.32		35.59	
1573	8— 8—49	2.92		35.31	
1574		3.05	3.08 ave.	36.65	36.20 ave.
1575		3.27		36.65	
1581	8—15—49	4.01		34.04	
1582		3.34	3.65 ave.	36.79	35.73 ave.
1583		3.60		36.35	
1590	8—23—49	4.30		33.30	
1591		3.58	3.81 ave.	35.46	34.60 ave.
1592		3.56		35.04	
1599	8—29—49	3.46		35.26	
1500		3.48	3.51 ave.	35.79	35.52 ave.
1399		3.60		35.50	
1508	6—20—49	3.68		No Sample	
1509		3.37	3.71 ave.		
1510		4.07			
1511	6—30—49	2.96		21.02	
1512		2.86	3.14 ave.	21.41	21.82 ave.
1513		3.59		23.03	
1521	7— 5—49	3.36		23.20	
1522		3.23	3.74 ave.	24.40	24.98 ave.
1523		4.64		27.33	
1530	7—11—49	3.53		26.51	
1531		3.66	3.84 ave.	29.85	27.47 ave.
1532		4.33		26.06	
1539	7—18—49	3.41		35.03	
1540		3.58	3.60 ave.	34.18	34.06 ave.
1541		3.82		32.98	

TABLE II—*Continued.*

VARIETY : CONCURRENT. PLANTED APRIL 15, 1949.

Sample	Harvest Date	% Wax		% Oil	
1548	7—25—49	3.47		35.55	
1549		3.58	3.57 ave.	34.46	35.08 ave.
1550		3.65		34.94	
1557	8— 2—49	3.56		35.44	
1558		3.56	3.73 ave.	35.16	34.54 ave.
1559		4.06		33.01	
1566	8— 8—49	3.50		33.85	
1567		3.63	3.74 ave.	33.52	33.03 ave.
1568		4.10		31.62	
1575	8—15—49	3.38		34.83	
1576		3.57	3.59 ave.	33.74	33.70 ave.
1577		3.82		32.53	
1584	8—23—49	3.60		32.92	
1585		3.78	3.72 ave.	33.53	32.74 ave.
1586		3.79		31.78	
1593	8—29—49	3.61		35.24	
1594		3.51	3.58 ave.	34.17	33.72 ave.
1595		3.62		31.74	

VARIETY : CASCADE. PLANTED APRIL 15, 1949.

Sample	Harvest Date	% Wax		% Oil	
1504	6—20—49	4.08		No Samples	
1505		3.33	3.76 ave.		
1506		3.86			
1515	6—30—49	2.76		No Samples	
1516		3.54	3.15 ave.		
1517		3.14			
1524	7— 5—49	3.39		23.41	
1525		3.96	3.60 ave.	26.18	25.10 ave.
1526		3.46		25.70	
1533	7—11—49	3.49		28.80	
1534		4.52	3.87 ave.	29.49	28.78 ave.
1535		3.60		28.06	
1542	7—18—49	3.27		35.94	
1543		3.51	3.46 ave.	35.34	35.51 ave.
1544		3.60		35.26	
1551	7—25—49	3.42		35.87	
1552		4.01	3.66 ave.	34.51	35.61 ave.
1553		3.56		36.45	
1560	8— 2—49	3.06		37.19	
1561		3.49	3.25 ave.	36.30	36.24 ave.
1562		3.19		35.24	
1569	8— 8—49	3.99		36.93	
1570		3.38	3.56 ave.	35.30	36.37 ave.
1571		3.30		36.89	

TABLE II—*Continued.*

Sample	Harvest Date	% Wax		% Oil	
1578	8—15—49	3.19		36.06	
1579		3.78	3.46 ave.	33.48	35.34 ave.
1580		3.42		36.49	
1581	8—23—49	3.17		36.06	
1588		3.14	3.27 ave.	35.16	35.89 ave.
1589		3.50		36.46	
1596	8—29—49	3.50		34.99	
1597		3.91	3.57 ave.	33.15	34.07 ave.
1598		3.30		No Sample	

TABLE III

FIBER FLAX MATURITY STUDIES—1950 CROP.

LIRAL PRINCE VARIETY. PLANTED 4—21—50.

Sample Number	Harvest Date	Percent Wax in Fiber		Percent Oil in Seed	
1A	6—26—50	3.17		No Samples	
1B		3.32	3.27 ave.		
1C		3.31			
2A	7— 3—50	3.30		25.63	
2B		3.29	3.21 ave.	25.32	25.68 ave.
2C		3.03		26.10	
3A	7—10—50	3.33		29.86	
3B		3.43	3.44 ave.	31.46	30.87 ave.
3C		3.56		31.28	
4A	7—17—50	3.43		35.18	
4B		3.31	3.43 ave.	36.18	35.83 ave.
4C		3.56		36.13	
5A	7—24—50	3.64		36.60	
5B		3.52	3.58 ave.	36.55	36.63 ave.
5C		3.58		36.73	
6A	7—31—50	3.65		36.18	
6B		3.66	3.66 ave.	36.44	36.38 ave.
6C		3.66		36.51	
7A	8— 7—50	3.32		35.90	
7B		3.44	3.30 ave.	36.42	36.27 ave.
7C		3.15		36.50	
8A	8—14—50	3.55		35.73	
8B		3.46	3.40 ave.	36.28	35.55 ave.
8C		3.18		34.64	
9A	8—21—50	3.39		36.17	
9B		3.71	3.42 ave.	36.54	36.00 ave.
9C		3.16		35.28	
10A	8—28—50	3.84		35.02	
10B		3.47	3.55 ave.	36.27	35.51 ave.
10C		3.35		35.24	
11A	9—13—50	3.04		36.43	
11B		3.21	3.10 ave.	36.61	36.27 ave.
11C		3.06		35.78	

TABLE III—*Continued.*

CONCURRENT VARIETY. PLANTED 4—21—50.

Sample Number	Harvest Date	Percent Wax in Fiber		Percent Oil in Seed	
1A	6—26—50	3.63		No Samples	
1B		3.58	3.59 ave.		
1C		3.57			
2A	7— 3—50	3.38		24.41	
2B		3.72	3.54 ave.	22.87	23.63 ave.
2C		3.53		23.61	
3A	7—10—50	3.61		26.63	
3B		3.98	3.70 ave.	28.49	28.15 ave.
3C		3.52		29.32	
4A	7—17—50	3.74		33.24	
4B		3.80	3.82 ave.	33.78	33.53 ave.
4C		3.91		33.62	
5A	7—24—50	4.23		33.89	
5B		4.46	4.24 ave.	34.53	34.17 ave.
5C		4.04		34.10	
6A	7—31—50	3.95		33.68	
6B		4.07	4.05 ave.	34.21	33.82 ave.
6C		4.13		33.56	
7A	8— 7—50	3.77		33.74	
7B		4.10	4.00 ave.	34.44	34.02 ave.
7C		4.13		33.89	
8A	8—14—50	4.12		33.80	
8B		3.92	3.93 avc.	34.51	34.21 ave.
8C		3.75		34.31	
9A	8—21—50	3.68		34.06	
9B		4.22	3.94 ave.	34.17	34.20 ave.
9C		3.92		34.38	
10A	8—28—50	3.62		34.31	
10B		4.39	3.99 ave.	34.02	33.82 ave.
10C		3.97		33.13	
11A	9—13—50	3.62		34.30	
11B		3.86	3.95 ave.	35.20	34.69 ave.
11C		4.38		34.56	

CASCADE VARIETY. PLANTED 4—21—50.

Sample Number	Harvest Date	Percent Wax in Fiber		Percent Oil in Seed	
1A	6—26—50	3.35		No Samples	
1B		3.57	3.55 ave.		
1C		3.73			
2A	7— 3—50	3.53		30.48	
2B		3.55	3.40 ave.	31.00	30.54 ave.
2C		3.13		30.15	
3A	7—10—50	3.37		32.74	
3B		3.52	3.51 ave.	32.55	33.06 ave.
3C		3.65		33.89	

TABLE III—*Continued.*

Sample Number	Harvest Date	Percent Wax in Fiber		Percent Oil in Seed	
4A	7—17—50	3.39		37.62	
4B		4.03	3.84 ave.	37.38	37.25 ave.
4C		4.10		36.75	
5A	7—24—50	3.83		36.59	
5B		4.22	4.08 ave.	37.24	36.59 ave.
5C		4.20		35.95	
6A	7—31—50	3.82		35.31	
6B		3.91	3.84 ave.	35.98	35.68 ave.
6C		3.79		35.74	
7A	8— 7—50	3.87		35.27	
7B		3.57	3.78 ave.	35.56	35.39 ave.
7C		3.91		35.35	
8A	8—14—50	3.78		36.18	
8B		3.80	3.82 ave.	35.49	36.17 ave.
8C		3.89		36.83	
9A	8—21—50	3.57		36.47	
9B		3.95	3.85 ave.	35.30	35.96 ave.
9C		4.04		36.11	
10A	8—28—50	3.72		36.60	
10B		4.21	3.88 ave.	36.65	36.83 ave.
10C		3.70		37.25	
11A	9—13—50	3.32		36.67	
11B		4.01	3.75 ave.	36.94	36.88 ave.
11C		3.91		37.03	

ANALYSIS OF VARIANCE.

Variation Due to:	Sum of Squares	Degrees of Freedom	Mean Square	F	Remarks
Total	10.5368	98	—	—	—
Replicates	.4924	2	.2462	6.25**	—
Harvests	2.5876	10	.2588	6.57**	—
Varieties	4.2703	2	2.1352	54.19**	—
HXV	.6624	20	.0331	.84	—
Error	2.5241	64	.0394	—	—

L.D.S. (harvests) = .1968 at 5% level.
= .2482 at 1% level.

L.D.S. (varieties) = .0977 at 5% level.
= .1298 at 1% level.

**Significant at the 1% level.

TABLE IV.

FIBER FLAX MATURITY STUDIES—1951 CROP.

Liral Prince Variety				Cascade Variety			
Tag No.	Planting Date	% Wax		Tag No.	Planting Date	%Wax	
700	3—30—51	2.90		1803	3—30—51	3.16	
751		2.74		1808		3.20	
752		2.97	2.80 ave.	1812		3.65	3.41 ave.
753		2.59		1816		3.53	
754		2.81		1820		3.53	
756	4— 6—51	2.73		1824	4— 6—51	3.04	
757		3.16		1828		2.96	
760		3.06	3.03 ave.	1832		3.08	3.19 ave.
761		3.08		1836		3.32	
762		3.12		1840		3.57	
764	4—13—51	3.27		1883	4—13—51	3.58	
765		3.13		1884		3.68	
767		3.01	3.10 ave.	1885		3.58	3.59 ave.
769		3.07		1886		3.64	
771		3.01		1887		3.46	
772	4—20—51	3.87		1888	4—20—51	3.81	
776		3.67		1889		3.62	
777		3.35	3.49 ave.	1890		4.01	3.95 ave.
779		3.25		1891		4.12	
780		3.29		1892		4.17	
781	4—27—51	3.28		1893	4—27—51	3.62	
782		3.59		1894		3.74	
783		3.43	3.50 ave.	1897		3.91	3.70 ave.
784		3.64		1898		3.52	
785		3.54		——		——	

TABLE V.

WAX CONTENT OF FIBER FROM 1952 FLAX VARIETY PLOTS.

Variety	East Farm (early) % Wax		East Farm (late) % Wax		Granger Farm % Wax		Santiam Plant Area % Wax		Overall Average
Cascade ..	3.08		3.29		4.12		3.82		
	2.98	Ave.	3.43	Ave.	4.18	Ave.	4.37	Ave.	3.64
	3.16	3.06	3.13	3.33	4.04	4.11	3.95	4.05	
	3.02		3.48		4.11		4.07		
Concurrent ..	2.82		3.58		4.39		3.55		
	3.13	Ave.	3.50	Ave.	4.12	Ave.	3.75	Ave.	3.49
	2.93	2.97	3.30	3.42	4.04	4.13	3.34	3.44	
	3.01		3.28		3.98		3.11*		
Cirrus ..	3.18		3.34		4.03		3.82		
	3.00	Ave.	3.45	Ave.	4.01	Ave.	3.80	Ave.	3.57
	3.31	3.17	3.24	3.38	4.08	4.00	3.55	3.74	
	3.18		3.49		3.89		3.80		
Norfolk Queen ..	2.69		3.00		3.88		2.75		
	2.66	Ave.	2.94	Ave.	3.68	Ave.	2.64	Ave.	3.00
	2.81	2.58	3.18	3.04	3.57	3.64	2.74	2.73	
	2.17*		3.03		3.41		2.80		

TABLE V—*Continued.*

Variety	East Farm (early) % Wax		East Farm (late) % Wax		Granger Farm % Wax		Santiam Plant Area % Wax		Overall Average
Liral Prince ..	2.41* 2.72 2.79 2.87	Ave. 2.70	3.43 3.38 3.19 3.19	Ave. 3.30	4.33 4.40 4.25 3.73*	Ave. 4.18	3.01 3.21 3.17 3.15	Ave. 3.14	3.33
Percello ..	2.72 2.89 3.12* 2.66	Ave. 2.85	2.99 3.40 3.22 3.47	Ave. 3.27	4.01 3.77 3.70 3.83	Ave. 3.83	3.02 2.98 3.09 3.00	Ave. 3.02	3.24
Tullmune ..	2.59 2.84 2.77 2.91	Ave. 2.78	3.05 3.08 3.36 3.18	Ave. 3.17	4.21 3.78* 4.17 4.20	Ave. 4.09	2.35 2.69 2.64 2.88	Ave. 2.64	3.17
1A ..	2.81 2.97 2.59* 2.86	Ave. 2.81	3.24 3.10 3.05 3.13	Ave. 3.13	3.47 3.44 3.41 3.65	Ave. 3.49	3.02 3.22 2.95 2.68	Ave. 2.97	3.10
Wiersema 339 ..	2.80 2.91 3.05 2.87	Ave. 2.91	3.30 3.41 3.12* 3.56	Ave. 3.35	4.03 3.82 4.18 3.83	Ave. 3.97	2.69 2.53 2.69 2.72	Ave. 2.66	3.22
7A ..	2.82 2.78 2.90 2.88	Ave. 2.85	3.44 3.04 3.29 3.28	Ave. 3.26	3.45 3.39 3.62 3.56	Ave. 3.51	3.11* 2.74 2.44 2.29	Ave. 2.64	3.06
Overall Average ..	2.87		3.26		3.09		3.10		3.28

* Values rechecked by second analysis.

	Planted	Harvested	Age (Days)
East Farm (early)	4–16	7–31	106
East Farm (late)	4–30	8–12	104
Granger Farm	4–11	7–28	108
Santiam Plant Area	4–9	7–31	113

Granger Farm samples very short fibered and contained much shive material.

ANALYSIS OF VARIANCE.

Variation Due to:	Sum of Squares	Degrees of Freedom	Mean Square	F	Remarks
Total	39.5649	159	—	—	—
Farms	23.1784	3	7.7261	195.10**	—
Reps in F	.4750	12	.0396	—	—
Varieties	7.0057	9	.7784	27.80**	—
V x F	5.8841	27	.2179	7.78**	—
V x R in F	3.0217	108	.0280	—	—

L.S.D. (varieties) = .1175 at 5% level.
= .1555 at 1% level.
L.S.D. (varieties x farms) = .2347 at 5% level.
= .3107 at 1% level.
**Significant at the 1% level.