Station Circular 133 July 1939

Seed-Flax Production in Oregon

D. D. Hill

Oregon State System of Higher Education
Agricultural Experiment Station
Oregon State College
Corvallis

SUMMARY

The yield of flax seed necessary to produce a return equivalent to a given yield of grain may vary widely from season to season. Tables and charts are presented to show the yields that have been necessary to produce equivalent returns during the period 1929-1938.

Flax offers good possibilities as a cash crop in western Oregon, in the Blue Mountain region, and in some irrigated regions. A ready market at Minneapolis prices is available in Portland for all the flax seed that is likely to be produced in the Pacific Northwest.

Flax is not recommended for the Columbia Basin section of Oregon, except for experimental plantings. Further research is necessary to determine the feasibility of flax production in this area.

Flax is adapted to most of the soil types in Oregon except the very sandy soils. In areas of high temperatures, heat canker is likely to cause serious injury unless the soils are well supplied with moisture and organic matter. Early planting will help to control heat canker and will result in larger yields in most sections.

Culture of seed flax is similar to that required for small grains. It is important that the seedbed be firm, of good tilth, and free from weeds. Good fertility is just as essential to seed flax as to small grains. The combine is the best method of harvest if fields ripen uniformly and are free from green weeds. The swather and pick-up, or the binder methods may be used satisfactorily. The straw must be thoroughly dry at threshing time.

The oil content of Oregon flax seed is comparable to that grown in other parts of the United States. The drying power of linseed oil produced from Oregon-grown flax seed, as indicated by the iodine number, is superior to that grown in other flax-growing sections of the country.

Seed-Flax Production in Oregon

By

D. D. Hill

INTRODUCTION

Seed flax offers certain opportunities to growers in many parts of Oregon to which the crop is adapted. Indications point toward a substantial increase in the acreage of flax within the next few years.

Seed flax has been grown in Oregon since 1849. As agriculture moved westward in the United States, seed flax was commonly grown as the first or breaking crop on new land, and was generally displaced by other crops after a few years. Despite the early introduction of seed flax in Oregon, there has been no extensive culture of it in this state, although a limited acreage of it has persisted for many years.

DISTINCTION BETWEEN SEED AND FIBER FLAX

Seed flax should not be confused with fiber flax. They are different crops, although both belong to the same species (*Linum usitatissimum*) and both are grown commercially in Oregon. Seed flax is shorter, more branching, and produces more seed than fiber flax. Although the stem of seed flax contains fiber, there is less of it than in fiber flax, and it is of inferior quality. A limited quantity of seed flax straw is used for the production of low-quality fiber; likewise, the extra seed of fiber flax is used for linseed-oil production. Despite these differences, the two types are often confused, and occasionally growers of seed flax will plant fiber-flax seed, or vice versa. As the harvesting, processing, and use of these types are so different, growers should be sure of the type planted.

TARIFF PROTECTS UNITED STATES FLAX GROWERS

Linseed oil is the chief product of flax seed. There appears to be no entirely satisfactory substitute for this oil, which is so widely used in the manufacture of paints and enamels. Linseed oil has certain drying properties that are peculiarly adapted to this use.

Linseed meal, or "Oil" meal, is the principal by-product and is one of the most valuable concentrate feeds for livestock.

Acknowledgments. Experimental data from the branch experiment stations were supplied by D. E. Richards, Union; M. M. Oveson, Moro; and J. F. Martin, Pendleton. The flax experiments at Moro were conducted by D. E. Stephens and B. B. Bayles. Experimental data from Klamath County and from Malheur County were supplied by A. E. Gross and Neal Hoffman, respectively. Information on flax insects was supplied by W. D. Edwards, Assistant Entomologist, Oregon Experiment Station. The writer wishes to thank Professor G. R. Hyslop, In Charge of the Division of Plant Industries, E. R. Jackman, Extension Agronomist, D. E. Richards, Superintendent, Eastern Oregon Livestock Experiment Station, and M. M. Oveson, Superintendent of the Sherman County Experiment Station, who read and corrected the manuscript.

Flax is a deficiency crop in the United States. The country normally will use from 25 to 45 million bushels of flax seed per year for domestic purposes. Not since about 1912 has the United States produced enough flax seed to meet domestic requirements. For a number of years prior to 1912, the annual production in the United States varied between 15 and 30 million bushels. Since then the production has fluctuated, but in general has declined. The average annual production from 1927 to 1936 was approximately 13 million bushels. A low point in production was reached in 1934 and 1936 when, due to the drought, the total production in the United States was only around 5 million bushels. This has increased until the 1938 crop approached 8 million bushels. This, however, is far below the domestic requirements. The average annual imports of flax from 1927 to 1936 were 16,198,000 bushels; the imports for the year 1937-38 amounted to 17,840,000 bushels.

The main flax-growing region of the United States has been in the northern Great Plains states, Minnesota, North Dakota, South Dakota, and Montana. The drought years of 1934 and 1936 were especially severe on flax production. As flax is unable to withstand severe drought or heat as effectively as small grains, farmers in that area have been hesitant to return to their previous acreage of flax. In recent years, flax acreage in North Dakota, South Dakota, and Montana has been greatly reduced, but an increased acreage is noted in Iowa and in eastern Kansas. The Imperial Valley of California has increased flax production from nothing in 1931 to almost 700,000 bushels in 1938.

This shift in production is of interest to Oregon farmers who are faced with the increasingly difficult problem of disposing of surplus grain crops. Seed flax is adapted to production in many parts and could replace a substantial quantity of grain in some areas of the state. Flax seed produced in the United States is protected by a tariff of 65 cents per bushel, a tariff that is effective in raising the United States price above the world price. The tariff of 42 cents per bushel on wheat and 20 cents per bushel on barley has little effect on the price of these commodities as they normally are export crops, whereas flax is imported in quantity each year. The following table, which shows the prices of flax at Minneapolis and at Buenos Aires and the price of wheat at Kansas City and Buenos Aires, indicates the extent to which the tariff affects United States prices. The prices of wheat in the United States and Argentina are comparable except for the period 1934-1936 when short United States crops made it necessary

Table 1. COMPARISON OF FLAX AND WHEAT PRICES IN THE UNITED STATES AND IN ARGENTINA. 1927-1936

Year	Flax			Wheat		
	Minneapolis	Buenos Aires	Difference	Kansas City	Buenos Aires	Difference
1927-28	2.21	1.65	— .56	1.35	1.38	+.03
1928-29	2.29	1.68	— .61	1.12	1.15	+.03
1929-30	3.11	2.02	—1.09	1.20	1.17	—.03
1930-31	1.76	1.04	— .72	.76	.66	—.10
1931-32	1.36	.64	— .88	.47	.47	.00
1932-33	1.18	.69	— .49	.51	.42	—.09
1933-34	1.87	1.07	— .80	.88	.56	—.32
1934-35	1.90	1.02	— .88	.98	.61	—.37
1935-36	1.73	1.15	— .58	1.05	.82	—.21
1936-37	2.14	1.25	— .89	1.21	1.06	—.15
Average	.....	.....	— .82	......	......	—.12

to import some wheat and thereby made the tariff effective in raising prices. Over the period 1927-1937, the average price of wheat was only 12 cents per bushel less in Buenos Aires than in Kansas City, yet during the same period flax seed averaged 81 cents per bushel more in Minneapolis than in Buenos Aires.

The two linseed-oil mills in Portland offer a ready market for all flax seed that is likely to be raised in the Pacific Northwest. These mills normally pay Minneapolis prices for flax seed delivered at Portland.

WHEN SHOULD FARMERS GROW FLAX

Many farmers raise the question as to what yields of flax are necessary before it becomes a more profitable crop than the small grains. There apparently is no close correlation between the price of flax and the price of wheat, since neither is a substitute for the other. Therefore, it is necessary to consider average prices for both before the relative advantage of either crop can be determined. In order to help in answering the question as to when flax becomes a profitable crop, the data presented in Table 2 were computed. This table shows the yields of flax necessary to bring returns equivalent to those obtained from wheat, barley, and oats at three given levels of production. These figures were computed from the September 1 price of each commodity at Portland. A comparison of the 1937 and 1938 figures is sufficient to indicate the variation that occurs from year to year. For example, in 1937, 12.11 bushels of flax were required to produce an income equivalent to that obtained from 25 bushels of wheat, whereas in 1938 only 8.81 bushels of flax were necessary. In contrast, in 1937, 11.13 bushels of flax were required to produce the same return as 40 bushels of barley, but in 1938, 12.94 bushels of flax were required. It will be noted that the relationship of flax to oats is similar to that for wheat in these two years. The answer is found, of course, in the fact that prices of wheat and oats were lower in 1938 than in 1937, whereas the price of barley was slightly higher.

Table 2. YIELDS OF FLAX NECESSARY TO BRING RETURNS EQUIVALENT TO THOSE OBTAINED FROM WHEAT, BARLEY, AND OATS AT VARYING YIELDS. 1929-1938

	Wheat, yield per acre			Barley, yield per acre			Oats, yield per acre		
	15 bushels	20 bushels	25 bushels	20 bushels	30 bushels	40 bushels	30 bushels	40 bushels	50 bushels
1929	6.45	8.60	10.75	5.59	8.42	11.08	5.93	7.83	10.03
1930	6.48	8.64	10.80	5.83	8.75	11.67	6.25	8.33	10.41
1931	4.71	6.28	7.85	6.14	9.21	12.28	6.42	8.57	10.71
1932	7.09	9.50	11.83	7.50	11.25	15.35	6.96	9.28	11.60
1933	6.16	8.13	10.13	6.00	9.00	12.00	5.00	6.66	8.33
1934	6.65	8.87	11.09	7.95	11.93	15.91	8.41	11.22	14.03
1935	7.15	9.54	11.92	5.75	8.62	11.50	6.66	8.88	11.11
1936	6.58	8.77	10.97	6.98	10.47	13.96	8.06	10.75	13.44
1937	7.76	9.71	12.11	5.56	8.36	11.13	6.95	9.27	11.59
1938	5.28	7.08	8.81	6.47	9.71	12.94	5.20	6.93	8.67
Average	6.43	8.51	10.63	6.38	9.57	12.78	6.58	8.77	10.99

Based on Portland market prices.

These data are shown in a slightly different fashion in Figure 1. The ratio of bushels of flax to wheat, barley, and oats based on equivalent returns has been computed and is shown graphically. This figure shows the number of bushels of grain that were required in the different years from

1929 to 1938 to produce a return equivalent to that obtained from one bushel of flax. This shows that in some years flax need produce only about half as many bushels per acre as wheat to produce the same returns, but in other years, as in 1931, for example, and also in 1938, only one-third as much flax as wheat was necessary to produce the same return.

Bushels of WHEAT, BARLEY and OATS Which Were Required to Equal One Bushel of FLAX.
1929-1938

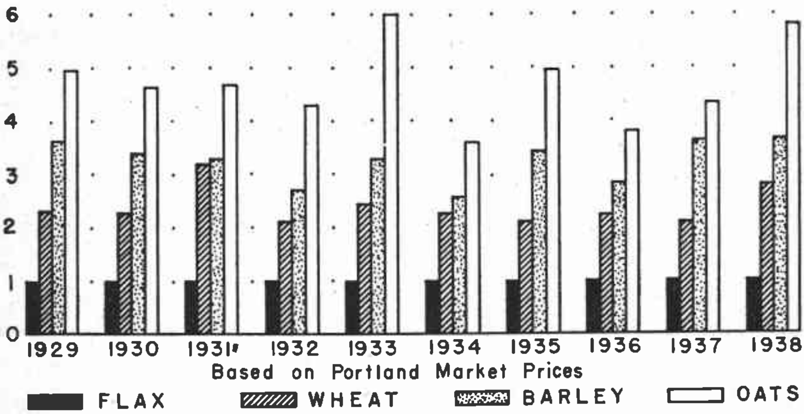

Fig. 1

Average yields of all spring wheat, oats, and barley in the Willamette Valley counties in the census years 1929 and 1934 were as follows:

	Wheat	*Barley*	*Oats*
1929	22.2 (9.5)	30.5 (8.5)	35.3 (7.0)
1934	9.6 (4.3)	20.9 (8.3)	20.4 (5.7)

The figures in parentheses show the yield of seed flax that would have been necessary in those years to have brought an equivalent return. Many Oregon farms produce about 20 bushels of wheat on the average. For the past ten years it would have required an average of eight and one-half bushels of flax per acre to bring in the same money that wheat did on such a farm.

ADAPTATION

Temperature

Flax production has continued only in regions of moderate to cool temperatures and where there is at least a fairly good supply of soil moisture during the growing season. Excessive heat and drought reduce flax yields more than they do grain yields. A moderately cool, moist growing season with a dry period for harvest is the ideal condition. Flax grows well in dry climates with irrigation or where rainfall is good and the season cool. The flax plant is relatively resistant to frost. Resistance to temperatures of 21° to 24° F. from spring planting has been reported,* although a 27° frost on May 25, 1926, seriously injured flax at Union. Fall-planted flax survived temperatures of 20° F. without apparent injury at Corvallis in December, 1938. No doubt the condition of the plant at the time of frost exposure has a great deal of influence on its frost resistance. In tests of fiber varieties, a correlation between frost resistance and wilt resistance has been noted.*

Soil

The best soils for flax are those that are fertile and provide moisture rather late into the growing season. Some of the lighter soils, such as sandy or gravelly ones that are irrigated or subirrigated may grow fairly good flax provided the temperatures are not excessively high. The soils best adapted are those that are medium to slightly heavy in texture, such as the silt loams, clay loams, and silty clays and in a few instances slightly heavier types. Soils of the Willamette, Carlton, Amity, Chehalis, Newberg, Wapato, Hillsboro, Grande Ronde, Sauvies, and Powell series classified as loams, clay loams, silt loams, and silty clay loams are very good flax soils. Some of the better types of the Dayton series will grow flax very well. Most of the eastern Oregon soils with the exception of the light sandy soils will grow flax well when moisture and temperature conditions are favorable.

The soils for flax should be fertile enough to grow good crops of grain, if satisfactory results are to be obtained. Flax is not hard on the land and removes the fertility from the soil no more rapidly than do the grain crops. Flax is a tap-rooted plant that sends out lateral roots in the surface soil. Most of these roots are found in the surface two feet. Soils that are low in fertility or in organic matter tend to dry out quickly, and the flax plant with a rather limited root system is at a disadvantage in comparison with the small grain crops, which have a deeper root system.

AREAS OF THE STATE SUITED FOR FLAX PRODUCTION

There are certain areas of the state where flax is well adapted and will produce profitable crops in comparison with small grains. There are other areas where flax is less well adapted and thus far has failed to produce profitable crops. This does not mean necessarily that flax will never be grown in those areas, but that the varieties tried were unadapted, and perhaps in some cases, methods were wrong. Additional experimentation is needed.

Willamette Valley

Seed flax may be grown satisfactorily on most of the soil types in the Willamette Valley, except in those rare years when the summers are so dry that other spring-seeded crops are failures also. Yields depend on drainage, soil fertility, moisture, and weed control. Early seeding is most important and this is not possible except on well-drained land.

* Davis, R. L. *Frost Resistance in Flax.* U. S. Department of Agriculture. Circular 264 (1923).

Lower Columbia

Flax is grown successfully along the Lower Columbia. Farmers on the diked lands in the Scappoose and Clatskanie areas have reported many yields of 20 to 30 bushels per acre. One of the limitations of flax production in this area is the difficulty in getting the flax matured uniformly early enough for harvest. Many of the diked-land soils are partly subirrigated and in those portions of the field that are supplied with additional moisture, the flax often remains green and continues to bloom until late in the summer. In order to overcome this difficulty, it is necessary to seed early-maturing varieties and occasionally to modify the harvesting methods.

Southern Oregon

Good crops of seed flax are grown occasionally in the southern Oregon area, in Douglas, Josephine, and Jackson Counties. This acreage has been limited because of the competition from other crops. If seed flax is planted very early in this area, however, good crops may be obtained, especially where irrigation is available for the crop.

Irrigated districts promising

Information regarding flax production in the irrigated regions of Oregon is inadequate to indicate just what may be expected. Preliminary experiments in Klamath Falls in 1938 indicate yields of 20 to 30 bushels per acre of flax on soils of rather high salinity. These results indicate that flax production has a possibility in this area in combination with certain rotations. The writer visited two commercial fields of flax in the Goose Lake Valley in Lake County during the summer of 1938. These made an excellent growth, and one field of 25 acres yielded 17 bushels per acre. Five farmers in Lake County who grow the crop reported that it returned $10.00 per acre more than grain crops. There appears to be no reason why the crop should not do well in this area.

A few trials of flax in the Deschutes area have given inconclusive results. It is believed that seed flax should do reasonably well, especially on those soils that are well supplied with organic matter. On the very sandy soils in this area it is likely that heat canker may be injurious unless there are frequent irrigations during hot weather. Flax makes an excellent nurse crop for legumes and it may eventually be used for this purpose in Central Oregon.

Several attempts have been made during the past ten years to grow flax in the Vale-Malheur irrigated district. Results have varied from good to failures. The failures have been due to heat canker. Nursery experi-

Table 3. YIELDS FROM FLAX NURSERIES IN MALHEUR COUNTY.

Variety	Old land		New land	
	Number of trials	Bushels per acre	Number of trials	Bushels per acre
Linota	6	26.7	3	6.0
Bison	6	21.5	3	7.9
Rio	6	28.5	3	6.3
Damont	6	25.6	3	4.6
Newland	6	37.2	3	6.0
Redwing	6	22.2	3	5.3
Golden	6	19.6	3	5.3

ments in 1937 and 1938 gave yields of from 20 to 37 bushels per acre in Malheur County. Weeds and high soil temperatures are the main problems. Yields of from 20 to 40 bushels per acre were reported by growers in 1938. Nursery yields given in Table 3 show favorable yields on old land.

Plantings made on newly developed land were uniformly poor. These soils, which have just been cleared of sagebrush, are sandy and low in organic matter. The low water-holding capacity, lack of leveling for irrigation, and high soil temperatures combined to make the crop a failure. It is impossible to maintain a satisfactory soil-moisture content on most of the new lands, and the resulting high soil temperatures cause serious damage from heat canker.

Northeastern Oregon

Certain parts of northeastern Oregon are well suited for seed flax. Good yields are produced in those parts of Baker, Union, Wallowa, and Umatilla Counties where there is adequate rainfall or irrigation water. Seed flax has been grown at the Union Experiment Station for many years with good results. In Umatilla County with present varieties, seed-flax production should be confined to the areas of higher elevation and rainfall.

Columbia Basin

For the present at least, no recommendations can be made for the replacement of any wheat acreage in the Columbia Basin counties with seed flax. The information available from the Sherman County Branch Experiment Station is limited to nursery trials for two years, 1924 and 1925. The

Table 4. YIELDS OF FLAX GROWN IN NURSERY ROWS AT MORO AND KENT, OREGON. 1924 and 1925

C. I. No.	Variety	Acre yield at Moro 1924	Acre yield at Moro 1925	Acre yield at Moro Average	Acre yield at Kent 1925
		Bushels	*Bushels*	*Bushels*	*Bushels*
186	Reserve Sel.	3.6	8.1	5.9	10.5
188	Reserve Sel.	3.1	7.5	5.3	9.3
274	Slope	1.7	8.0	4.9	....
182	Cantania	2.3	7.1	4.7	7.8
267	Matania	1.2	7.4	4.3	....
189	Sel. 8-4	2.0	6.5	4.3	9.6
187	Reserve Sel.	1.7	6.7	4.2	....
272	Long No. 79 (Argentine)	1.6	6.7	4.2	....
179	Winona	1.2	6.9	4.1	....
178	Chippewa	.8	7.2	4.0	....
3	Damont	.5	7.3	3.9	....
241	North Dakota 40,013	1.0	6.8	3.9	....
13	North Dakota Resistant 114	1.2	6.5	3.9	....
184	Billings	.0	7.6	3.8	....
19	Reserve	.6	6.9	3.8	9.6
275	North Dakota 3,082	1.3	5.7	3.5	....
107	Morteros	.3	6.6	3.5	....
23	Lethbridge Golden	.5	6.4	3.5	....
109	Rosquin (Argentine)	.4	6.4	3.4	....
262	Smyrna Sel.	.7	6.0	3.4	....
263	Smyrna Sel.	.6	6.1	3.4	....
8	North Dakota Resistant 52	.2	6.2	3.2	....
271	Long No. 71 (Argentine)	.5	5.6	....	....
25	Williston Golden	....	9.3	....	....
185	Stark	....	7.5	....	....
	Union (local)	....	6.8	....	....
	Federation wheat	21.0	24.5	22.7	....
	Baart wheat	20.6	18.7	19.6	....

results of these trials are given in Table 4. The difference in yield in these two years is easily explained by reference to the weather data. During the growing season of 1924, only .92 inch of rainfall was available, whereas in 1925 during the same period 3.56 inches were available. In addition to the drought injury, the effect of high temperature was evident. The average maximum temperature for May, 1924, was 77.4° F., as compared to 69.2° F. in 1925. In 1924, three periods (May 11 and 12, June 1 and 2, and June 30) were recorded with temperatures about 90° F. In 1925, the first hot period came June 19-21, after the flax was in full bloom. Heat canker was the primary cause of low flax yields in both years, but was much more pronounced in 1924.

Figure 2. Flax nursery grown on the Sherman County Branch Experiment Station in 1924. The thin stand is a result of heat canker.

Attention is directed to the yields of Federation and Baart wheat given in Table 4. The results are not directly comparable because the wheat was planted seven to ten days earlier than the flax. The high temperatures of 1924 had less influence on wheat yields than on flax yields, as no particular wheat injury was noted. Analysis of these preliminary trials,

Table 5. YIELDS OF FLAX OBTAINED FROM NURSERIES GROWN NEAR PENDLETON*
Date of seeding: 1925, March 10; 1934, March 8; 1938, March 30.

Variety	1925	1934	1938
	Bushels	*Bushels*	*Bushels*
Reserve	13.4	......	......
Winona	12.0	......	......
Chippewa	11.0	......	......
North Dakota Resistant 3,082	10.8	......	......
North Dakota Resistant 114	10.5	......	......
Rio	......	3.9	......
Bison	......	6.4	1.4
Linota	......	6.6	2.8
Redwing	......	4.8	3.3
Golden	......	......	1.8
Newland	......	......	3.7

* The 1925 nursery was grown under the supervision of the Sherman County Branch Experiment Station; the 1934 and 1938 nurseries were grown at the Pendleton Branch Experiment Station.

together with the somewhat higher yields from the Kent nursery in 1925, indicate that there may still be some possibilities for the production of seed flax under some of the drier conditions in the Columbia Basin. Much more investigational work will be needed to determine the feasibility of flax culture in this region. Successful production may depend on the development of entirely new varieties and cultural methods.

Trials of flax at Pendleton have not been encouraging. Yields from nursery plantings are given in Table 5.

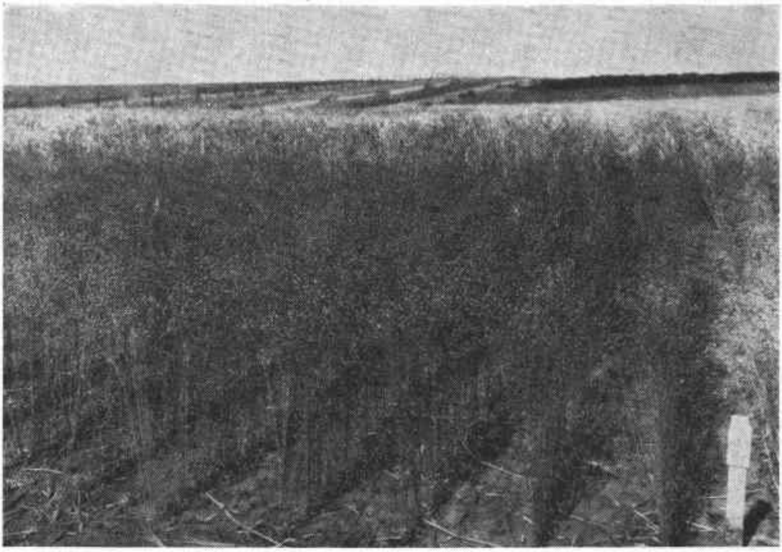

Figure 3. Flax nursery grown on the Sherman County Branch Experiment Station in 1925. Compare growth and stand with that shown in 1924.

These results indicate little possibility for successful commercial production of flax with present varieties and production methods. Growers in the Columbia Basin should recognize that all plantings made now are purely experimental in nature.

LIMITATIONS IN FLAX PRODUCTION

The limitations in the production of flax in Oregon have been indicated in the preceding discussion. These are: (1) ability to sow in good season, (2) weed competition, (3) heat canker, (4) drought resistance, (5) disease.

Relation of early planting to adaptation

The so-called lack of adaptation of flax to certain conditions is often nothing more than an inability to prepare the seedbed and to plant the flax in good season. Many of the heavy soils in western Oregon produce good crops of flax in those years when weather conditions permit early planting. Flax makes its best growth in the cool period of spring, and in Oregon it normally is in full blossom at about the time of greatest day length. Over a four-year period at Corvallis, a difference of fourteen days in time of planting resulted in an average difference of seven days in time of full bloom. At Moro in 1925, a difference of twenty-one days in time of planting made a difference of eight days in time of full bloom. Since flax makes little vegetative growth after the bloom stage, a long growing season prior to blooming (normally June 20 to 30) is essential to maximum plant growth and seed yield.

Weed control

Because of its habit of upright growth during the early stages, and because of its relatively small root system at that time, flax does not compete with annual weeds so vigorously as do the small grains. Cultural and rotation practices, therefore, should be of such a nature that flax may be grown on soil relatively free from weeds. This is best done by following either a cultivated crop or a perennial legume crop such as alfalfa or clover. Otherwise, the tillage practices should be adjusted in such a way that as many weeds as possible may be killed before the flax is planted. Since the necessity for early seeding interferes with weed control, rotations that provide for weed control ahead of flax are helpful. Flax should be sowed shallow immediately after the seedbed preparation is finished, in order to allow it every advantage over sprouting weeds.

Heat canker

Heat canker is a possible source of injury to seed flax in all areas of the state where soil temperatures are likely to be high. Heat canker is not a disease, but is merely an injury to the stem resulting from high soil temperatures. It shows as a black lesion, or scar, near the base of the stem. It is especially serious when high soil temperatures occur before the flax has made sufficient growth to shade the ground. The high temperatures in some areas will destroy the plant tissues on all or part of the stems. If the entire surface of the stem is destroyed, the flax will die promptly. If only a portion of the stem is destroyed, the plants may grow to a considerable height before the weakened stem will break under the increasing weight. Plants bearing the heat-canker lesions may occasionally grow to maturity.

It has been noted that heat canker is much more likely to occur on soils low in organic matter than on those that are adequately supplied. The low-organic-matter soils, especially if sandy, are likely to heat much more rapidly than other soils. A soil high in humus holds more moisture and this in itself results in lower soil temperatures. Experiments in the Malheur area indicate that plantings of flax on land poorly supplied with organic matter and therefore with somewhat low moisture, are likely to have a high mortality from heat canker. Heat canker is a possibility throughout most of the flax-growing regions of eastern Oregon. It seldom is of serious consequence in the western Oregon area, although in the southern Oregon district this may be a problem, particularly with late plantings.

When conditions in the early spring are such that fairly prompt emergence can be obtained, early planting is desirable. Flax will withstand temperatures as low as 25° F. without injury and there are indications that even lower temperatures may be withstood at this stage of development.

Drought resistance

Flax is apparently less drought-resistant than wheat or barley. One of the principal problems in connection with flax production in the dry areas is to get the small-seeded flax germinated and the plants established before moisture is lost from the surface soil. When this is done and the lateral branches of the roots are established and growing downward for moisture, flax appears to stand dry weather satisfactorily. The critical period appears to be in the earlier stages.

Diseases few

Diseases of seed flax have been of little importance in Oregon. The most common is flax wilt (*Fusarium lini*), a fungous disease that has been responsible for most of the so-called flax sickness of soil. Thus far, flax wilt has not become established in Oregon. The disease has been reported occasionally, but apparently has not been identified definitely except on one occasion. Whether the failure of the disease to develop in Oregon is due to conditions unfavorable to the disease or whether it is due to the rather general growth of resistant varieties is not known. The possibility of wilt infection must be recognized by flax growers and if the disease appears, such corrective measures as resistant varieties, crop rotation, and seed treatment must be used.

There have been occasional infections of flax rust (*Melampsora lini*), a disease that appears on the stems of the flax. Thus far, flax rust has done no damage to seed flax although occasionally it has caused minor losses in connection with the fiber-flax crop.

Insect pests

The department of Entomology, Oregon State College, reports that the principal pest of flax is the omnivorous leaf-tier, or flax worm, *Cnephasia longana* Haworth. In addition to flax, this pest will feed on ninety-five other species, most of which are legumes, wild flowers, and weeds. This pest attacks flax during the growing period, webs the leaves, and feeds on the tip, stopping its growth. The flax plant then sends out laterals of which many ultimately mature seed. The most important loss occurs on fiber flax when the flax, weakened by the injury and the attachment of the lateral branches, is put through the scutching machine and the fiber breaks, falling into the tow, but seed flax may also be injured seriously.

The omnivorous leaf-tier has been found to be very resistant to insecticides and, to date, only cultural practices have shown reduced injury in experimental trials. These practices, in general, avoid following a host plant of the insect, such as alfalfa or clover, with flax. In infested areas of the Willamette Valley, flax planted in fields preceded by leguminous crops showed an average injury of 10.55 per cent for the years 1937 and 1938 while in fields preceded by a cultivated crop, such as corn, it showed an average injury of 3.11 per cent, for the same period. The recommendations that flax be preceded by a cultivated crop are of double value since it serves to hold weeds in check for the flax crop during the coming year.

Other insects associated with flax are the following:

1. California alfalfa semi-looper, *Autographa californica* (Speyer). Damage is generally slight as it is controlled by native parasites. Occasionally it occurs in epidemic numbers, as in 1935.

2. Spittle bug, *Philaenus spumarius* Linn., commonly found in flax fields, probably causes little damage except under unusual conditions.

3. Western 12-spotted cucumber beetle, *Diabrotica soror* Lec., occurs in flax fields in small numbers and damage is negligible.

CULTURAL PRACTICES

Firm seedbed needed

More care is required in the seedbed preparation for flax than is necessary for most small grains. The ideal seedbed for flax is one that is firm, in good physical condition, free of clods, and one that has been handled in such a way as to kill as many weeds as possible. On the medium- to heavy-textured soils this will require disking, harrowing, and rolling after plowing. The rolled ground should be harrowed shallow so as to provide a surface mulch. The firm seedbed underneath will prevent too deep planting of the seed. Under certain conditions of moisture or tillage such soils will be sufficiently packed without rolling. On the lighter soils rolling is usually necessary to produce the firm seedbed required. Flax should not be planted as deeply as small grain. Moisture must be close enough to the surface so that shallow-planted flax will germinate promptly.

In all flax-growing areas of the state, early plowing and seedbed preparation is especially important. Early plowing and cultivation will permit better weed control and will allow for more available plant food in the soil. In the event of favorable weather early in the spring, early-prepared seedbeds may be planted well in advance of the regular planting season and in many areas, particularly in the Willamette Valley, this will result in a greatly increased yield.

Place in the rotation

Flax should be grown in a rotation if best results are to be obtained. While disease has not been a factor in Oregon, continuous growing of the crop on the same land in other states has usually led to lower yields due to disease.

One of the most important factors affecting seedbed preparation is the place of flax in the rotation, as both fertility and weed control are influenced by the previous crop. Likewise, the preceding crop has much to do with the presence of the so-called flax worm, found in the Willamette Valley. Where this insect is present it is best to precede the flax with a cultivated crop. As a general rule, flax does well following a cultivated crop because of the relative freedom from weeds. If it is more desirable to follow the cultivated crop with a fall grain, then flax may well follow the legume crop, either clover or alfalfa. In the irrigated regions of eastern Oregon, flax will do especially well following alfalfa, red clover, alsike clover, or sweet clover.

Trials at the Eastern Oregon Experiment Station at Union indicate this method to be one of the best for the production of seed flax. The picture represented by Figure 4 shows seed flax after five years of alfalfa at Union in 1938. This field produced in excess of 27 bushels of flax to the acre. When an alfalfa sod is plowed under, the excess fertility resulting from the accumulation of nitrates sometimes will cause severe lodging in small grains. When flax is used to follow alfalfa, lodging is rarely a factor. In most areas alfalfa is an excellent smother crop for weed control, and when the sod is broken the following crop is relatively weed free.

Rotations that may be used in different flax-growing areas of the state will vary widely. The following are suggested merely as examples. In western Oregon, rotations might be (1) cultivated crop, such as corn, beans, or potatoes, (2) flax, (3) vetch; or (1) alfalfa, four to six years, (2) corn, (3) flax. In certain areas unaffected by the flax worm where grass sod that is free from weeds is being plowed up, flax might well follow the grass. In irrigated regions, similar rotations could be followed, but in most cases it will be most desirable to plant flax after the legume.

Time of planting

Normally, flax should be planted as early in the spring as a seedbed can be prepared and conditions become favorable for germination and early growth. As indicated earlier, the flax seedlings will withstand a reasonable degree of frost and the early planting will allow for a long period of growth before blooming. Flax makes very little growth after the blooms appear and will make its best growth during the growing weather of April, May, and early June. Results of rate and date of planting trials at Corvallis, as given in Table 6, show the early planting to give the best results in every season. In practice this experiment was planted as early as possible in the spring, normally during the first week or two of April. The midseason planting normally followed the early ones two weeks later and the late planting normally came two weeks after the midseason one.

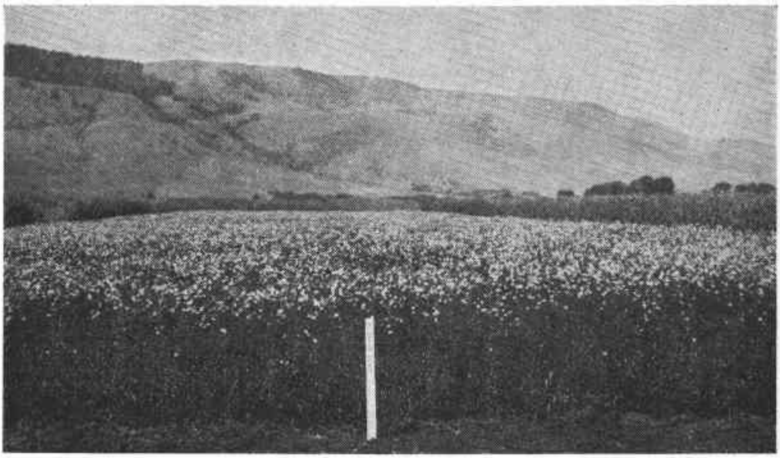

Figure 4. Flax after alfalfa on the Eastern Oregon Livestock Experiment Station at Union. Average yield, 27 bushels an acre. Note the excellent growth and absence of weeds.

The normal dates of planting were, therefore, early April, middle to the latter part of April, and early May.

Table 6. SUMMARY OF RATE AND DATE OF PLANTING TRIALS WITH SEED FLAX, OREGON EXPERIMENT STATION, CORVALLIS, OREGON. 1933-1937.

Rate and date of planting	Yield per acre					
	1933	1934	1935	1936	1937	Average
Pounds per acre	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
31 Early	12.8	8.9	4.4	12.8	17.9	11.4
41 Early	13.1	7.8	3.6	13.2	17.1	11.0
51 Early	13.0	7.5	3.1	12.7	16.6	10.6
Average	12.9	8.0	3.7	12.9	17.2	10.9
31 Midseason	11.9	4.8	2.9	10.2	....	6.5
41 Midseason	12.1	5.6	2.3	10.6	....	7.5
51 Midseason	10.1	4.6	2.3	10.2	....	6.9
Average	11.3	5.0	....	....	....	7.0
31 Late	5.1	5.0	....	....	....	....
41 Late	4.8	3.4	....	....	....	....
51 Late	....	2.7	....	....	....	....
Average	4.9	3.7	....	....	....	....

The date-of-planting trials at Union, given in Table 7, show that best results were obtained from the third date of planting (May 13). Unfavorable temperatures during the early part of the season there result in rather slow and uneven germination. The plants established themselves much more quickly from the third date and consequently gave better results. Similar results would be expected in the high-elevation, irrigated sections of the state. In the Snake River Valley, however, it is believed that planting as early in the season as the seedbed can be prepared will result in better stands and greater protection against the damages from heat canker. In that area planting can usually be done in early March.

Table 7. RESULTS FROM DATE OF SEEDING TRIALS, EASTERN OREGON LIVESTOCK BRANCH EXPERIMENT STATION, UNION, OREGON. 1925-1930

Date of seeding	Yield per acre					1928-1930 Average	Per cent of May 13 for years grown
	1925	1928	1929	1930	Average		
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Per cent*
April 26	16.6	......	......	......	9.0	......	79.0
May 3	......	19.1	22.7	16.7	15.0	19.5	90.6
May 13	21.0	18.5	24.5	21.4	21.3	21.5	100.0
May 24	18.1	15.8	17.7	17.9	17.4	17.1	81.6
June 4	......	14.6	5.8	8.6	9.7	9.7	45.1
June 12	......	9.2	11.9	6.3	9.2	9.1	42.3

Amount of seed

As indicated in Table 6, best results at Corvallis have been obtained from a rate of 31 pounds per acre. Practically the same yield has been obtained from planting 41 and 51 pounds per acre, but there is no apparent advantage in the heavier rates of planting under conditions comparable to those at Corvallis. For general practice in the Willamette Valley, 30 to 35 pounds per acre will be sufficient. If the soil is exceptionally fertile, or if abundant moisture is available, then the planting rate can be increased to 40 pounds per acre or even higher. On the diked lands along the Lower Columbia, 40 to 50 pounds per acre would appear to be a better rate of seeding.

Table 8. RESULTS FROM RATE OF SEEDING TRIALS, EASTERN OREGON LIVESTOCK BRANCH EXPERIMENT STATION, UNION, OREGON, 1924-1931

Rate of seeding	Yield per acre									Percentage of 30-pound rate for years grown
	1924	1925	1926	1927	1928	1929	1930	1931	Average	
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Per cent*
30 pounds	†	16.1	1.8*	19.8	25.6	24.9	19.9	25.0	19.0	100.0
43 pounds	6.5	18.1	2.4*	15.7	†	24.0	18.5	26.5	16.0	97.8
52 pounds	6.1	15.2	2.5*	16.3	24.4	25.8	17.3	22.3	16.2	93.1

* Frosted.
† Rate not included in trial.

The rate-of-planting trial at Union, shown in Table 8, indicates 30 pounds per acre to be sufficient for most conditions in that area. A planting rate of 43 pounds per acre gave yields only slightly below those obtained from the 30-pound rate, but the 52-pound rate was definitely inferior. While rate-of-planting data are not available for the irrigated regions, observations on such plantings as have been made indicate that seeding rates of 50 pounds per acre give the highest yields.

Varieties

The flax varieties now being grown generally in the United States have been developed in recent years. Many of these are resistant to flax wilt. Most of these varieties have been grown experimentally at Corvallis and at Union and also in some experimental plantings in other areas. Yields from some of the better-adapted flax varieties at Corvallis and at Union are given in Tables 9 and 10.

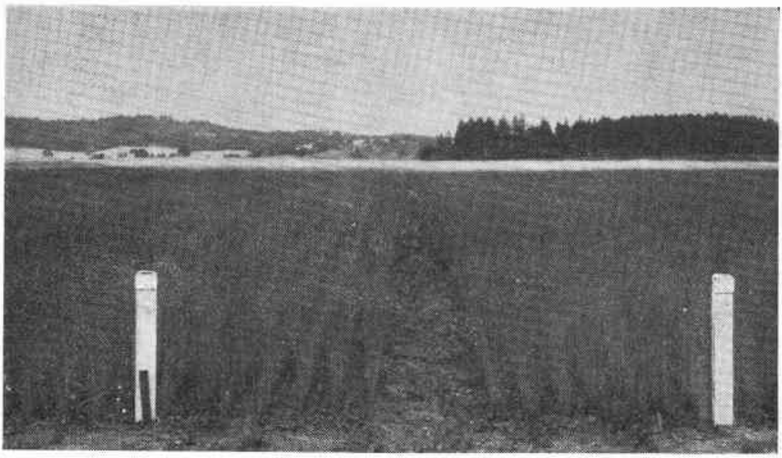

Figure 5. Seed-flax plots on the Oregon Experiment Station, Corvallis, Oregon. Bison, left; Linota, right.

Table 9. YIELDS OF FLAX VARIETIES GROWN ON THE OREGON EXPERIMENT STATION AT CORVALLIS, OREGON. 1929-1937

Variety	Yield per acre									Average	Percentage of Damont
	1929	1930	1931	1932	1933	1934	1935	1936	1937		
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Per cent*
Damont	6.2	6.2	12.2	14.2	11.8	8.3	4.3	12.3	15.1	10.1	....
Linota	4.2	6.4	12.2	15.8	12.1	8.6	4.4	11.7	14.6	10.0	99.0
Redwing	4.6	6.6	12.6	15.8	11.1	9.6	4.8	10.9	11.6	9.7	96.0
Bison	6.7	7.6	13.1	16.0	10.2	11.2	5.2	12.2	14.8	10.8	106.9
Long	3.3	6.5	11.9	15.0	12.3	7.0	3.8	12.0	16.2	9.8	97.0
Newland	....	....	8.6	15.0	12.4	7.3	4.1	12.7	16.1	10.9	89.2
Rio	5.6	4.9	9.3	16.3	11.4	6.2	4.3	12.1	....	10.0	92.6
North Dakota 114	3.6	6.4	11.9	16.2	12.1	8.0	4.9	11.9	....	10.7	99.1
P.L.O.	7.5	6.2	13.1	15.5	12.2	7.8	5.2	12.7	....	11.4	105.5

Table 10. SUMMARY OF FLAX VARIETY YIELDS AT EASTERN OREGON LIVESTOCK EXPERIMENT STATION, UNION, OREGON. 1924-1938

Variety	Yield per acre						Average	Percentage of Rio for years grown	Years grown
	1930	1931	1932	1933	1936	1938			
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Per cent*	
Rio	22.8	31.3	17.0	28.8	14.9	9.2	20.7	100.0	6
Linota	19.7	25.0	......	33.3	15.5	13.1	21.3	99.5	5
Redwing	19.4	22.8	......	31.5	15.8	10.1	21.5	93.0	6
Bison	13.9	27.3	......	30.0	16.1	10.1	19.5	91.1	5
Chinese	......	......	......	......	16.4	14.3	15.3	127.3	2
Newland	......	......	......	......	......	12.1	12.1	131.5	1
Golden	......	......	......	......	......	11.0	11.0	119.5	1
Union	17.0	24.8	......	30.5	12.8	......	18.9	87.3	10
North Dakota Resistant 52	21.6	29.2	17.4	30.0	......	......	21.1	98.0	10
Reserve	21.2	28.4	13.7	29.1	......	......	20.4	92.4	10
Prinost	23.2	19.0	25.5	......	......	......	18.5	95.3	8
North Dakota Resistant 114	24.8	29.0	......	......	......	......	19.4	99.6	8
Damont	23.4	25.2	......	......	......	......	19.9	90.0	8

The variety Bison has given the best yields at Corvallis and is generally recommended for western Oregon. At Union the variety Rio has outyielded Bison rather consistently. Redwing is recommended for the diked lands along the Columbia because of its early maturity. It is sometimes a problem in this area and in the Wallowa Valley to mature flax, so that it may be harvested at a reasonble time in the fall. Where maturity is not a problem, however, Redwing is usually lower yielding than Bison or Rio.

The only comparable yield data of varieties in Malheur County are found in some nursery trials made there in 1937 and in 1938. A summary of these nursery trials is shown earlier in Table 3. This table shows Newland to be the highest-yielding variety there, although Rio gave very good yields also. A preliminary trial made on single plots in Klamath County also shows Newland to be a high-yielding variety there. More information is needed about the performance of the various flax varieties in different parts of the state.

Harvest

Seed flax may be harvested in the same way as small grain and with the same equipment. Where conditions permit, the small combine is probably the best implement to use. For combining, it is essential that the flax be thoroughly and uniformly ripe. Seed-flax straw contains a considerable amount of fiber that, when green and moist, is extremely difficult to thresh. The green fiber will wrap around all moving parts of the threshing equipment, causing seed loss and expensive loss of time. In fields that dry out uniformly during the harvest season, the flax should ripen evenly, but much of the seed will be thoroughly ripe before the flax straw itself is dry enough to be harvested. Fortunately, standing flax will not shatter badly even though the seed is thoroughly mature. If the straw must be handled after maturity, however, flax will shatter very readily. Racks or truckbeds used for hauling unthreshed flax should be tight or covered with canvas.

In the event that the field does not ripen evenly or contains too many green weeds to combine directly, the field can be cut with a binder and the flax shocked, and run through the stationary separator, or it may be swathed for later pick-up by the combine.

Under certain conditions it will be noted that flax will start a second growth just before maturity. Late summer showers, subirrigation, or careless handling of irrigation water will bring on a period of second growth that will interfere with harvesting.

Flax seed is small, and, therefore, it is essential that all threshing equipment be in good adjustment. Much seed can be lost if the threshing equipment is not in good mechanical condition. It is usually necessary to reduce cylinder speed and air blast from that used for grain. Grain conveyors should be tight to prevent loss of the small seed. Special flax screens are necessary to insure good cleaning and to prevent seed loss during threshing..

OREGON FLAX SEED IS OF GOOD QUALITY

The quality of flax seed grown in Oregon compares favorably with that produced in other parts of the United States. The oil content and iodine number of four varieties of flax grown at Corvallis from 1929 to 1931 are given in Table 11. This table also shows the average obtained from these varieties when grown in other flax-growing areas of the United States. The oil content is comparable to the average, but the iodine number of Oregon-grown flax is consistently and significantly higher. The iodine number is used as an index of the drying properties of this oil. These analyses show the Oregon-grown flax to be of excellent quality. Oil content of flax grown at Moro in 1924 and 1925 ranges from 36.6 to 42.1 per cent. Oil content and iodine number of four varieties of flax grown at Union are given in Table 12. These data show the same high oil content and iodine number as those shown by the flax grown at Corvallis.

Table 11. OIL CONTENT AND IODINE NUMBER OF FOUR VARIETIES OF FLAX GROWN ON THE OREGON EXPERIMENT STATION AT CORVALLIS. 1929 1937

Year	Per cent Oil, Basis eight per cent moisture				Iodine number			
	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio
1929	35.7	37.2	39.8	40.6	200	201	195	193
1930	38.2	36.1	38.2	39.8	195	196	189	189
1931	34.8	36.3	37.6	39.0	192	192	189	186
1932	36.8	38.0	39.2	40.6	197	193	194	193
1934	35.9	37.3	37.6	39.3	199	201	194	193
1935	35.8	38.0	37.7	37.5	190	197	183	187
1936	39.3	40.3	41.6	42.0	200	202	199	199
1937	38.3	39.0	39.8	39.6	195	197	192	196
Average	35.6	37.8	38.9	39.8	196	197	192	192
U. S. Average (1929-1931)	36.2	37.4	39.3	40.3	182	183	172	172

Table 12. OIL CONTENT AND IODINE NUMBER OF FOUR VARIETIES OF FLAX GROWN ON THE EASTERN OREGON LIVESTOCK EXPERIMENT STATION AT UNION. 1930-1936

Year	Per cent Oil, Basis eight per cent moisture				Iodine number			
	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio
1930	36.5	37.6	38.6	40.0	187	191	180	183
1931	35.9	37.6	38.9	40.9	186	186	180	184
1932	35.7	38.1	39.5	41.7	188	188	180	183
1933	36.6	37.6	37.4	39.9	191	194	189	188
1935	38.7	36.8	38.3	42.1	193	192	193	186
1936	37.8	37.6	38.0	40.6	191	191	188	184
Average	36.9	37.6	38.5	40.9	189	190	185	186
U. S. Average (1929-1931)	36.2	37.4	39.3	40.3	182	183	172	172