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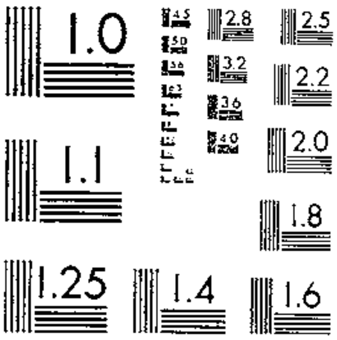
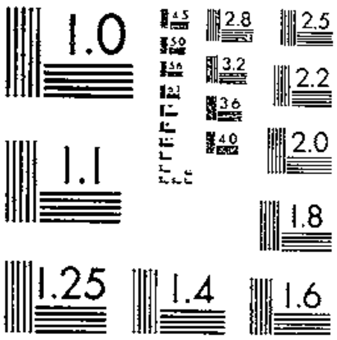


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A



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NATIONAL BUREAU OF STANDARDS 1963-A

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Effect of Climate on the Yield and Oil Content of Flaxseed and on the Iodine Number of Linseed Oil[1]

By A. C. Dillman, *associate agronomist, Division of Cereal Crops and Diseases, Bureau of Plant Industry, Agricultural Research Administration, United States Department of Agriculture*, and T. H. Hopper, *formerly agricultural chemist, North Dakota Agricultural Experiment Station*

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INTRODUCTION

The experiments reported here were undertaken to determine the effect of climate or weather, especially of temperature and rainfall, on the yield and oil content of flaxseed and the quality of linseed oil produced under various conditions in the United States and Canada. Four varieties of seed flax (linseed) were grown for 1 to 10 years at 54 field stations extending from Fairbanks, Alaska (lat. 65° N.), to San Jacinto, D. F., Mexico (19° N.), and from Nappan, Nova Scotia (long. 65° W.), to Corvallis, Oreg. (123° W.). In altitude the stations ranged from 50 feet below sea level near El Centro, in the Imperial Valley of California, to about 8,000 feet at San Jacinto, in the Federal District of Mexico. The average annual precipitation among the stations ranged from 45 inches at New Brunswick, N. J., to only 3 inches at El Centro, Calif.

The cultivation of flax (*Linum usitatissimum* L.) probably originated in the eastern Mediterranean region, but the crop is now grown on every continent under a wide range of climatic conditions. The wide distribution of flax can be attributed to its cultivation for two distinct products—the linen fiber obtained from the stems and its seeds, which yield linseed oil and the valuable livestock feed, linseed meal. Flax has been grown since ancient times, and it is probable

[1] Submitted for publication October 1942. Cooperative investigations by the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and the North Dakota Agricultural Experiment Station. The generous cooperation of the many State, Federal, and Dominion experiment stations in conducting the field experiments is acknowledged in the text.

that primitive man used flaxseed for food long before the art of spinning and weaving was developed in ancient Egypt. Flaxseed is still used for human food to some extent in many countries.

In the United States, flax formerly was grown extensively in New York, Pennsylvania, and Virginia, but during the past century its cultivation has shifted westward to Minnesota and adjoining States, where the principal acreage is now located. During this migration of the crop the States of Ohio, Indiana, Illinois, and Iowa, in turn, took the lead in flaxseed production. In the cooler northern latitude of Europe, Canada, and the northern United States, flax is grown as a spring-sown crop, whereas in mild climates it is fall-sown. In Argentina and Uruguay, in the Southern Hemisphere, flax is sown during July and August, the winter season, and is harvested in early summer, from November to January. In the flax-growing area of India, latitude 20° to 30° N., flax is sown in October, at the end of the rainy season, or wet monsoon, and it ripens in March or April. In the mild climate of southern Texas and in California, flax usually is sown in November, and it ripens in late April or May.

It is well known that the growth and physiological development of flaxseed, including the yield and drying quality of the oil, are affected to a marked degree by environmental conditions, especially by temperature and soil-moisture supply. Much of the linseed oil produced from domestic flaxseed grown in the hot dry seasons of 1934 and 1936 was of low iodine number and of inferior drying quality. It was the purpose of the experiments reported in this bulletin to determine more definitely the effect of weather conditions on the development of the flax plant and the formation of oil in the seed.

COOPERATION

The writers desire to express their hearty appreciation for the generous cooperation of the agronomists and other officials of the State and Canadian agricultural experiment stations who grew the flax, recorded the field notes, and supplied seed samples for analysis. The experiment, covering 1 to 10 seasons at 54 stations, is a tribute to the fine spirit of cooperation which exists in scientific research. The writers have assumed the responsibility for planning the investigation, the seed analyses, and the compilation of results. A list of the cooperating stations and names of cooperators, including the location of each station, the elevation, annual precipitation, and type of soil, is given in table 1.

The writers also are indebted to the Archer-Daniels-Midland Co., of Minneapolis, Minn., for the analyses of the samples grown in 1929 and 1930 and part of those of the 1931 crop, and for the complete chemical and physical tests of the oils reported in tables 18 and 19 (see pp. 60, 62). These analyses were made by S. O. Sorensen, chief chemist, and his assistants, R. E. Anderson and L. H. Martin. The chemical analyses of the remaining 1931 samples and all samples from the crops of 1932 to 1938 were made under the direction of the junior author, in the Division of Agricultural Chemistry, North Dakota Agricultural Experiment Station, Fargo, N. Dak. The writers are greatly indebted to A. J. Pinckney and L. L. Nesbitt for their careful work in making the analyses and to Muriel Johnson, also of that Division, for her painstaking work in making the mathematical computations and for checking and typing the numerous tables.

TABLE 1.—*List of stations where flaxseed was grown, showing approximate latitude, longitude, elevation, mean annual precipitation, and soil type*

Region and location of experiments	Institution and cooperator	Latitude, north	Longitude, west	Elevation	Mean annual precipitation	Soil type
				Feet	*Inches*	
Alaska and Canada:						
Fairbanks, Alaska	Alaska Agricultural Experiment Station, F. L. Higgins	64°51′	147°[illegible]2′	500	11.8	
Matanuska, Alaska		61°30′	149°15′	152	15.6	Silt loam.
Edmonton, Alberta	University of Alberta, O. S. Aamodt (1930–34), K. H. Neatby	53°32′	113°30′	2,200	17.1	Black loam.
Fallis, Alberta		53°40′	114°40′	2,300	17.1	Do.
Saskatoon, Saskatchewan	University of Saskatoon, J. B. Harrington	52°20′	106°45′	1,662	14.3	Dark clay loam.
Morden, Manitoba	Dominion Experimental Farm for southern Manitoba, W. J. Breaky.	49° 2′	98°	991	19.5	Sandy loam.
Ottawa, Ontario	Central Experimental Farm, W. G. McGregor	45°24′	75°43′	273	34.3	Light sandy loam.
Nappan, Nova Scotia		45°46′	64°15′	28	36.2	Clay loam.
Pacific Northwest and Intermountain:						
Corvallis, Oreg	Oregon Agricultural Experiment Station, D. D. Hill	44°30′	123°10′	266	40.3	Willamette loam.
Union, Oreg	Eastern Oregon Livestock Branch Experiment Station, D. E. Richards.	45°25′	117°50′	2,787	13.1	Catherine silt loam.
Pullman, Wash	Washington Agricultural Experiment Station, O. E. Barbee	46°44′	117°10′	2,550	20.5	Palouse silt loam.
Prosser, Wash	Washington Irrigation Branch Experiment Station, H. P. Singleton.	46°10′	119°45′	850	7.4	Sagemoor fine sandy loam.
Moscow, Idaho	Idaho Agricultural Experiment Station, K. H. Klages	46°44′	117°	2,628	21.8	Palouse silt loam.
Bozeman, Mont	Montana Agricultural Experiment Station, Clyde McKee, A. H. Post.	46°	111°	4,800	[illegible].7	Huffine [illegible] loam.
Aberdeen, Idaho	Aberdeen Substation, Harland Stevens	42°56′	112°50′	4,400	8.8	Aberdeen silty clay loam.
Logan, Utah	Utah Agricultural Experiment Station, D. C. Tingey and R. W. Woodward.	41°45′	111°48′	4,600	16.4	Millville silty clay loam.
Murray, Utah		40°36′	111°52′	4,300	15.0	Welby loam.
Fort Duchesne, Utah		40°18′	109°55′	4,900	6.8	Navajo clay.
Fort Collins, Colo	Colorado Agricultural Experiment Station, D. W. Robertson	40°35′	105°	5,000	14.7	Fort Collins loam.
Great Plains:						
Havre, Mont	North Montana Branch Station, M. A. Bell	48°30′	109°47′	[illegible],660	13.4	Scobey loam.
Moccasin, Mont	Judith Basin Branch Station, Joe L. Sutherland, R. M. Williams	47°	109°45′	4,300	14.9	Dark clay loam.
Dickinson, N. Dak	Dickinson Substation, Ralph W. Smith	46°50′	103°	2,543	15.8	Fine sandy clay loam.
Mandan, N. Dak	Northern Great Plains Field Station, J. C. Brinsmade, Jr	46°50′	101°	1,750	16.0	Deep sandy silt loam.
Sheridan, Wyo	Sheridan Field Station, R. S. Towle	44°50′	106°50′	3,800	15.2	Dark heavy clay loam.
Newell, S. Dak	United States Department of Agriculture Belle Fourche Field Station, Beyer Aune (deceased).	44°40′	103°20′	2,875	15.7	Pierre clay.
Ardmore, S. Dak	United States Department of Agriculture Ardmore Experiment Station, O. R. Mathews.	43°	103°40′	3,557	15.9	Rosebud clay loam.
Hays, Kans	Fort Hays Branch Station, A. F. Swanson	38°50′	99°20′	2,000	23.7	Hays silty clay loam.
Woodward, Okla	United States Department of Agriculture Southern Great Plains Field Station, Edmund Stephens.	36°20′	99°20′	1,900	23.1	Woodward sandy loam.
Denton, Tex	Denton Substation, I. M. Atkins	33°	97°	600	32.5	Denton dark clay.

TABLE 1.—*List of stations where flaxseed was grown, showing approximate latitude, longitude, elevation, mean annual precipitation, and soil type*—Continued

Region and location of experiments	Institution and cooperator	Latitude, north	Longitude, west	Elevation	Mean annual precipitation	Soil type
				Feet	*Inches*	
Northern Prairie:						
Fargo, N. Dak	North Dakota Agricultural Experiment Station, T. E. Stoa	46°50′	96°50′	935	23.4	Fargo clay.
Crookston, Minn	Northwest Experiment Station, R. S. Dunham	47°45′	96°40′	888	20.6	Fargo clay loam.
Morris, Minn	West Central Experiment Station, R. O. Bridgford	45°40′	96°	1,170	23.9	Sandy clay loam.
St. Paul, Minn	Minnesota Agricultural Experiment Station, A. C. Arny	45°	93°	1,050	27.7	Merrimac silt loam.
Brookings, S. Dak	South Dakota Agricultural Experiment Station, S. P. Swenson	44°18′	96°48′	1,636	20.5	Barnes sandy loam.
Madison, Wis	Wisconsin Agricultural Experiment Station, O. S. Aamodt	43° 5′	89°23′	846	31.1	Miami clay loam.
Central and Eastern:						
Lincoln, Nebr	Nebraska Agricultural Experiment Station, T. A. Kiesselbach	40°45′	96°45′	1,230	27.9	Clay loam.
Manhattan, Kans	Kansas Agricultural Experiment Station, H. H. Laude	9°10′	96°[illegible]	1,100	33.0	Derby silt loam.
Moran, Kans	Kansas Agricultural Experiment Station, I. K. Landon and F. E. Davidson.	37°55′	95°[illegible]	1,070	38.1	Oswego silt loam.
Fredonia, Kans	(Kansas Agricultural Experiment Station, I. K. Landon and F. E. Davidson.)	37°30′	95°45′	860	37.2	Cherokee silt loam.
Ames, Iowa	Iowa Agricultural Experiment Station, L. C. Burnett	42°	93°39′	1,000	31.0	Clarion loam.
Urbana, Ill	Illinois Agricultural Experiment Station, J. J. Pieper (deceased)	40° 8′	88°15′	743	35.6	Muscatine silt loam.
Wooster, Ohio	Ohio Agricultural Experiment Station, L. E. Thatcher	40°47′	81°56′	1,034	37.8	Wooster silt loam.
New Brunswick, N. J	New Jersey Agricultural Experiment Station, Howard Sprague	40°29′	74°27′	110	45.5	Sassafras loam.
Southern Texas:						
San Antonio, Tex	San Antonio Field Station, George Ratliffe	29°20′	98°30′	640	27.2	Dark clay.
Beeville, Tex	Beeville Substation, R. A. Hall	28°32′	97°38′	240	30.9	Fine sandy clay loam.
College Station, Tex	Texas Agricultural Experiment Station, E. S. McFadden	30°39′	96°16′	308	38.5	Lufkin fine sandy loam.
Angleton, Tex	Angleton Substation, R. H. Stansel	29° 9′	94°24′	23	45.8	Lake Charles clay loam.
Victoria, Tex	Private farm, E. S. McFadden	28°45′	96°56′	187	35.7	Dark calcareous clay loam.
Orange Grove, Tex	do	27°50′	98°	200	24.7	Dark calcareous loam.
Winter Haven, Tex	Winter Haven Substation, E. Mortensen	28°40′	99°50′	600	19.1	Fine sandy loam.
Southwestern:						
El Centro, Calif	Imperial Valley Experimental Station, L. G. Goar	32°47′	115°34′	−53	2.8	Silty clay loam.
Mesa, Ariz	Salt River Valley Experimental Farm, A. T. Bartel	33°20′	111°50′	1,245	8.7	Laveen silt loam.
Sacaton, Ariz	United States Department of Agriculture Field Station, C. J. King	33°	111°50′	1,200	10.0	Alluvial sandy loam.
San Jacinto, Mexico	San Jacinto Experiment Station, Gumaro Garcia de la Cardena	19°20′	99°	8,000	29.3	

REVIEW OF LITERATURE

Although the literature on the relation of climate to crop production is very extensive, only a few of the more important papers dealing with flaxseed and other oil-bearing seeds are reviewed here.

In 1918 Rabak (*18*) [2] reported the results of analyses of 4 varieties of flax grown at 6 stations in the northern Great Plains. The oil content appeared to vary according to the nature of the growing season, the greatest range being at Archer, Wyo., where the average oil content of air-dry seed was 33.4 percent in 1914 and 38.8 percent in 1915. The 4 varieties differed somewhat in oil content, the 14-sample averages being 33.2 percent for N. D. R. 114, 33.8 percent for Primost, 35.1 percent for Damont, and 36.4 percent for Reserve.

In 1920 Clark (*5*) reported the yields and analyses of 14 varieties of flax grown on new land at Mandan, N. Dak., during the 3 years, 1914 to 1916, inclusive. The average oil content of air-dry seed ranged from 33.8 percent in Primost to 37.8 percent in N. Dak. No. 1221. Clark was perhaps the first to observe the relation of size of seed to oil content. He stated:

> It is apparent that there is a positive correlation between seed size and oil percentages in these varieties and that the seed-flax strains are superior to the short-fiber strains in both of these characters.

Johnson (*15*), in a study of 46 flax varieties at University Farm, St. Paul, Minn., found a high positive correlation between the weight of 1,000 seeds and the percentage yield of oil and a small but significant negative correlation between seed weight and iodine number. In another study Johnson (*16*) found little or no effect of soil fertility on oil content or weight of 1,000 seeds at maturity. He obtained a progressive reduction in yield of flaxseed when seeding was delayed 10 to 40 days after the optimum date (May 1), but he found little effect of date of seeding on the percentage of oil.

Garner et al. (*7*) concluded that under practical conditions climate is a more potent factor than soil type and fertility in affecting the size and oil content of soybeans.

In the Union of Soviet Socialist Republics, N. N. Ivanov (*9*) reported the analyses of 12 varieties of flaxseed grown at 20 or more stations in 1924 and 1925. He found that the large-seeded varieties produced a higher percentage of oil than medium- or small-seeded varieties. He stated:

> It was of great interest to ascertain that the varietal differences preserve their peculiarities as to oil production through all stations where sowings were carried on:—varieties for seed (linseed) yield the highest oil percentages, the varieties for fiber a low one, while the intermediate varieties approach those for seeds as regards oil production.

Referring to the relative oil yield of distinct varieties, he stated:

> Geographical factors exert almost no influence on the oil content of flax varieties, the latter tenaciously preserving their differences acquired in the process of selection.

His test showed that—"oils obtained from different localities were greatly different in their iodine values." From northern stations the iodine values ranged from 187 to 191, from central stations 183 to 186, and from southern stations 164 to 183.

[2] Italic numbers in parentheses refer to Literature Cited, p. 68.

Ivanov et al. (*10*) concluded from their studies that in general the oil content of a plant species decreases from northerly to southerly latitudes. However, increasing moisture content of the soil was found to increase the total oil in the seeds and, also, in the case of flax, the iodine number of the oil, so that in the irrigated southern districts of Russia the oil content reached 40 percent with an iodine number up to 1[illegible].

S. L. Ivanov (*11*) reported that climatic conditions greatly influenced the formation of fatty acids in the oil of seeds. Warm climate lowered and cold climate raised the percentages of unsaturated acids in the oils. Linolenic acid was the most sensitive to climatic conditions.

He also presented (*13*) a scheme of the oil-building process in the seeds of plants and discussed the effect of climate on the oil content and iodine number. He stated:

> In the mild climate of the South, where the day temperature is high and with little fluctuation during the day and night, the main product of the oil-building process is oleic acid; in the rough northern climate, with sharp changes in the temperature of the day and night, unsaturated acids are created. Such changes of the temperature of the day and night produce more linolenic acids.

He further reported (*14*) on linseed from Nolinsk (Russia) which was cultivated at two stations in Switzerland—at Liebefled, 55 m. above sea level, and Davos, 1,550 m. above sea level—and also in the tropical house of the botanical gardens at Berlin, Germany. The iodine numbers (Hubl) of the oils produced were: Nolinsk 185.1, Liebefled 188.4, Davos 189.6, and Berlin tropical house 92.6. The climate at the Swiss station was rainy and cold, whereas the Berlin tropical greenhouse was kept at a temperature of 25° to 30° C., with the atmosphere saturated.

Gross and Bailey (*8*) showed that all oils from the Bison flax contained higher percentages of oleic acid and lower percentages of linolenic acid than did those from Abyssinian yellow flax grown in the same locality. The amount of unsaturation in an oil, or its iodine number, appears to be a characteristic that can be varied by growing the plants under different environmental conditions.

Dillman (*6*) and Johnson (*16*) in Minnesota, and Lehberg, McGregor, and Geddes (*17*) in Canada showed that the seed weight and oil content of flaxseed increased progressively with maturity up to approximately 30 days after flowering. The deposition of oil in the seed was very rapid from about the fifth up to the twentieth day after flowering, at which time 80 to 90 percent of the total oil had been laid down. Oil content and dry weight of seeds reached a maximum several days before visual maturity.

EXPERIMENTAL METHODS

Field Plot Experiments

Four distinct varieties of flax were grown in drilled plots or in three-row nursery plots kept free from weeds by cultivation. In nearly all the experiments the varieties were replicated three or more times. Although no definite rotation or crop sequence was practiced at most stations, flax usually followed a cultivated crop, a legume crop, or clean-cultivated summer fallow. Commercial fertilizers were not used except at a few stations, as noted elsewhere. The soil preparation and rate and date of seeding were those considered best in each locality as determined by previous experience. The rate of seeding was about 2 pecks an acre in the drier areas and 3 pecks in humid areas and under irrigation. The crop was grown under irrigation at Bozeman, Mont.; Newell, S. Dak.; Fort Collins, Colo.; Aberdeen, Idaho; Prosser, Wash.; Winter Haven, Tex.; and at all stations in Utah, California, and Arizona. At all other stations the crop was grown without irrigation.

Some comparative data on the percentage yield and quality of oil of flax varieties grown in drilled plots and in cultivated rows at Mandan and Fargo, N. Dak., under relatively dry conditions, and at Bozeman, Mont., and El Centro, Calif., under irrigation, indicated little or no significant difference in oil content or iodine number between the two methods of cropping. It is believed, therefore, that no serious error is introduced in this bulletin in combining the data from drilled plots and nursery rows. The varieties were grown in drilled plots at Corvallis and Union, Oreg.; Havre and Moccasin, Mont.; Dickinson, Mandan, and Fargo, N. Dak.; Sheridan, Wyo.; Newell and Ardmore, S. Dak.; Crookston, Morris, and St. Paul, Minn.; Moran and Fredonia, Kans.; San Antonio, Tex.; and Mesa, Ariz. At all other stations the flax varieties were grown in replicated three-row nursery plots.

The flax was harvested when ripe and threshed as soon as dry. At a few stations the crop from nursery plots was stored under cover until dry enough to thresh. In only a few instances was the seed discolored by exposure in the field after harvest. After threshing, the seed was cleaned and weighed and the test weight per bushel determined. About 3 pounds of seed of each variety from the drilled plots was sent to the Washington laboratory, where the test weight was again determined, and a sample (80 gm.) was recleaned for chemical analysis. Smaller lots of seed from the nursery plots also were sent to Washington where they were recleaned and the test weight determined.

DESCRIPTION OF VARIETIES

The four flax varieties grown uniformly at all stations were Linota, Redwing, Bison, and Rio (fig. 1). These varieties were chosen because of differences in time of maturity, size of seed, and yield and drying quality of oil. They also are resistant to flax wilt, which practically eliminated that disease as a factor affecting the yields in these experiments. Two additional varieties, Punjab and Abyssinian Yellow, were grown in California and Arizona because of their excellent adaptation to fall sowing in those States. Brief descriptions of the six varieties follow:

Linota.—Early maturing; plants midheight (24 to 30 inches); flowers funnelform, petals common flax blue; bolls semidehiscent, septa ciliate; seeds brown, small.

Redwing.—Early maturing; plants short to midheight (20 to 28 inches), stems strong, rarely lodging; flowers funnelform, petals light blue; bolls semidehiscent, septa ciliate; seeds brown, small.

Bison.—Midseason in maturity; plants midheight (24 to 30 inches); flowers funnelform, petals deep blue; bolls semidehiscent, septa ciliate; seeds brown, midsize.

FIGURE 1.—Panicle branches and seeds of six varieties of flax showing comparative size of bolls and the seeds and the dehiscent character of the bolls. *A*, Linota; *B*, Redwing; *C*, Bison; *D*, Rio; *E*, Punjab; and *F*, Abyssinian Yellow. The varieties Rio and Punjab have firm indehiscent bolls, whereas the other varieties have semidehiscent bolls.

RIO.—Midseason to late; plants short to midheight (20 to 30 inches); stems stout, often with two or more tall basal branches; flowers large, saucer-shaped, petals common flax blue; bolls indehiscent, septa ciliate; seeds brown, large. Rio is a selection of Argentine flax that is well adapted to fall sowing in California and southern Texas. When fall-sown it is taller, has a longer blooming period, and is later in maturity than the other varieties mentioned.

PUNJAB.—Midseason; plants short (16 to 24 inches); stems stout, often with two or more basal branches; flowers funnelform, petals blue; bolls indehiscent, septa ciliate; seeds brown, midsize. Punjab is the principal commercial variety grown in California and Arizona because of its high-yielding capacity and its nonshattering habit. Its firm bolls, however, are difficult to thresh.

ABYSSINIAN YELLOW.—Early; plants short (16 to 24 inches); stems relatively slender, with two to several basal branches, the branches spreading and leafy; flowers funnelform, petals blue; bolls semidehiscent, septa smooth (nonciliate); seeds yellow, small. This variety produces an oil of good quality; that is, of high iodine number. It shatters somewhat when overripe and for that reason is not so well adapted to combine harvesting in a dry climate as is the Punjab variety.

PHYSICAL AND CHEMICAL ANALYSES

The following physical and chemical properties of the seed, oil, and meal were determined: Test weight per bushel, weight of 1,000 seeds, moisture content, and oil content of the seed; iodine number of the oil; and crude-protein content of the meal.

Test Weight per Bushel

The test weight in pounds per bushel is used as a grading factor for flaxseed under the Official Grain Standards of the United States. Grade No. 1 requires a minimum test weight of 49 pounds, and grade No. 2, 47 pounds per measured busnel. In these experiments, the test weights were determined at each station soon after threshing, or after a short period of storage. Later, the test weights were again determined in the Washington laboratory by the official standard method (*21*), after the seed had been recleaned and stored for some time, at which time the seed contained approximately 6 percent moisture. For the small samples from nursery plots a small unofficial test kettle was used.

The test weights reported from the cooperating stations in Canada were computed to the basis of the Winchester bushel (2,150.42 cubic inches) used in the United States. The Imperial bushel used in Great Britain and Canada contains 2,219.36 cubic inches, which is about 3 percent larger than the Winchester bushel.

Size of Seeds

The size of the seeds is expressed as the weight in grams of 1,000 seeds. In all cases the seed represented a random air-dry sample (about 6 percent moisture), and the count was obtained by use of a seed counter operated by air suction (fig. 2). The counter shown is a

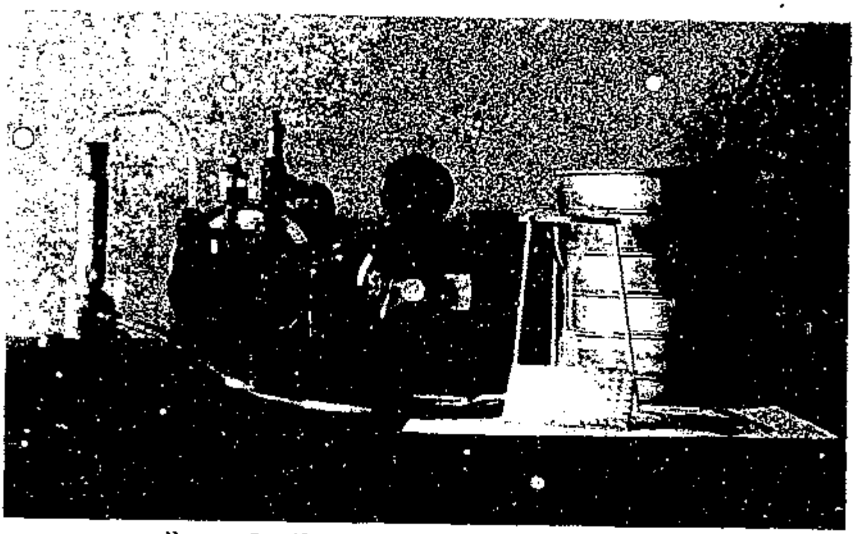

Figure 2.—Vacuum seed counter and accessories.

modification of the one developed by Brown, Toole, and Goss (4). In most samples, 1,000 seeds were weighed, but, in a few of the earlier analyses, the weight was determined on three 100-seed samples.

Preparation of Seed Samples for Analyses

The recleaned samples of seed were ground with a 6-inch roller mill, the rolls having 40 corrugations per inch. The two rolls were run at speeds of about 400 and 600 revolutions per minute. After extraction, about 90 percent of the meal would pass through a 40-mesh sieve.

The oil used for the determination of iodine number was pressed from the ground meal by means of a hydraulic press (fig. 3). The meal was warmed slightly in a steam bath before pressing, and the

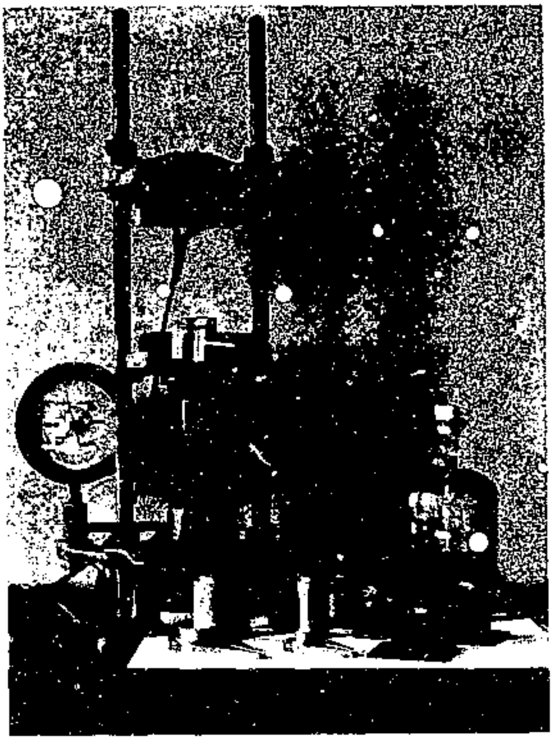

FIGURE 3.—Hydraulic press and accessories.

electrically heated plates of the press were maintained at a temperature of 60° to 70° C. The pressed oil was filtered by suction through an asbestos mat in a Gooch crucible and collected in a bottle. The oil samples were kept in a refrigerator until the analyses were completed. The method of warm pressing was found to have no appreciable effect on the oil. No selective flow of oil from the press cake could be determined, indicating that the seed had been uniformly and finely ground and consequently that the oil sample obtained was representative of the total oil in the seed.

Moisture and Oil Content of Seed

The moisture content and oil content of the seed were determined by using a modification of the official procedure of the Association of Official Agricultural Chemists (*1*). The samples of finely ground meal were placed in special glass extraction tubes and dried both before and after extraction in a vacuum oven for 7½ hours at 100° to 105° C., under a pressure kept below 100 mm. of mercury. This standard period of drying was determined by experimentation. The dry samples were extracted in Soxhlet extractors with anhydrous ethyl ether for 22 hours. This time of treatment is necessary to obtain uniform and approximately complete extraction. The percentages of moisture and of oil were determined by difference or loss in weight.

The oil content was computed on a basis of 8 percent moisture in the seed, which is about the normal or average moisture content of good-quality flaxseed as marketed in the North Central States and as used in commercial crushing. The authors believe that this gives a truer measure of the commercial value of flaxseed than if the oil content were reported on a dry basis. Formerly, many chemists reported oil analysis on air-dry basis, which makes comparison of data uncertain. In general, flaxseed stored in a relatively dry atmosphere for a short time will contain about 6 percent moisture.

Iodine Number of Oil

The iodine absorption number of the oil was determined by the Wijs method (*2*). Carbon tetrachloride was used as the oil solvent.

The iodine number of linseed oil or other oils is the number of grams of iodine that 100 gm. of oil will absorb under the rigid conditions of the method of analysis. It is a measure of the chemical unsaturation and is commonly used to indicate the relative drying quality of an oil as compared to other oils of the same or similar type. In general, oils of high iodine numbers dry more quickly and form firmer paint films than oils of low iodine numbers. The generally high iodine numbers of linseed oils are dependent on the percentages of the more highly unsaturated fatty acids, linoleic and linolenic, as compared to percentages of saturated and oleic acids.

Crude-Protein Content of Meal

The crude-protein content (N × 6.25) of the ground seed was determined by the Kjeldahl-Gunning-Arnold method (*3*). The results were calculated on the basis of 12 percent moisture and 4.5 percent oil, which approximates the average values for commercial linseed meal. This gives a practical and uniform basis for comparing samples.

EXPERIMENTAL RESULTS

The experiments conducted in the United States are reported by grouping stations located in regions of more or less similar climatic conditions.

State boundaries were disregarded in grouping stations because of frequent wide differences in rainfall and soil type within a State. Thus in Oregon, the annual precipitation ranges from about 40 inches at Corvallis to 13 inches at Union; in North Dakota, from 16 inches at

Dickinson to 23 inches at Fargo; and in Kansas, from 24 inches at Hays to 38 inches at Moran. A map showing the location of cooperating stations is shown in figure 4.

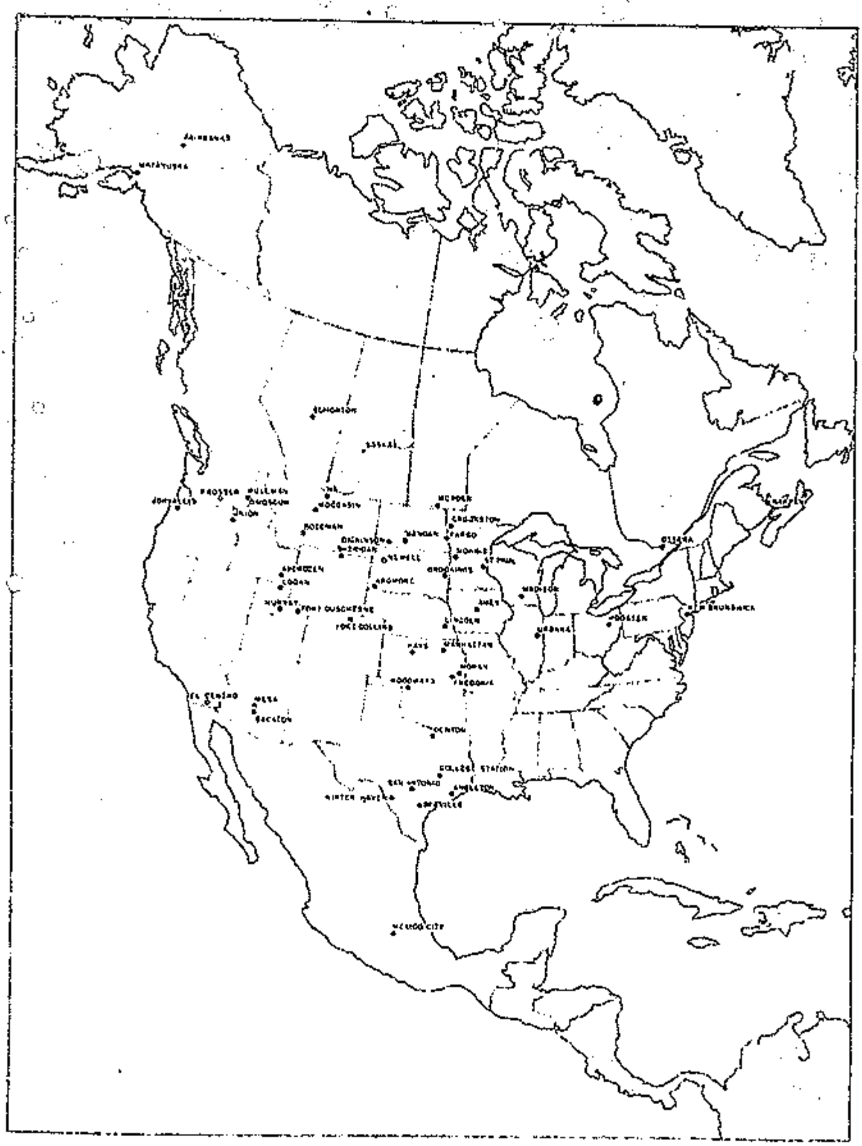

FIGURE 4.—Outline map of North America showing the location of the cooperating stations.

ALASKA AND CANADA

Data from two stations in Alaska and from six stations in Canada are grouped together in table 2. The results from Alaska are limited. There is a wide range in climatic conditions among these northern stations, as shown in table 10.

In Alaska a large number of flax varieties were sown at Fairbanks (lat. 64°5′ N.) in 1929 and at Matanuska (lat. 61°30′ N.) in 1930 and 1931. These stations are the most northerly points at which flax was grown in these experiments. The climate is cool with only light or moderate precipitation. The mean July temperature is 60° F. at Fairbanks and 58° at Matanuska, and the temperature rarely reaches 80°. The long days, nearly 22 hours in June, induced rapid growth of the flax plant, but the cool weather of August caused slow ripening. Only early varieties, such as Linota and Redwing, matured fully in 1929 and 1931, and none matured fully in 1930.

The Linota and Redwing varieties required 110 days from seeding to maturity in 1929 and 120 days in 1931. Oils of high-drying quality, iodine numbers 200 to 206, were obtained from flaxseed grown at the two Alaskan stations.

In Canada nearly complete data were obtained at five stations. Although they include a wide range in climatic conditions, it is believed that these stations are representative of the principal agricultural areas of the Dominion. At Edmonton and Fallis, Alberta, the summer temperatures are moderate or cool, and precipitation generally is adequate for flax production. The long days are favorable for the rapid growth of crops. The experiments were conducted for 9 years at Edmonton and 2 years at Fallis. In 1935 a severe frost occurred on August 16, when all varieties were frozen at Fallis, and only Redwing matured at Edmonton. High average yields were obtained at Edmonton, but relatively low yields at Fallis. At both stations the oil content and iodine numbers were high. Edmonton is located in the so-called park zone of central Alberta, and Fallis is located some 50 miles west of Edmonton, on a podzol type of soil, the surface of which contains considerable organic matter.

Saskatoon is located approximately on the border between the mixed short-grass area of southern Saskatchewan and the so-called park zone of central Saskatchewan, where clumps of small trees, chiefly aspen, are a prominent feature of the native vegetation. The soil is a dark clay loam of glacial origin. The July temperatures are higher than at Edmonton. During the period of these experiments, 1930 to 1938, frequent drought was the chief factor in limiting the yield of flax.

Morden, Manitoba, is located near the border between the prairie of the Red River Valley and the typical short-grass area of the northern Great Plains. The soil is a glacial sandy loam of the Barnes series. Drought and high temperatures occurred during the growing seasons of 1931, 1933, 1934, and 1936, which reduced the yield of flaxseed.

Ottawa, Ontario, is in about the same latitude as St. Paul, Minn., and the climate of southern Ontario, where flax is a crop of some importance, is more or less like that of southern Minnesota. Relatively high yields of flaxseed of good quality were obtained during the 5-year period 1934 to 1938.

TABLE 2.—*Acre yield, test weight, weight per 1,000 seeds, oil content of seed, iodine number of oil, and crude-protein content of meal of 4 varieties of flax grown at 2 stations in Alaska and 6 stations in Canada*

Station and crop year	Acre yield				Test weight				Weight per 1,000 seeds				Oil content (basis, 8 percent moisture)				Iodine number of oil (Wijs)				Crude protein in meal [1]			
	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio
Fairbanks, Alaska:	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*					*Pct.*	*Pct.*	*Pct.*	*Pct.*
1929	18.2	20.2	16.0	...	...	...	...	...	5.4	5.6	6.8	...	35.4	38.1	40.3	...	205	203	200	...	...	...	...	...
Matanuska, Alaska:																								
1931	18.0	19.0	...	...	...	...	...	...	4.8	5.3	...	...	40.0	41.2	...	...	206	206	...	...	...	...	...	...
Edmonton, Alberta:																								
1930	17.3	13.3	6.4	15.3	53.8	54.1	51.8	52.2	4.3	4.4	5.8	8.2	36.1	36.1	38.3	40.7	191	192	186	189	...	...	...	...
1931	29.8	25.0	22.3	24.8	53.5	53.2	52.8	51.2	4.9	5.3	6.6	8.5	35.8	36.9	39.3	40.2	197	195	193	187	...	...	...	...
1932	14.5	16.0	16.0	16.0	52.3	52.1	51.4	51.2	3.6	4.2	5.7	6.7	33.8	35.0	37.1	37.9	188	190	179	178	...	...	...	...
1933	28.3	24.4	23.2	21.1	53.4	53.9	52.1	51.6	4.7	5.0	6.7	8.0	36.2	36.2	38.4	40.9	192	192	183	190	...	...	...	...
1934	21.3	22.9	19.5	18.3	51.0	52.0	48.5	46.0	4.3	4.9	5.5	6.7	36.2	37.6	39.2	39.2	198	196	189	190	...	40.0	40.5	...
1935	...	28.0	...	...	...	52.9	...	...	...	4.3	...	...	...	38.2	...	...	...	198	...	...	...	...	...	...
1936	[2] 15.0	15.0	15.2	...	53.4	53.4	51.4	...	4.2	4.6	6.5	...	35.7	36.2	37.9	...	196	195	186	...	40.8	41.9	44.6	...
1937	16.7	20.9	19.8	...	55.8	55.8	55.3	...	4.7	5.0	6.8	...	36.2	37.7	39.2	...	200	198	192	...	37.6	38.5	41.7	...
1938	18.4	21.7	16.7	...	55.3	55.8	53.9	...	4.3	4.5	6.1	...	36.6	37.4	39.4	...	197	196	191	...	39.3	39.9	40.6	...
Average	20.2	20.8	17.4	19.1	53.6	53.7	52.2	50.4	4.4	4.7	6.2	7.6	35.8	35.8	38.6	39.8	195	195	187	187	39.2	40.1	41.8	...
Fallis, Alberta:																								
1934	7.3	5.3	3.3	...	51.0	50.0	50.0	...	3.8	4.2	4.9	...	38.8	40.1	39.4	...	203	202	197	...	...	...	...	...
1936	7.8	6.6	[2] 7.0	...	53.4	53.4	52.0	...	5.0	5.2	6.9	...	37.1	37.7	39.5	...	204	202	196	...	37.9	38.6	39.7	...
Average	7.6	6.0	5.2	...	52.2	51.7	51.0	...	4.4	4.7	5.9	...	38.0	38.9	39.4	...	204	202	196	...	37.9	38.6	39.7	...
Saskatoon, Saskatchewan:																								
1930	6.9	6.4	6.4	6.0	53.3	53.0	52.4	52.0	4.0	4.2	5.8	7.1	34.3	35.0	37.2	38.8	190	186	173	180	...	...	...	...
1931	16.8	13.3	18.7	17.1	54.1	53.9	53.9	53.3	4.2	4.6	6.4	7.1	35.5	36.5	38.3	39.4	195	194	187	188	...	...	...	...
1932	11.4	11.4	11.2	12.6	52.3	52.7	52.0	50.9	3.6	4.1	5.4	6.3	33.8	35.1	37.4	37.9	187	190	182	179	...	...	...	...
1933	6.4	6.4	7.7	8.5	54.0	54.2	53.0	53.0	3.6	4.1	5.6	6.5	34.3	35.6	37.4	38.4	192	189	182	182	...	...	...	...
1934	5.3	6.0	6.1	5.9	53.2	53.1	52.0	51.8	3.6	4.0	5.6	6.4	34.4	35.5	37.5	38.5	187	189	184	184	...	...	...	...
1935	10.2	9.1	8.9	12.8	54.7	54.7	54.0	53.4	3.9	4.6	6.3	6.7	35.7	37.4	39.1	40.1	196	195	188	189	38.7	39.7	41.9	39.4
1936	5.0	5.5	5.2	5.4	55.3	53.9	54.6	53.9	3.4	3.7	5.1	5.8	31.0	34.8	37.2	37.6	186	185	180	176	41.5	43.0	44.3	42.0

1937	3.0	3.2	3.8	2.9	54.6	55.1	54.4	54.4	3.4	3.7	5.2	5.5	34.0	34.0	37.0	37.7	193	194	187	185	40.0	42.2	43.7	41.9
1938	8.7	9.2	9.1	9.0	54.6	54.8	54.1	53.6	3.6	4.1	5.4	5.6	34.5	36.0	37.4	37.4	191	190	181	185	39.0	40.6	41.7	40.0
Average	8.2	7.8	8.6	8.9	54.9	53.9	53.4	52.9	3.7	4.1	5.6	6.3	34.5	35.6	37.6	38.4	191	190	183	183	39.8	41.4	42.9	40.8
Morden, Manitoba:																								
1930	23.8	25.2	25.0	27.4	54.4	54.5	52.4	53.2	4.1	4.7	5.8	7.1	33.3	35.1	37.0	37.1	181	183	176	173	.....	.....	.....	.....
1931	11.8	10.9	11.2	10.8	52.0	53.0	51.6	52.0	3.5	4.2	6.0	7.9	32.9	34.1	36.7	37.0	183	183	174	174	.....	.....	.....	.....
1932	16.6	13.2	13.7	17.5	54.2	54.2	53.0	52.5	4.1	4.5	5.8	6.7	33.0	34.6	36.4	37.1	184	185	177	175	.....	.....	.....	.....
1933	6.8	9.5	9.0	6.7	54.4	54.1	53.0	52.2	3.9	4.3	6.0	6.8	33.9	34.9	36.7	37.5	184	187	177	179	.....	.....	.....	.....
1934	14.1	9.0	13.0	8.3	54.0	54.0	53.0	52.2	3.6	4.1	5.6	6.3	33.6	34.7	37.5	37.5	186	185	180	178	.....	.....	.....	.....
1935	19.2	18.2	13.3	.....	53.9	54.4	53.4	.....	4.2	4.5	5.5	.....	34.1	35.4	36.6	.....	179	180	171	.....	.....	.....	.....	.....
1936	4.8	4.3	5.2	5.0	55.3	53.4	54.5	53.4	3.0	3.6	4.8	6.1	31.6	33.6	35.3	37.3	178	182	169	176	41.3	43.4	44.0	42.2
1937	.....	18.3	16.2	.....	.....	55.3	54.8	.....	.....	4.6	6.0	.....	.....	35.7	37.5	.....	.....	188	180	.....	.....	40.6	41.8	.....
1938	.....	31.3	31.4	.....	.....	55.8	54.4	.....	.....	5.0	6.7	.....	.....	37.3	38.3	.....	.....	192	180	.....	.....	38.2	40.2	.....
Average	13.9	15.5	15.3	12.6	54.0	54.3	53.4	52.6	3.8	4.4	5.8	6.8	33.2	35.0	36.9	37.2	182	185	176	176	41.3	40.7	42.0	42.2
Ottawa, Ontario:																								
1934	17.5	18.7	18.7	18.3	55.8	55.1	55.1	54.9	3.8	4.4	5.8	6.6	34.7	35.6	37.1	38.1	191	191	181	181	41.7	43.4	44.3	40.9
1935	21.7	24.5	18.5	25.5	55.0	55.0	52.7	53.0	3.3	4.5	6.3	6.5	34.1	36.9	38.1	38.6	189	190	181	181	41.5	38.7	44.2	41.5
1936	18.2	18.7	24.0	17.1	56.2	55.4	54.8	54.8	4.3	4.6	6.7	7.8	35.4	36.3	38.3	39.2	193	191	178	185	41.1	42.2	43.6	41.7
1937	16.2	14.3	14.8	22.1	54.0	54.0	52.4	52.4	4.2	4.5	5.8	7.0	35.0	36.3	36.8	38.2	185	188	169	169	38.7	40.2	42.2	38.4
1938	17.4	15.1	19.0	18.5	54.8	54.8	53.4	53.0	4.4	4.8	6.1	7.9	35.4	37.5	38.1	40.3	192	196	184	188	36.6	35.2	38.9	34.6
Average	18.2	18.3	19.0	20.3	55.2	54.9	53.7	53.6	4.0	4.6	6.1	7.2	34.9	36.5	37.7	38.9	190	191	179	181	39.9	39.9	42.6	39.4
Nappan, Nova Scotia:																								
1934	16.6	18.0	14.7	15.9	55.1	54.0	54.4	53.4	4.7	4.9	6.5	9.0	37.5	38.4	41.2	42.4	199	195	195	196	33.4	34.5	35.1	33.9
1935	12.4	14.5	16.0	17.8	54.0	53.8	53.5	52.9	4.4	4.7	6.4	8.6	38.9	39.9	41.4	43.0	200	200	196	194	30.5	31.5	32.7	31.8
1936	21.1	20.6	23.2	21.2	54.2	54.3	53.5	52.4	4.5	4.8	6.1	7.8	38.2	39.6	41.6	42.7	198	199	192	195	29.9	31.4	33.2	31.4
1937	21.0	20.0	19.8	21.0	55.4	54.4	55.0	52.2	4.2	5.5	5.8	7.5	37.0	38.0	39.9	40.3	195	197	188	183	30.5	31.7	32.8	32.6
1938	18.7	16.4	12.3	8.7	53.6	53.2	44.0	47.5	4.7	4.8	6.5	7.7	36.5	37.3	39.5	40.2	192	192	185	183	33.8	34.0	37.6	33.7
Average	18.0	17.9	17.2	16.9	54.5	53.9	52.1	51.7	4.5	4.9	6.3	8.1	37.6	38.6	40.7	41.7	197	197	191	190	31.6	32.6	34.3	32.7

[1] Crude protein (N×6.25) in meal, basis of 12 percent moisture and 4.5 percent oil.
[2] Interpolated yields.

Nappan, Nova Scotia, is located near Amherst, in the extreme northeastern part of the Province. The summer climate is relatively cool and humid. The mean annual precipitation is 36.2 inches, of which about 6 inches occur during June and July. Relatively high yields of flaxseed were obtained except in 1938, when yields of Bison and Rio were reduced by lodging. The average oil content was high and the iodine number of the oils exceptionally high. On the other hand, the average crude-protein content of the meal was the lowest obtained at any station included in these experiments.

Pacific Northwest and Intermountain Regions

In the Pacific Northwest and in those portions of the Intermountain region west of the Rocky Mountain Continental Divide, precipitation occurs chiefly during the fall, winter, and early spring (October to April), and spring-sown crops, such as flax, are dependent largely on stored soil moisture for their later growth during the period of seed filling and maturity. Winter temperatures generally are too low to permit the survival of flax sown in the fall. Data are available from 11 stations (table 3) in these 2 regions. Of these, Corvallis, Oreg., is located in a section of heavy winter rainfall, cool summers, and mild winters. The remaining 10 stations are located in areas of more extreme temperature, medium to high elevation, and light to moderate precipitation (see table 11). The flax was grown under irrigation at 7 of the stations.

Corvallis, Oreg., is located in the Willamette Valley. The soil is classified as Willamette loam and is typical of the better soil types in the area. The annual precipitation is about 40 inches, which occurs chiefly as rain during the fall, winter, and early spring. The average rainfall from May to August, inclusive, is only 3.5 inches. Summer temperatures are mild, the maximum rarely exceeding 90° F. during the growing season. The date of seeding ranged from April 10 to May 6, the average date being April 18. The growing season—from date of seeding to maturity—ranged from 93 to 109 days and averaged 101 days. The fruiting period—from first bloom to ripening—ranged from 36 to 47 days and averaged 41 days. There was, however, no significant difference between the four varieties in the length of the growing or fruiting periods. The yield of flax at Corvallis often depends on favorable rainfall during May and June, the critical period in the growth of the crop. The dry season of 1938, with temperatures much above normal, resulted in low yields and a somewhat low oil content and low iodine number of the oils.

Union, Oreg., is located in the northeastern part of the State. The soil, a dark sandy loam classified as Catherine silt loam, is subirrigated by drainage from adjacent irrigated lands. The depth to the water table varies from 2 to 5 feet, according to the amount of irrigation above. The success of flax, however, often depends on timely rains to provide surface moisture for germination and early growth. Flax was a failure in 1934 and 1937 because of early summer drought, the soil being too dry to obtain satisfactory stands.

Pullman is located in the Palouse area of eastern Washington. The soil is classified as Palouse silt loam, which is typical of the fertile soils of the locality. Winter wheat is the principal crop in this area, although flax has been grown to a limited extent in recent years. The average annual precipitation is 20.5 inches, of which about 5.4 inches fall during the growing season. As flax is grown without irrigation, favorable yields often depend on the amount of precipitation during late spring and early summer.

Prosser, Wash., is located in the Yakima Valley. The soil is a sandy loam, of low moisture-holding capacity. The mean annual precipitation is 7.4 inches and the seasonal (April to August) rainfall is less than 2 inches. In 1938, the flax varieties were irrigated four times, a total of about 24 inches of water being applied. High temperatures prevailed during July, which may account in part for the low yields obtained.

Moscow is located in the Palouse area of northwestern Idaho, about 9 miles east of Pullman, Wash. The soil and climatic conditions are similar to those at Pullman.

Bozeman is located in the Gallatin Valley in south-central Montana. The soil is a fertile silt loam, 2 to 4 feet deep, underlain with sand and gravel. The flax varieties were grown on fallowed land each year and given one irrigation (4 to 6 inches of water) at about the beginning of the blossoming period, except in 1933, when no irrigation was given.

Aberdeen, Idaho, is located in the Snake River Valley. The soil is a silty clay loam. The average annual precipitation is only 8.8 inches, so that crop production is dependent on irrigation. The flax varieties were irrigated three or four times during the growing season.

At Logan, Murray, and Fort Duchesne, Utah, flax varieties were grown during 4 to 6 years of the period from 1931 to 1937. All three stations lie at elevations above 4,000 feet. The flax was irrigated from two to four times, as necessary, each season. The soils are productive and relatively high yields of flaxseed were obtained.

Fort Collins, Colo., is located just east of the Rocky Mountains at an elevation of 5,000 feet. The average annual precipitation is 14.7 inches, of which about 8 inches occur during the 4 months, April to July. The flax varieties were irrigated once or twice each season. In 1930 and in 1931 the flax was grown on alfalfa land plowed the previous fall; in 1932 flax followed sugar beets, in 1933 corn, and in 1934 fallow. Fairly satisfactory yields were obtained in 1934, but in the tests of 1930 to 1933 the plots were very weedy and yields were low.

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TABLE 3.—*Acre yield, test weight, weight per 1,000 seeds, oil content of seed, iodine number of oil, and crude protein content of meal of 4 varieties of flax grown at 11 stations in the Pacific Northwest and Intermountain region*

Station and crop year	Acre yield				Test weight				Weight per 1,000 seeds				Oil content (basis, 8 percent moisture)				Iodine number of oil (Wijs)				Crude protein in meal [1]			
	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio
Corvallis, Oreg.:	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*					*Pct.*	*Pct.*	*Pct.*	*Pct.*
1929	4.3	4.7	6.8	5.6	53.0	52.0	51.5	51.0	3.5	4.1	5.4	7.1	35.7	37.2	39.8	40.6	200	201	195	193	...	...	...	...
1930	6.4	6.7	7.7	4.9	47.8	50.5	48.6	47.4	4.4	4.1	5.3	6.8	38.3	26.1	38.2	39.8	194	196	189	189	...	...	...	...
1931	12.8	12.2	12.2	12.2	54.7	54.7	54.2	52.9	3.9	4.4	4.9	6.6	34.8	36.3	37.6	39.0	192	192	188	184	...	...	...	...
1932	15.8	15.8	16.0	15.0	53.7	53.7	53.1	52.7	3.4	3.9	4.5	5.6	36.8	38.0	39.2	40.6	198	193	194	193	...	...	...	...
1933	12.1	11.1	8.3	11.4	53.1	53.5	52.9	51.5	3.6	4.4	4.6	5.7	35.0	36.4	36.8	38.5	189	194	189	186	...	...	...	...
1934	8.4	9.6	11.2	6.3	54.5	54.2	53.8	53.5	3.8	4.1	5.0	5.8	35.9	37.3	37.6	39.3	199	201	194	193	...	38.7	41.1	...
1935	4.4	4.7	5.2	4.3	53.8	53.8	53.2	53.4	4.1	4.5	5.2	4.7	35.8	38.0	37.7	37.5	191	197	183	187	36.0	36.5	39.1	38.9
1936	11.7	10.9	12.1	12.1	55.0	55.5	55.0	54.9	4.4	4.8	5.5	5.7	39.4	40.3	41.6	42.0	200	202	199	199	28.9	29.8	31.4	30.7
1937	14.4	10.9	14.4	15.9	56.0	56.0	55.8	55.5	4.3	4.7	5.3	5.0	38.3	39.0	39.8	39.6	195	197	192	196	30.9	31.2	33.0	31.8
1938	1.8	1.7	2.3	2.1	54.1	54.0	53.7	54.3	3.7	3.9	4.7	4.5	36.1	36.1	37.0	37.8	192	194	186	189	38.5	38.9	39.8	39.3
Average	9.2	8.8	9.6	9.0	53.6	53.8	53.2	52.7	3.9	4.3	5.0	5.8	36.6	37.5	38.5	39.5	195	197	191	191	33.8	35.0	36.9	35.2
Union, Oreg. (subirrigated):																								
1930	10.7	19.4	13.9	22.8	53.1	53.8	52.3	51.9	4.4	4.7	6.1	7.7	36.5	37.6	38.6	40.0	187	191	180	183	...	...	...	...
1931	25.0	22.8	27.3	31.3	52.5	52.6	52.5	51.7	4.0	4.2	6.1	7.1	35.9	37.6	38.9	40.9	186	186	180	184	...	...	...	...
1932	15.3	15.8	15.5	17.0	52.3	52.5	52.0	52.0	3.8	4.1	6.0	6.9	35.7	38.1	39.5	41.7	188	188	180	183	...	...	...	...
1933	33.3	31.5	30.0	28.8	52.9	52.5	52.2	52.2	4.5	4.7	5.7	6.4	36.6	37.6	37.4	39.9	191	194	189	188	...	...	...	...
1935	9.4	7.2	7.2	4.5	52.0	54.0	52.0	50.0	3.8	3.9	3.7	5.6	38.7	36.8	38.3	42.1	193	192	193	186	33.1	39.6	35.2	31.4
1936	15.5	15.8	16.1	14.9	...	...	...	...	4.0	4.6	4.5	5.3	37.8	37.6	38.0	40.6	191	191	188	184	33.0	35.4	36.4	33.3
1938	13.1	10.1	10.1	9.2	52.0	51.0	51.0	51.0	3.8	4.3	6.2	5.7	36.1	38.4	39.3	40.2	189	194	189	192	38.4	34.8	41.4	34.4
Average	18.8	17.5	17.2	18.4	52.5	52.7	52.0	51.5	4.0	4.4	5.5	6.4	36.8	37.7	38.6	40.8	189	191	186	186	34.8	36.6	37.7	33.0
Pullman, Wash:																								
1938	16.3	14.7	16.6	14.9	...	...	...	...	3.9	4.3	4.3	5.6	34.6	35.9	36.0	36.9	180	186	178	171	38.3	39.8	39.8	38.2
Prosser, Wash. (irrigated):																								
1938	4.9	5.3	6.8	3.1	...	...	...	...	4.4	...	5.8	6.7	37.3	...	38.9	37.7	196	...	185	186	34.7	...	37.6	30.6
Moscow, Idaho:																								
1938	16.0	9.7	9.7	...	...	...	...	...	4.0	4.5	5.6	...	35.2	37.4	37.4	...	190	190	176	...	34.9	35.1	38.9	...
Bozeman, Mont. (irrigated):																								
1929	27.9	27.7	25.8	19.0	53.3	53.2	52.8	50.6	4.7	5.2	7.1	8.8	34.8	36.2	39.2	38.1	190	191	182	179	...	...	...	...
1930	19.0	24.8	28.2	15.1	53.5	53.6	52.3	51.9	4.8	5.2	7.2	8.4	34.7	35.8	37.4	38.9	187	188	174	178	...	...	...	...
1931	42.1	45.0	43.6	47.1	53.5	53.6	52.8	52.2	4.6	5.1	7.0	8.9	35.0	36.5	38.8	40.0	182	180	172	180	...	...	...	...
1932	35.0	37.1	40.4	42.9	53.7	52.6	53.1	52.1	4.8	5.2	6.8	7.6	35.4	36.7	37.8	39.3	186	185	177	180	...	...	...	...
1933	16.6	15.3	21.4	25.0	55.2	55.1	54.9	52.8	3.8	4.2	6.1	7.5	34.5	35.5	37.9	40.0	187	188	178	180	...	...	...	...

1934	16.0	15.7	16.3	21.4	53.5	53.0	52.0	52.5	3.8	4.4	6.0	6.6	34.6	36.2	37.8	38.2	181	182	172	176		40.5	42.3	
1935	21.9	22.7	27.6	34.1					4.2	4.6	6.4	7.5	35.3	37.2	38.7	40.0	190	188	179	181	40.0	40.8	43.5	39.6
1936	21.6	22.8	26.4	29.4					4.1	4.9	6.4	7.4	35.2	37.7	38.2	39.2	188	186	176	178	39.7	41.0	43.4	39.5
1937	20.4	28.2	28.5	25.7					4.6	5.3	6.8	7.2	35.0	37.7	38.4	39.1	191	187	184	180	39.3	40.6	43.2	39.7
1938	29.3	25.1	26.9	20.6					5.0	5.5	7.2	6.9	35.6	37.7	39.4	37.8	193	190	182	174	37.5	38.5	41.1	38.1
Average	25.0	26.4	28.5	28.0	53.8	53.5	53.0	52.0	4.4	5.0	6.7	7.7	35.0	36.7	38.4	39.1	188	186	178	179	39.1	40.3	42.7	39.2
Aberdeen, Idaho (irrigated):																								
1935	39.5	35.2	36.3	39.7	52.0	53.0	51.0	52.0	4.6	4.9	6.7	7.0	37.8	38.7	41.3	42.2	190	190	183	186	33.9	35.8	37.1	35.6
1937	29.8	25.5	28.7	28.2	54.0	54.0	54.0	53.5	4.4	5.2	6.6	6.9	37.9	38.6	40.5	41.9	194	194	184	188	32.8	34.0	36.5	33.6
1938	27.4	28.6	37.0	36.6	53.0	53.0	52.0	52.0	4.6	4.9	6.6	6.9	38.2	39.1	41.5	42.9	192	192	185	190	32.0	33.3	35.6	33.4
Average	32.2	29.8	34.0	34.8	53.0	53.3	52.3	52.5	4.5	5.0	6.6	6.9	38.0	38.8	41.1	42.3	192	192	184	188	32.9	34.4	36.4	34.2
Logan, Utah (irrigated):																								
1932	26.8	27.9	27.9	30.1	55.0	55.0	53.5	53.0	4.4	4.7	6.7	7.9	35.6	36.6	38.9	40.3	191	193	183	182	...	...	...	...
1933	21.1	20.8	21.3	22.7	54.7	55.0	53.0	52.3	4.2	4.7	6.7	7.1	34.7	36.2	37.8	38.6	186	188	175	174	...	...	...	...
1934	38.8	31.5	35.8	33.7	53.5	53.5	52.3	51.4	4.3	4.8	6.5	7.9	35.3	36.6	38.2	34.7	188	189	179	179	...	...	...	...
1935	32.4	30.6	29.8	33.7					4.6	4.9	6.7	7.4	35.3	36.9	38.6	39.6	187	188	177	176	39.3	39.5	41.0	38.0
1936	32.0	30.4	38.1	32.0					4.5	4.9	6.8	6.5	36.6	37.6	39.5	38.7	190	191	178	172	36.9	38.4	40.4	40.0
1937	15.6	19.6	19.7	23.1	53.2	53.2	52.5	51.7	4.5	4.9	6.7	7.4	36.2	37.6	39.2	39.9	189	190	181	179	36.0	36.8	39.0	36.0
Average	27.8	26.8	28.8	29.2	54.1	54.2	52.8	52.1	4.4	4.8	6.7	7.4	35.6	36.9	38.7	38.6	188	190	179	177	37.4	38.2	40.1	38.0
Murray, Utah (irrigated):																								
1932	21.6	24.2	25.8	30.5	53.5	54.0	52.5	52.0	3.8	4.5	5.9	7.2	34.4	35.9	38.0	39.2	190	191	181	178	...	...	...	...
1933	16.8	13.9	18.9	20.8	53.9	54.0	52.7	52.1	3.8	4.1	5.6	6.5	34.5	35.3	37.2	38.4	182	185	173	173	...	...	...	...
1934	24.2	23.4	28.2	29.7	54.0	53.7	53.0	52.0	4.2	4.8	6.4	7.0	35.1	36.7	38.0	39.1	192	193	178	180	...	...	...	...
1935	19.9	16.9	21.9	19.8	...	...	...	...	4.1	4.5	5.8	6.2	34.9	37.1	38.7	39.3	190	192	180	176	39.9	40.9	41.9	38.9
Average	20.6	19.6	23.7	25.2	53.8	53.9	52.7	52.0	4.0	4.5	5.9	6.7	34.7	36.2	38.0	39.0	188	190	178	177	39.9	40.9	41.9	38.9
Fort Duchesne, Utah (irrigated):																								
1931	33.2	30.3	33.1	35.5	54.0	54.4	53.5	53.2	4.1	4.6	6.4	7.5	35.8	37.5	38.6	40.3	187	187	177	174	...	...	...	...
1932	31.3	29.9	32.0	31.4	53.5	54.0	53.0	53.0	4.1	4.5	6.2	7.5	35.6	36.7	38.7	40.0	191	192	181	179	...	...	...	...
1933	20.5	22.4	25.8	24.1	55.0	55.0	53.1	52.1	3.8	4.0	5.8	6.6	34.7	36.0	37.8	38.6	185	184	172	170	...	...	...	...
1934	21.6	18.9	21.2	17.4	53.2	54.0	52.6	51.6	3.8	4.3	5.7	6.3	35.7	36.8	38.5	40.0	187	189	176	176	...	...	...	...
Average	26.7	25.4	28.0	27.1	53.9	54.4	53.0	52.5	4.0	4.4	6.0	7.0	35.4	36.8	38.4	39.7	188	188	177	175	...	...	...	...
Fort Collins, Colo. (irrigated):																								
1930	5.5	[2] 5.5	6.2	[2] 5.0	50.9	...	50.3	...	3.4	...	4.5	...	34.1	...	36.7	...	183	...	176		...	...	...	...
1931	6.1	6.1	7.8	3.5	54.5	53.5	52.5	46.0	3.6	4.0	5.6	5.7	34.0	34.8	37.3	36.3	184	182	166	166	...	...	...	...
1932	4.8	2.4	5.5	4.3	51.2	50.4	51.8	51.8	3.6	4.0	5.5	7.0	33.5	34.2	36.9	39.1	182	184	172	174	...	...	...	...
1933	6.4	6.2	9.0	7.6	53.5	53.5	52.7	51.6	3.5	4.0	5.6	6.8	34.3	35.4	37.2	39.8	187	185	173	175	...	...	...	...
1934	13.1	18.1	17.6	15.3	54.6	54.5	53.6	53.1	3.4	4.2	5.4	6.0	34.2	36.0	37.7	37.8	183	181	171	165	...	...	...	...
Average	7.2	7.7	9.2	7.1	52.9	53.0	52.2	50.6	3.5	4.1	5.3	6.4	34.0	35.1	37.2	38.2	184	183	-72	170	...	...	...	...

[1] Crude protein (N×6.25) in meal, basis of 12 percent moisture and 4.5 percent oil.
[2] Interpolated yields.

GREAT PLAINS REGION

Experiments were conducted at 10 stations in the Great Plains region. The crops were grown without irrigation except at Newell, S. Dak. The Great Plains has a midcontinental climate with extremes of temperature and moderate or light precipitation. The average annual precipitation ranges from about 13 inches at Havre, Mont., to 25 inches at Woodward, Okla. Fortunately, most of the precipitation occurs during the growing season, April to August, which makes it possible to produce fair crops in most seasons. Drought and high summer temperatures were, however, the chief limiting factors to successful flax production during the period of these experiments. Russian-thistles, also, were a pest in dry seasons, as they drew heavily on soil moisture. Climatic data are reported in table 12 and the experimental data in table 4.

Havre, Mont., is located in the north-central part of the State. The soil is a glacial clay loam. Although the flax was sown on corn stubble each year, Russian-thistles were usually a factor in reducing the yield. The crop was a failure in 1931, 1934, 1936, and 1937 because of drought and weeds.

Moccasin, Mont., is located in the Judith Basin in the central part of the State. The topsoil is very shallow, consisting of a dark clay loam, 3 to 10 inches deep, overlying a limestone gravel subsoil. The flax experiments were conducted on land fallowed the previous year, but, in spite of this favorable preparation, the yields were often reduced by weeds and drought.

Dickinson is located in southwestern North Dakota. The soil is a glacial fine sandy loam. The flax varieties were grown on land previously cropped to corn. Drought was the chief factor in reducing yields. The crop was a failure in 1936 when the total annual precipitation was only 5.94 inches. In 1937 the crop was destroyed by soil blowing and in 1938 by grasshoppers.

Mandan is located in central North Dakota. The soil of the field where the flax tests were conducted is a deep alluvial loam. During the period of these experiments drought generally was the cause of low yields. The crop was a total failure in 1936 because of drought, and it was nearly a failure in 1934 and in 1937. Fair yields were obtained only in 1935.

Sheridan is located in north-central Wyoming. The soil is a dark heavy clay loam, and the average annual precipitation is 15.2 inches. The flax varieties were grown on fallow in 1930, on potato ground in 1931, and after corn from 1932 to 1938. No yields were obtained in 1931 or in 1936, when the crops were a near failure due to drought, heat, and insect injury.

Newell, S. Dak., is located some 30 miles northeast of the Black Hills in the extreme western part of the State. The soil, derived from Cretaceous shales, is classified as Pierre clay and known locally as gumbo. The soil absorbs water slowly when the surface is wet, but it shrinks to form deep cracks when dry. The flax varietal tests were conducted under irrigation from 1928 to 1936. In 1928, however, the crop was not irrigated because the seasonal rainfall was so heavy that additional water was not needed. Low yields were obtained in 1936, when extremely high temperatures occurred, the mean maximum for July being 98° F. No varietal test was conducted in 1934.

Ardmore, S. Dak., is located south of the Black Hills, in the extreme southwestern part of the State. The four varieties of flax grown in 1930 produced low yields, and in 1931 and 1932 they were a total failure, due to drought and high temperatures.

Hays is located in west-central Kansas. The soil is classified as silty clay loam, and the mean annual precipitation is 23.7 inches. Ten varieties of flax were grown in single rows in triplicate for five seasons, 1929 to 1933. Analyses were made only for the crop of 1929.

Woodward is located in northwestern Oklahoma. The soil is classified as Woodward sandy loam. Flax was grown in nursery plots for several years, but without much success. In most seasons the crop suffered from drought and high temperatures during the critical period of growth, from blossoming to maturity. Only in favorable seasons were moderate yields obtained. Data for only one crop, 1934, are reported.

Denton is located in north-central Texas. The average annual precipitation is 32.5 inches. The rainfall during April, May, and June, the critical period for flax, averages about 11 inches. The soil is a dark clay of the Denton series.

TABLE 4.—*Acre yield, test weight, weight per 1,000 seeds, oil content of seed, iodine number of oil, and crude-protein content of meal of 4 varieties of flax grown at 10 stations in the Great Plains*

Station and crop year	Acre yield				Test weight				Weight per 1,000 seeds				Oil content (basis, 8 percent moisture)				Iodine number of oil (Wijs)				Crude protein in meal [1]			
	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio
Havre, Mont.:	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*					*Pct.*	*Pct.*	*Pct.*	*Pct.*
1930	2.1	2.9	2.4	2.6	52.4	53.2	51.8	51.6	3.4	3.7	5.7	6.0	33.0	33.9	37.4	37.0	184	187	175	175	----	----	----	----
1932	7.0	6.1	2.9	5.9	53.7	53.7	52.6	52.3	3.4	4.1	5.2	6.4	33.5	35.1	36.4	37.5	184	185	177	178	----	----	----	----
1933	4.1	3.6	4.6	2.1	52.3	53.0	51.2	51.2	3.8	4.4	5.6	7.0	33.3	34.8	36.6	37.4	184	187	174	175	----	----	----	----
1935	1.3	1.9	1.9	1.0	47.5	50.8	50.2	50.4	3.0	3.5	4.6	4.6	30.4	31.8	34.3	33.2	177	179	173	172	38.5	39.7	41.5	39.4
1938	5.4	6.3	4.4	2.9	43.5	48.6	48.6	40.3	2.6	3.2	3.6	4.3	26.0	30.4	29.3	27.5	185	185	177	174	32.0	34.9	33.7	30.4
Average	4.0	4.2	3.2	2.9	49.9	51.9	50.9	49.2	3.2	3.8	4.9	5.7	31.2	33.2	34.8	34.5	183	185	175	175	35.2	37.3	37.6	34.9
Moccasin, Mont.:																								
1929	1.9	2.1	2.2	2.5	50.1	52.1	50.5	50.0	2.6	3.3	4.6	5.1	30.1	32.7	35.7	35.1	182	178	174	174	----	----	----	----
1930	4.2	6.0	3.8	4.0	53.6	53.7	51.4	51.4	3.7	4.2	5.7	7.6	34.2	35.9	37.2	38.4	187	188	179	178	----	----	----	----
1931	2.6	3.4	2.8	3.0	54.0	53.5	52.6	52.8	3.1	3.8	5.2	6.8	33.3	35.1	37.5	37.8	191	189	186	187	----	----	----	----
1932	7.3	8.0	7.0	4.9	52.8	53.3	52.3	52.0	3.6	4.3	5.6	6.8	34.1	35.8	37.5	38.3	188	190	180	181	----	----	----	----
1933	.9	.9	.9	.4	50.7	51.0	50.0	49.1	2.9	3.6	4.4	5.4	32.8	35.1	35.9	37.1	184	187	170	172	----	----	----	----
1934	5.7	7.5	4.6	4.3	52.0	51.5	50.0	50.0	3.1	3.8	4.8	5.7	31.9	34.2	34.5	35.1	181	182	172	172	----	----	----	----
1936	2.2	3.3	2.2	1.6	53.0	54.0	52.0	50.0	2.8	3.4	4.4	5.1	31.7	33.8	36.0	34.8	183	184	165	165	40.2	42.8	42.2	40.6
Average	3.5	4.5	3.4	3.0	52.3	52.7	51.3	50.8	3.1	3.8	5.0	6.1	32.6	34.7	36.3	36.7	185	185	175	176	40.2	42.8	42.2	40.6
Dickinson, N. Dak.:																								
1928	14.5	10.9	14.1	15.8					4.4	4.6	6.4	7.9	36.9	38.4	39.5	41.1	195	190	182	179	----	----	----	----
1929	6.1	4.2	4.8	5.4	52.3	52.3	51.2	50.6	3.3	3.8	5.2	6.3	32.1	33.4	36.7	37.4	177	174	170	172	----	----	----	----
1930	3.5	4.9	4.0	3.8	51.0	52.1	51.2	51.2	3.4	4.0	5.8	6.4	32.4	33.6	36.2	36.6	174	177	164	164	----	----	----	----
1931	.1	.8	.3	.1					2.5	3.2	4.2	4.8	28.8	31.0	33.8	34.7	170	171	160	161	----	----	----	----
1932	3.4	5.9	7.5	6.3	51.7	52.2	51.7	51.4	3.1	3.7	4.9	5.7	31.9	33.0	35.7	36.3	178	175	169	172	----	----	----	----
1933	2.9	2.5	3.3	2.2	53.4	53.5	52.4	51.7	3.8	4.1	5.6	6.3	33.0	34.5	36.6	37.7	182	181	170	168	----	----	----	----
1934	.2	.6	.9	.3					3.1	3.5	5.1	4.8	31.5	33.0	35.9	34.9	174	177	159	163	----	----	----	----
1935	3.3	5.2	4.3	3.5	52.5	52.5	51.5	51.5	3.3	3.8	4.9	6.4	33.1	34.7	36.3	38.6	180	179	168	170	39.8	41.3	42.0	39.0
Average	4.2	4.4	4.9	4.7	52.2	52.5	51.6	51.3	3.4	3.8	5.3	6.1	32.5	34.0	36.3	37.2	179	178	168	169	39.8	41.3	42.0	39.0
Mandan, N. Dak.:																								
1929	4.0	4.9	5.0	4.1	52.1	52.0	51.4	52.2	3.0	3.3	5.1	5.6	30.8	31.9	36.8	36.6	174	175	172	171	----	----	----	----
1930	4.5	1.9	5.0	4.2	53.6	52.4	51.8	51.8	3.3	3.5	5.5	6.8	30.2	31.7	35.2	35.8	177	182	168	166	----	----	----	----
1931	4.3	2.6	6.3	6.4	53.5	54.0	52.0	51.6	3.8	4.2	5.4	6.7	30.9	30.4	35.0	36.2	178	179	166	169	----	----	----	----
1932	3.2	3.4	2.8	4.1	53.0	53.4	52.0	51.5	3.5	3.9	5.4	6.8	34.2	35.1	37.2	38[illegible]	186	186	178	176	----	----	----	----
1933	2.5	2.3	3.3	1.8	54.0	54.0	52.3	52.0	3.7	3.6	5.4	6.7	33.6	33.1	37.0	37.[illegible]	179	178	171	171	----	----	----	----
1934	.3	.3	.6	.5				------	2.7	2.8	4.6	4.9	31.8	31.9	35.3	33.6	173	181	156	159	----	----	----	----
1935	11.4	9.6	10.6	8.6	54.0	54.1	53.3	52.6	3.9	4.4	5.7	6.7	35.1	36.6	38.1	40.2	188	188	177	179	37.3	38.4	40.5	36.2

1937	.7	.6	1.6	1.8	54.0	53.0	54.0	53.0	3.6	3.7	5.3	6.6	35.3	35.8	37.9	39.5	188	190	180	181	36.1	36.7	39.5	36.5
1938	4.4	6.2	6.4	7.1	54.5	54.5	53.5	52.5	4.0	4.3	6.0	6.8	36.3	37.3	39.2	39.8	193	193	185	184	34.7	35.4	37.8	35.4
Average	3.9	3.5	4.6	4.3	53.6	53.4	52.5	52.2	3.5	3.7	5.4	6.4	33.1	33.8	36.8	37.5	182	184	172	173	36.0	36.8	39.3	36.0
Sheridan, Wyo.:																								
1930	4.5	6.7	8.6	8.3	52.5	52.1	52.9	51.0	2.8	3.4	4.6	5.9	30.4	31.7	36.5	36.3	173	170	164	161	...			...
1932	7.9	6.9	7.2	6.9	52.8	53.3	52.3	52.0	2.9	3.8	5.1	3.8	32.1	34.0	36.2	36.2	178	176	168	167	...		...	...
1933	6.4	7.2	7.0	7.1	52.2	51.7	51.6	50.0	3.3	3.8	5.1	5.7	33.2	34.9	36.6	37.1	180	180	168	164	...		...	...
1934	.5	1.5	1.0	.2	52.2	53.5	51.5	51.0	2.6	3.2	4.3		30.7	32.8	35.0	...	170	170	157					
1935	5.2	5.9	4.9	5.6	50.8	51.8	50.1	49.7	2.8	3.4	4.7	5.6	31.4	33.7	36.4	37.3	175	175	162	166	41.6	42.2	44.2	41.8
1937	6.1	10.3	5.4	7.0	53.5	54.0	52.5	52.0	3.7	4.6	5.8	5.7	34.2	35.4	37.2	37.2	182	182	169	163	42.1	40.2	41.1	38.8
1938	9.3	9.0	10.0	6.4	54.0	53.0	53.0	51.0	3.8	4.6	5.5	5.4	34.3	36.1	36.6	35.5	186	186	169	164	38.3	39.2	41.9	40.3
Average	5.7	6.8	6.4	5.9	52.6	52.8	52.0	51.0	3.1	3.8	5.0	5.4	32.3	34.1	36.4	36.6	178	177	165	164	40.7	40.5	42.4	40.3
Newell, S. Dak. (irrigated):																								
1928	24.4	22.6	25.3	22.3					3.8	4.3	5.8	6.1	34.3	35.6	36.2	36.2					...	...	...	...
1929	11.0	12.8	15.3	14.4	52.8	52.3	51.9	50.5	3.4	3.9	5.5	6.0	33.4	34.0	37.1	36.8	188	176	172	169	...		...	...
1930	9.4	9.0	10.2	11.2	53.0	52.5	52.1	51.7	3.7	4.1	5.6	7.4	35.7	36.6	37.6	39.7	184	189	180	176		...		...
1931	6.5	6.5	7.7	5.7	52.8	52.7	51.9	51.5	3.5	4.0	5.1	5.7	32.3	34.7	36.1	36.3	177	176	164	169				...
1932	13.1	11.8	13.2	13.1	53.6	53.4	52.3	51.5	4.5	4.2	5.3	6.2	33.4	35.7	37.1	37.7	181	182	175	173		...	...	...
1933	10.7	8.6	10.1	10.7	51.3	51.3	51.0	50.5	4.0	4.8	5.8	6.9	34.2	37.2	38.0	39.2	186	184	176	174				...
1935	7.7	9.4	9.7	7.9	52.7	51.5	51.5	49.7	3.4	4.2	3.8	6.0	38.9	36.4	34.7	38.8	183	182	174	176	43.1	41.1	41.4	39.3
1936	3.6	4.6	4.8	4.2	36.0	41.0	43.0	38.0	2.4	3.3	3.2	3.8	27.4	31.4	30.7	30.0	174	172	174	162	33.9	37.6	36.4	35.6
Average	10.8	10.7	12.0	11.2	50.3	50.7	50.5	49.0	3.6	4.1	5.0	6.0	33.7	35.2	35.9	36.9	182	180	174	171	38.5	39.4	38.9	37.4
Ardmore, S. Dak.:																								
1930	1.4	2.7	3.0	2.2	51.2	51.7	49.8	48.6	2.7	2.7	2.8	4.2	29.9	32.6	33.0	33.1	161	162	141	139				...
Hays, Kans.:																								
1929	6.2	6.2	7.2	4.8	...	...	...	...	3.2	3.7	5.0	5.4	29.8	31.1	33.7	34.1	176	182	162	162			...	...
Woodward, Okla.:																								
1934	5.2	4.8	5.4	6.4			...	...	2.7	3.1	4.6	4.5	31.4	31.3	34.9	33.8	171	171	157	154	38.0	38.1	40.0	37.6
Denton, Tex.:																								
1933	18.6		16.1	14.1			...	...	3.5	...	4.7	5.0	33.7		35.2	35.1	173	...	162	160		...	...	...
1934	11.9		11.0	13.3	53.5		50.5	50.5	3.3	...	4.4	4.9	33.5		34.7	34.9	168	...	156	161	...		...	...
1935	12.1		10.1	10.5			...		3.9	...	5.2	6.1	35.8		37.1	38.0	178	...	169	170	40.2		42.4	38.6
1936	13.5	...	10.7	14.3					3.8	...	5.0	5.5	34.6		36.1	36.8	172	...	161	162	40.7	...	41.1	39.6
1937	8.4	...	11.4	6.5	54.0		53.5	52.0	3.4	...	4.6	5.0	33.3		34.8	35.4	169	...	158	162	41.0	...	42.8	41.2
1938			...		...		...	...	4.0		5.4	5.8	35.3	...	36.6	36.9	176	...	168	170	39.9	...	41.5	40.2
Average	12.9	...	11.9	11.7	53.8	...	52.0	51.2	3.6	...	4.9	5.4	34.4	...	35.8	36.2	173	...	162	164	40.4	...	42.0	39.9

[1] Crude protein (N× 6.25) in meal, basis of 12 percent moisture and 4.5 percent oil.

Northern Prairie Region

Six stations at which climatic conditions are more or less similar are included in the Northern Prairie region (table 1). Actually, St. Paul, Minn., and Madison, Wis., are not located on prairie soils but in the former timbered area of those States. The average annual precipitation for the region covered by the six stations ranges from about 20 inches in western Minnesota to 31 inches at Madison, Wis. The greatest precipitation occurs during the growing season from April to August. Climatic data for the region are reported in table 13 and experimental data in table 5.

Fargo is located in the Red River Valley on the eastern border of North Dakota. The soil is a phase of Fargo clay. The mean annual precipitation for the period 1881–1930 was 22.9 inches, but during the 10-year period of these experiments (1929–1938) it was only 16.0 inches. The flax varieties were grown in a rotation following corn, and the plots were relatively free from weeds. The average yield of four varieties for the 10-year period was 15.8 bushels per acre, or approximately 1 bushel of flaxseed for each inch of annual precipitation. This is a remarkable record of flax production under generally unfavorable climatic conditions.

Crookston, Minn., is located in the Red River Valley in the northwestern part of Minnesota. The soil is a heavy calcareous clay, classified as Fargo clay loam. The flax varieties usually were grown following a cultivated crop or on fallow. The crop was a failure in 1936 because of drought and high temperatures.

Morris is located in west-central Minnesota. The soil is a sandy clay loam of glacial origin. The flax varieties were grown on cornland except in 1931 and 1932. Drought was the cause of the low yields in 1933 and 1936 and the failure of the crop in 1934.

St. Paul is located in east-central Minnesota. The elevation is 1,050 feet and the mean annual precipitation is 27.7 inches. The soil is Merrimac silt loam, with a more sandy subsoil. The flax varieties were grown following a cultivated crop, usually corn. Low yields were obtained in 1931 and 1937 because of drought and in 1934 because of weeds.

Brookings, S. Dak., is located on the east-central border of the State. The soil is Barnes sandy loam. Low yields were obtained in 1936 when drought and high temperatures prevailed during the growing season.

Madison, Wis., is located in the south-central part of the State. The soil is Miami clay loam and the mean annual precipitation is 31.1 inches. Data for only one season are available.

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TABLE 5.—*Acre yield, test weight, weight per 1,000 seeds, oil content of seed, iodine number of oil, and crude protein content of meal of 4 varieties of flax grown at 6 stations in the Northern Prairie region*

Station and crop year	Acre yield				Test weight				Weight per 1,000 seeds			
	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*
Fargo, N. Dak.:												
1929	17.5	15.8	16.0	19.9	53.5	54.0	52.2	51.8	3.5	4.0	5.5	7.1
1930	13.4	12.9	16.9	17.1	54.2	54.5	53.4	52.5	3.7	4.0	5.2	6.8
1931	18.9	18.7	20.5	17.5	53.6	53.5	52.7	51.4	3.9	4.2	6.2	7.1
1932	17.1	16.5	16.7	16.5	53.0	53.4	51.7	50.9	3.5	4.1	5.4	6.2
1933	17.8	15.0	18.8	18.0	54.5	55.1	54.0	52.9	4.1	4.5	6.1	7.0
1934	15.1	14.9	15.3	13.5	54.0	53.5	52.0	51.5	3.4	3.9	5.3	5.6
1935	19.4	17.0	19.5	22.1	53.8	53.0	52.0	51.5	3.8	4.3	5.5	6.6
1936	1.3	1.5	.8	.1	39.2	40.3	37.3	32.0	2.2	2.6	3.0	
1937	17.2	15.4	17.2	19.1	54.0	53.8	53.2	52.7	3.4	4.0	5.2	6.3
1938	20.7	19.0	19.8	23.8	54.5	54.7	53.0	54.0	4.2	4.5	6.1	7.7
Average	15.8	14.7	16.2	16.8	52.4	52.6	51.2	50.1	3.6	4.0	5.4	6.0
Crookston, Minn.:												
1929	13.1	17.2	15.4	15.7	53.6	53.8	52.8	52.8	4.2	4.9	6.0	7.9
1930	[2]7.0	6.9	12.1	9.7	---	55.0	53.0	53.2	-----	4.4	6.1	7.0
1931	[2]11.1	11.2	11.6	10.5		54.0	52.9	53.0	-----	4.4	5.6	6.7
1932	[2]10.4	10.2	10.6	11.2	52.5	52.2	51.5	51.9	3.1	3.9	5.0	5.8
1933	[2]14.0	13.9	14.1	14.3	54.2	53.8	53.1	52.8	4.2	4.6	5.6	6.2
1934	14.2	14.2	14.5	16.1	53.4	53.2	53.0	52.4	3.9	3.8	5.9	7.1
1935	17.0	17.6	17.9	19.2	55.1	55.1	54.0	52.1	4.1	4.5	6.0	7.5
1937	14.6	11.1	15.2	14.3	54.3	54.0	53.9	52.5	4.2	4.4	6.2	7.0
1938	6.8	8.8	8.5	9.1	54.0	53.3	52.8	51.5	3.6	4.1	5.3	6.4
Average	12.0	12.3	13.3	13.3	53.9	53.8	53.0	52.5	3.9	4.3	5.7	6.8
Morris, Minn.:												
1930	23.2	23.0	29.0	21.2	53.0	53.6	52.7	52.1	4.4	4.8	6.6	7.3
1931	9.3	12.1	11.8	12.5	53.8	53.7	53.3	52.4	3.5	3.9	5.3	6.6
1932	14.5	14.9	14.0	16.7	53.8	54.5	53.2	52.2	4.4	4.4	6.0	7.1
1933	[2]3.9	3.8	4.0	4.0	53.2	52.8	50.6	51.2	3.5	4.1	5.2	6.5
1935	24.1	20.8	23.4	24.5	53.5	53.6	53.1	53.0	4.5	4.5	6.3	-----
1936	.2	1.4	.9	.2	-----	-----	-----	-----	-----	2.7	2.8	-----

Station and crop year	Oil content (basis, 8 percent moisture)				Iodine number of oil (Wijs)				Crude protein in meal [1]			
	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio
	Pct.	*Pct.*	*Pct.*	*Pct.*					*Pct.*	*Pct.*	*Pct.*	*Pct.*
Fargo, N. Dak.:												
1929	32.8	34.0	37.1	38.3	177	179	166	168	-----	-----	-----	-----
1930	33.7	34.7	36.5	37.8	183	182	171	172	-----	-----	-----	-----
1931	30.8	32.6	34.7	36.3	183	185	170	173	-----	-----	-----	-----
1932	32.5	35.1	35.8	37.1	177	177	162	155	-----	-----	-----	-----
1933	33.6	34.7	36.5	37.3	187	188	176	170	-----	-----	-----	-----
1934	33.6	34.6	35.9	36.1	181	182	163	158	-----	42.1	42.8	-----
1935	34.1	35.3	37.0	38.9	178	181	166	166	40.0	41.3	42.0	40.2
1936	25.5	26.8	28.1	-----	145	147	134	-----	33.6	35.3	34.7	-----
1937	33.9	35.1	37.2	37.8	185	186	178	177	38.9	40.7	41.8	40.9
1938	35.9	37.3	38.6	39.7	193	192	184	185	38.9	38.9	41.0	38.9
Average	32.6	34.0	35.7	37.6	179	180	167	169	37.8	39.7	40.5	40.0
Crookston, Minn.:												
1929	33.6	35.6	37.4	39.1	184	185	178	175	-----	-----	-----	-----
1930	-----	35.0	37.1	39.4	-----	187	174	182	-----	-----	-----	-----
1931	-----	34.8	35.9	36.0	-----	181	173	167	-----	-----	-----	-----
1932	31.4	34.2	37.2	37.4	174	178	164	165	-----	-----	-----	-----
1933	34.3	36.4	37.5	37.6	184	189	179	172	-----	-----	-----	-----
1934	34.8	34.7	38.3	39.8	184	180	173	178	-----	39.8	40.9	-----
1935	35.1	36.6	38.0	40.6	181	180	170	172	-----	-----	-----	-----
1937	35.3	36.5	38.4	40.3	190	192	182	185	39.2	40.0	41.8	37.3
1938	33.5	34.5	36.7	36.8	180	180	172	169	39.5	38.5	40.8	38.8
Average	34.0	35.4	37.4	38.6	182	184	174	174	39.4	39.4	41.2	38.0
Morris, Minn.:												
1930	35.2	35.7	37.5	39.1	187	182	174	173	-----	-----	-----	-----
1931	33.4	36.0	37.5	39.2	189	192	175	177	-----	-----	-----	-----
1932	36.8	36.5	37.9	38.8	189	192	178	179	-----	-----	-----	-----
1933	33.5	34.5	36.0	38.8	176	180	167	178	-----	-----	-----	-----
1935	36.4	36.7	38.0	-----	175	184	169	-----	41.0	39.0	41.9	-----
1936	-----	26.8	29.6	-----	-----	154	151	-----	-----	35.7	37.6	-----

See footnotes at end of table.

TABLE 5.—*Acre yield, test weight, weight per 1,000 seeds, oil content of seed, iodine number of oil, and crude protein content of meal of 4 varieties of flax grown at 6 stations in the Northern Praire region*—Continued

Station and crop year	Acre yield				Test weight				Weight per 1,000 seeds				Oil content (basis, 8 percent moisture)				Iodine number of oil (Wijs)				Crude protein in meal [1]			
	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio
Morris, Minn.—Con.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*					*Pct.*	*Pct.*	*Pct.*	*Pct.*
1937	18.5	15.0	15.2	13.6	55.0	53.7	53.0	52.0	3.6	3.5	4.9	5.3	32.7	32.3	36.1	36.6	176	173	167	169	37.9	38.2	40.4	39.9
1938	27.5	23.5	20.7	26.5	54.5	54.3	54.0	52.5	4.5	4.8	6.4	8.3	35.6	36.8	39.3	40.1	190	187	186	186	38.2	38.2	39.2	37.1
Average	15.2	14.3	14.9	14.9	53.8	53.7	52.8	52.2	4.0	4.1	5.4	6.8	34.8	34.4	36.5	38.8	183	180	171	177	39.0	37.8	39.8	38.5
St. Paul, Minn.:																								
1930	21.0	20.9	18.7	21.9	51.8	53.4	52.4	52.2	4.2	4.6	6.4	7.7	33.6	35.4	35.5	37.7	182	182	165	162	-----	-----	-----	-----
1931	7.0	7.8	7.2	9.6	53.3	52.3	52.0	51.5	2.7	3.3	4.7	5.6	29.3	31.2	34.3	34.5	189	90	181	179	-----	-----	-----	-----
1932	16.8	13.6	18.5	11.3	53.1	52.9	51.8	51.4	3.7	4.3	5.7	7.2	33.8	35.6	37.0	38.4	184	189	171	180	-----	-----	-----	-----
1933	[2] 9.5	8.9	10.9	9.8	53.8	54.0	52.0	52.1	3.4	3.8	5.3	6.1	33.1	33.4	36.0	36.7	181	182	169	171	-----	-----	-----	-----
1934	3.6	2.8	3.0	3.2	53.0	53.5	53.0	52.0	3.1	3.6	5.0	6.2	32.3	33.6	36.0	36.5	178	182	168	166	-----	-----	-----	-----
1935	13.8	12.4	13.0	13.6	53.4	54.0	51.7	51.6	3.7	4.2	5.7	6.4	33.6	35.0	36.7	37.6	182	183	165	165	39.7	40.9	42.3	40.0
1936	8.2	8.6	6.3	[2] 2.0	52.4	52.8	49.9	-----	2.7	3.3	4.1	3.8	30.8	32.7	33.5	30.2	170	177	143	145	38.8	40.7	40.1	38.1
1937	-----	2.8	4.0	1.5	-----	-----	-----		-----	3.2	4.2			31.3	31.9	-----	-----	165	151	-----		40.6	40.9	-----
1938	14.0	13.3	16.5	17.0	56.0	55.8	52.5	52.0	4.3	4.4	5.7	7.4	34.5	35.3	36.8	38.1	185	186	171	179	38.2	39.7	41.6	37.6
Average	11.7	10.1	10.9	10.0	53.4	53.6	51.9	51.8	3.5	3.8	5.2	6.3	32.6	33.7	35.3	36.2	181	182	165	168	38.9	40.5	41.2	38.6
Brookings, S. Dak.:																								
1935	14.1	12.7	14.0	11.7	-----	-----	-----	-----	3.3	3.9	5.0	5.8	32.5	34.4	35.8	36.6	177	177	163	161	41.5	42.0	42.9	40.1
1936	2.6	3.0	2.8	1.4	54.0	53.0	54.0	43.0	2.1	2.6	3.4	3.2	27.7	29.9	31.8	26.8	158	156	137	141	37.4	39.6	40.4	35.5
1937	9.3	8.3	8.5	5.3	-----	-----	-----	-----	3.2	4.1	4.0	5.5	31.6	33.0	34.0	36.4	178	177	175	174	40.9	41.0	40.6	41.0
1938	13.0	10.2	12.6	10.3	55.5	55.0	54.0	53.0	4.0	4.5	4.8	6.7	34.6	35.8	36.2	38.9	187	186	182	180	38.1	38.8	39.4	37.2
Average	9.8	8.6	9.5	7.2	54.8	54.0	54.0	48.0	3.2	3.8	4.3	5.3	31.6	33.3	34.4	34.7	175	174	164	164	39.5	40.4	40.8	38.4
Madison, Wis.:																								
1938	18.9	20.8	15.3	-----	55.0	55.5	52.0	-----	4.3	4.7	6.6	-----	38.8	35.5	36.2	-----	177	178	167	-----	42.3	38.9	41.4	-----

[1] Crude protein (N×6.25) in meal, basis of 12 percent moisture and 4.5 percent oil.
[2] Interpolated yields.

Central and Eastern Regions

Eight stations in Kansas, Nebraska, Iowa, Illinois, Ohio, and New Jersey are grouped into the Central and Eastern regions for the purposes of this study. The mean annual precipitation ranges from about 28 inches at Lincoln, Nebr., to 45 inches at New Brunswick, N. J. Perhaps the chief limiting factor to flax production in this region is the high temperatures that often prevail during the critical growth period of flax; that is, the period from first bloom to maturity. Early seeding and the growing of early-maturing varieties, to allow the crop to make its principal growth before the hot weather of midsummer occurs, is of prime importance. Climatic data are recorded in table 14 and yields and other experimental data in table 6.

Lincoln is located in southeastern Nebraska. Flax is grown in eastern Nebraska only to a slight extent. The flax experiments were conducted in six seasons, but low yields were obtained in all except 1935, when the precipitation in June and July was much above normal. The crop was a failure in 1936 when exceptionally high temperatures prevailed during June and July.

Manhattan is located in the Kaw Valley of northeastern Kansas. The soil is classified as Darby silt loam. Flax seldom is grown commercially in that section.

The commercial flaxseed crop of Kansas is grown in six or eight counties of southeastern Kansas. The mean annual precipitation in this area is about 38 inches. The soils are derived from sandstones and shales and range from sandy loams to clay loams. High summer temperatures and generally low soil fertility are the chief limiting factors in flax production. Flax experiments were conducted in that section in Allen County, near Moran, from 1930 to 1938; in Wilson County, near Fredonia, in 1929 and 1938; and in Cherokee County in 1931 and 1932.

Ames is located in central Iowa. Some flax is grown in Iowa, largely in the northern portion. Data are available from only two varieties for two seasons at Ames.

Urbana is located in east-central Illinois. Low yields were obtained in 1933, and the seed was of extremely poor quality because of wet weather during the harvest period. The crop was a failure in 1934, due to weeds and unfavorable weather conditions. The Redwing variety only was grown from 1935 to 1937.

Wooster is located in north-central Ohio. The flax experiments were conducted at Wooster for 5 years. In 1931, the crop was a failure, due to crusting of the soil before the flax emerged, but samples of each variety were gathered and threshed for seed analysis.

New Brunswick, N. J., is located in the east-central part of the State. Varieties of flax were grown in replicated nursery plots for 11 years. The flax usually followed corn, and the soil was given a moderate application of commercial fertilizer before the flax was sown. The tests at New Brunswick probably are the longest continuous experiments with flax in the eastern United States.

TABLE 6.—*Acre yield, test weight, weight per 1,000 seeds, oil content of seed, iodine number of oil, and crude protein content of meal of 4 varieties of flax grown at 8 stations in the Central and Eastern regions*

Station and crop year	Acre yield				Test weight				Weight per 1,000 seeds			
	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio
Lincoln, Nebr.:	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*
1933	3.5	------	4.8	------	49.0	------	47.1	------	3.7	------	5.3	------
1934	.7	1.1	1.3	0.9	50.0	50.5	49.4	48.4	2.5	2.9	3.9	4.3
1935	9.9	12.5	5.9	6.1	52.6	53.3	51.6	50.5	3.4	4.1	5.1	5.6
1937	1.0	1.6	.9	1.8	50.7	50.3	49.7	48.5	2.4	3.0	4.1	4.4
1938	2.9	4.2	1.0	3.0	51.0	55.0	------	50.0	3.2	3.6	4.2	4.5
Average	3.6	4.8	2.8	3.0	50.7	52.3	49.4	49.4	3.0	3.4	4.5	4.7
Manhattan, Kans.:												
1937	10.9	13.9	10.2	------	52.0	53.5	51.0	------	3.2	3.8	4.2	------
1938	15.7	20.9	17.3	------	50.1	54.3	52.3	------	3.8	4.2	5.4	------
Average	13.3	17.4	13.8	------	51.0	53.9	51.6	------	3.5	4.0	4.8	------
Moran, Kans.:												
1930	13.5	[2] 13.0	12.1	13.6	52.0	------	51.8	48.7	3.8	------	4.2	6.5
1931	15.5	16.2	10.8	9.8	54.0	54.3	53.1	52.5	3.4	4.1	5.2	5.8
1932	18.3	16.3	16.9	15.3	53.4	53.8	52.8	52.7	4.0	4.5	6.0	6.3
1933	14.7	14.5	14.7	15.1	51.9	50.0	50.8	59.0	3.4	3.7	4.9	6.7
1934	9.4	9.1	6.0	4.6	52.0	53.0	50.5	50.5	3.6	4.0	5.5	6.1
1935	12.0	14.8	9.2	13.1	50.7	52.0	49.8	49.0	3.5	4.0	5.3	6.1
1936	7.7	7.9	7.2	3.7	52.0	52.5	50.0	49.0	4.0	3.7	4.9	4.8
1937	10.0	12.9	8.2	------	54.5	54.5	54.5	------	3.2	3.6	4.1	------
1938	17.8	15.0	16.3	15.8	54.8	55.0	54.0	54.0	3.9	4.1	5.6	6.8
Average	13.2	13.3	11.3	11.4	52.8	53.1	51.9	50.8	3.6	4.0	5.1	6.1
Fredonia, Kans.:												
1929	7.7	8.9	7.5	7.7	50.5	50.5	48.9	48.1	3.4	3.8	5.1	5.7
1931 [3]	6.3	6.3	5.3	5.5	53.0	53.7	51.6	51.4	3.7	4.4	5.8	6.8
1932 [3]	15.1	14.3	13.2	11.7	50.8	50.5	49.3	48.0	3.8	4.0	5.6	6.4
1938	9.5	10.0	10.4	------	54.8	54.8	54.2	------	4.5	4.2	4.8	------
Average	9.6	9.9	9.1	8.3	52.3	52.4	51.0	49.2	3.9	4.1	5.3	6.3

Station and crop year	Oil content (basis, 8 percent moisture)				Iodine number of oil (Wijs)				Crude protein in meal [1]			
	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio
Lincoln, Nebr.:	*Pct.*	*Pct.*	*Pct.*	*Pct.*					*Pct.*	*Pct.*	*Pct.*	*Pct.*
1933	32.2	------	35.2	------	165	------	151	------	------	------	------	------
1934	29.2	30.4	33.1	33.0	167	166	150	156	------	39.8	40.6	------
1935	32.4	31.7	35.9	36.5	170	172	156	158	40.0	40.0	40.9	38.6
1937	29.4	30.8	33.3	33.3	176	174	161	162	38.6	40.8	40.3	39.1
1938	29.4	33.1	32.6	33.6	167	177	153	152	37.4	40.4	38.9	38.0
Average	30.5	32.2	34.0	34.1	169	172	154	157	38.7	40.2	40.2	38.6
Manhattan, Kans.:												
1937	30.3	32.7	32.8	------	171	175	154	------	37.1	39.1	37.8	------
1938	33.4	34.0	35.9	------	176	180	164	------	39.8	39.7	41.6	------
Average	31.8	33.6	34.4	------	174	178	159	------	38.4	39.4	39.7	------
Moran, Kans.:												
1930	36.1	------	37.5	39.9	182	------	179	172	------	------	------	------
1931	33.1	35.0	36.1	36.9	173	178	159	158	------	------	------	------
1932	34.6	35.5	37.5	37.5	184	188	173	178	------	------	------	------
1933	33.1	33.4	37.0	37.4	184	180	172	171	------	------	------	------
1934	34.5	35.4	37.4	38.9	182	184	168	175	------	------	------	------
1935	33.3	35.4	36.2	37.8	171	165	158	160	38.4	38.0	41.1	35.5
1936	31.4	34.0	35.5	35.3	176	178	163	166	37.0	38.7	39.4	37.7
1937	32.4	33.4	34.2	------	177	176	169	------	40.1	40.8	40.4	------
1938	36.1	37.5	38.7	41.2	185	187	176	180	33.8	34.4	37.1	33.2
Average	33.8	35.0	36.7	38.1	179	180	169	170	37.3	38.0	39.5	35.5
Fredonia, Kans.:												
1929	35.0	36.4	37.3	38.0	183	183	171	171	------	------	------	------
1931 [3]	34.3	35.5	37.1	38.3	178	183	164	168	------	------	------	------
1932 [3]	34.5	35.2	38.1	39.4	183	187	175	180	------	------	------	------
1938	34.3	38.8	37.6	------	178	174	171	------	35.6	37.2	37.2	------
Average	34.5	36.5	37.5	38.6	180	182	170	173	35.6	37.2	37.2	------

Ames, Iowa:																								
1932		13.7	13.0							4.4	6.0			36.0	37.3			187	175					
1933		6.5	6.9			49.0	48.6			3.6	5.1			32.6	35.0			175	161					
Average		10.1	10.0			49.0	48.6			4.0	5.6			34.3	36.2			181	168					
Urbana, Ill.:																								
1932	8.5	6.8	8.9	7.0	51.8	52.6	50.2	49.8	3.8	4.2	5.6	6.0	37.6	33.7	36.1	36.1	178	181	166	172				
1933					32.7	37.2	32.4	31.4	2.1	2.8	3.5	3.6	24.2	29.5	27.7	28.4	171	175	165	162				
1935		13.8				53.4				4.7				36.2				182						
1936		13.2				47.0				4.3				34.0				184						
1937		7.7				51.5				5.1				35.6				184				38.4		
Average					42.2	48.3	41.3	40.6	3.0	4.2	4.6	4.8	30.6	33.8	31.6	32.2	174	181	166	167		38.4		
Wooster, Ohio:																								
1930	11.5	11.7	10.3	5.9	52.6	52.9	51.2	49.5	3.5	4.2	5.2	5.5	32.3	34.3	34.4	34.5	182	184	165	159				
1931									3.7	4.3	5.8	6.2	32.1	33.3	35.3	36.5	186	188	173	177				
1932	11.2	12.2	10.5	9.1	54.1	54.3	52.9	52.7	4.1	4.7	6.0	7.4	34.8	35.9	36.7	38.8	186	188	174	178				
1933					54.1				3.6				34.5				189							
1934	9.5	9.8	3.5		53.0	52.0	51.0		3.9	4.2	4.9		33.6	34.0	34.7		181	178	170					
Average	10.7	11.2	8.1	7.5	53.4	53.1	51.7	51.1	3.8	4.4	5.5	6.4	33.5	34.4	35.3	36.6	185	184	170	171				
New Brunswick, N. J.:																								
1928	10.2	12.9	7.7	5.3					4.2	4.5	6.4	7.3	33.3	34.4	36.3	37.5	172	178	162	161				
1929	16.7	11.3	13.0	10.3					4.1	4.5	5.9	6.6	34.4	35.1	36.2	37.1	185	186	174	173				
1930	15.0	14.0	12.6	10.5					4.2	4.6	6.2	7.2	34.4	35.2	36.2	37.1	185	187	176	176				
1931	18.3	17.4	17.1	19.9	52.7	53.5	52.7	51.3	4.0	4.4	5.9	6.8	33.4	34.8	35.6	36.6	185	188	173	165				
1932	12.7	12.2	12.5	13.0	53.7	53.8	52.7	51.8	4.0	4.5	6.0	7.1	34.4	35.9	36.6	37.3	180	188	176	179				
1933	16.2	15.8	16.9	18.5	54.3	54.0	53.4	53.0	4.0	5.1	6.1	7.2	34.6	36.0	37.1	38.0	184	183	175	175				
1934	9.9	8.5	5.6	11.0	54.5	53.5	53.0	52.5	4.0	4.5	6.1	5.5	33.8	35.6	36.7	37.2	184	184	174	178				
1935	12.0	11.0	14.0	14.8					3.9	4.3	5.6	4.5	35.1	36.0	37.3	37.2	187	187	174	179	37.0	38.7	40.8	38.3
1936	5.8	5.4	7.2	6.5					3.7	4.2	5.8	6.6	34.7	36.0	36.8	37.8	188	188	171	169	36.2	37.2	39.5	36.0
1937	12.3	12.5	15.9	14.6	56.0	55.8	55.0	53.4	4.1	4.6	6.2	8.1	36.0	37.0	38.2	38.4	194	193	182	179	35.3	36.3	40.0	38.4
1938	9.4	8.0	9.0	7.8					4.2	4.4	5.8	6.8	35.7	36.5	38.5	38.7	193	192	183	171	36.6	37.3	38.6	38.2
Average	12.6	11.7	12.0	12.0	54.2	54.1	53.4	52.4	4.4	4.5	6.6	6.7	34.5	35.7	35.7	37.5	186	187	174	173	36.3	37.4	39.7	37.7

[1] Crude protein (N×6.25) in meal, basis of 12 percent moisture and 4.5 percent oil.
[2] Interpolated yields.
[3] Columbus, Kans.

South Texas Region

Flax has been grown experimentally as a fall-sown crop in southern Texas since 1914, and since 1938 it has been grown commercially to some extent in the Gulf Coastal area where the climate is mild. The annual precipitation in this region is from 20 to 45 inches, nearly one-half of which occurs from November to April, the growing period of flax. The soils of the region range from sandy loam to clay. Flax yields and analyses from seven stations in southern Texas are reported in table 7 and the climatic data in table 15.

San Antonio is located in south-central Texas, on the southern border of the Edwards Plateau. The soil is Houston sandy clay loam. The subsoil is clay with some mixture of limestone gravel. The average annual precipitation is about 27 inches, of which about 12 inches occur from November to April, inclusive, the growing season for flax. December, January, and February are the driest months, and April, May, June, September, and October are the wettest. The crop of 1933 was a failure because of drought, but samples of seed were obtained for analysis.

Beeville, Tex., is located about 80 miles southeast of San Antonio. The mean annual precipitation is about 31 inches, and its seasonal distribution is about the same as at San Antonio. The soil is a fine sandy clay loam.

Varietal experiments with flax were conducted at the State Experiment Station, College Station (Brazoria County), Angleton (Brazoria County), Victoria (Victoria County), Orange Grove (Jim Wells County), and at Winter Haven (Dimmit County) for one or more seasons during the period 1936 to 1938. The tests at Winter Haven were conducted under irrigation. The soil at College Station is a fine sandy loam; at Victoria, dark calcareous clay loam; at Winter Haven, a fine sandy loam; and at Orange Grove, a dark calcareous loam. The mean annual precipitation ranges from 19.1 inches at Winter Haven to 45.8 inches at Angleton.

TABLE 7.—*Acre yield, test weight, weight per 1,000 seeds, oil content of seeds, iodine number of oil, and crude-protein content of meal of 4 varieties grown at 7 stations in southern Texas*

Station and crop year	Acre yield				Test weight				Weight per 1,000 seeds				Oil content (basis, 8 percent moisture)				Iodine number of oil (Wijs)				Crude protein in meal[1]			
	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*					*Pct.*	*Pct.*	*Pct.*	*Pct.*
San Antonio, Tex.:																								
1929	11.0	7.8	7.7	12.2	51.1	50.7	51.5	50.0	3.8	3.9	5.2	6.3	33.7	35.4	36.2	36.7	175	184	166	163				
1930	9.2	[2] 8.3	7.6	8.2	53.5		50.8	50.6	3.3		5.0	5.7	33.3		36.1	35.6	169		159	150				
1931	17.9	[2] 17.5	17.4	22.3	53.4		53.1	52.2	4.4		6.0	7.5	35.7		37.4	38.5	186		176	178				
1932	11.0	9.6	10.4	11.2	54.1	54.1	53.6	53.6	3.6	3.4	4.8	5.6	35.2	34.4	36.3	36.4	177	179	168	165				
1933	0	0	0	0					3.3	3.2	4.4	4.5	33.5	32.5	34.3	33.4	166	173	155	159				
1934	14.7	15.7	14.1	9.9	53.5	53.5	53.0	51.0	3.5	3.4	5.1	5.1	33.4	33.5	35.9	35.2	182	181	171	173				
Average	10.6	9.7	9.5	10.6	53.1	52.8	52.4	51.5	3.7	3.5	5.1	5.8	34.1	34.0	36.0	36.0	176	179	166	166				
Beeville, Tex.:																								
1935	21.0			33.5					3.3			5.5	33.2			36.0	185			165	38.7			37.4
1936	11.2		11.7	13.9					3.3		5.0	6.0	34.9		37.7	38.4	190		181	182	37.6		41.5	39.6
1937	5.8		8.2	9.8					3.1		4.5	5.5	31.6		34.2	35.4	183		166	164	39.5		41.4	41.3
1938	8.2	11.1	9.9	12.1					3.1	3.8	4.8	5.3	32.5	33.1	35.3	36.2	177	178	168	173	40.4	41.8	41.4	41.6
Average	11.6			17.3					3.2		4.8	5.6	33.0	33.1	35.7	36.6	184	178	172	171	39.0	41.8	41.4	40.0
College Station, Tex.:																								
1937	7.4		9.8	9.0					3.7		5.2	6.7	35.4		38.1	39.6	189		182	183	31.3		34.6	33.0
1938	7.3	6.3	8.5	11.2					3.9	4.1	5.4	6.2	35.9	36.9	38.6	39.6	189	189	182	181	31.0	33.6	34.1	32.6
Average	7.4		9.2	10.1					3.8		5.3	6.4	35.6	36.9	38.4	39.6	189	189	182	182	31.2	33.6	34.4	32.8
Angleton, Tex.:																								
1936	9.4		8.4	11.6					3.5		5.1	6.2	35.8		38.1	39.6	188		179	178	33.8		40.0	35.4
1937	7.7		6.7	6.1					3.6		5.0	6.3	36.2		37.8	39.4	189		180	182	31.6		36.6	35.2
1938	7.5	7.9	8.4	8.1					3.4	3.7	4.8	5.6	35.1	35.5	36.9	37.9	189	185	180	177	33.2	35.9	36.5	36.6
Average	8.2		7.8	8.6					3.5		5.0	6.0	35.7	35.5	37.6	39.0	189	185	180	179	32.9	35.9	37.7	35.7
Victoria, Tex.:																								
1936	9.8		8.9	21.4								6.5				38.7				180				38.4
1937	6.3		7.3	7.2					3.1		4.5	5.7	34.0		36.9	38.1	186		176	176	35.2		38.4	37.6
Average	8.0		8.1	14.3					3.1		4.5	6.1	34.0		36.9	38.4	186		176	178	35.2		38.4	38.0
Orange Grove, Tex.: 1936	10.0		5.7	18.2					4.2		4.3	5.5	34.2		36.1	38.1	186		177	176	38.0		40.3	35.1
Winter Haven, Tex. (irrigated): 1938	23.4	16.7	25.0	24.6					3.8	4.4	5.3	5.9	35.0	36.6	37.6	37.6	184	185	179	177	36.2	37.6	37.2	36.5

[1] Crude protein (N×6.25) in meal, basis of 12 percent moisture and 4.5 percent oil.

[2] Interpolated yields.

Southwestern Region

Varietal experiments with flax under irrigation were conducted for several years in the Southwestern region, California and Arizona. The experimental flax was sown in November and was irrigated four to six times, the total quantity of water applied being 20 to 30 inches. Punjab and Abyssinian Yellow were included in the experiments, in addition to the four varieties grown at northern stations. A test for one season was conducted at San Jacinto, near Mexico City, Mexico.

Experimental data covering the 10-year period (1929–38) are recorded in table 8, and the climatic data are shown in table 15.

El Centro is located in the Imperial Valley of southern California. The altitude is some 50 feet below sea level. The soil is a silty clay loam of the Colorado River deposit. The winter climate is mild, clear, and dry—an ideal climate for flax where water is supplied by irrigation. The average annual precipitation is less than 3 inches. There is a high percentage of clear days, and humidity is low. Although high winds often occur, Punjab flax does not shatter as it has firm indehiscent bolls.

Mesa is located in the Salt River Valley of Arizona, and Sacaton is in the Gila River Valley, some 40 miles south of Mesa. At Mesa, the elevation is 1,245 feet, the average annual precipitation 8.7 inches, and the soil is Laveen silt loam. The soil at Sacaton is composed of fine sand and silt of alluvial deposit. Climatic conditions are similar to those at Mesa. The flax was grown under irrigation at both stations.

Data on three varieties of flax grown in 1933–34 at San Jacinto, near Mexico City, are reported in table 8. Although San Jacinto is some 700 miles south of San Antonio, Tex., its higher altitude (8,000 feet) gives it a winter climate somewhat similar to that of southern Texas. The mean annual precipitation is about 29 inches, most of which occurs during the 5 months May to September. The mean temperature for January is about 54° F., and for May (the warmest month) it is about 68° F. Flax is sown in October and ripens in March or April.

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TABLE 8.—*Acre yield, test weight, weight per 1,000 seeds, oil content of seed, iodine number of oil, and crude-protein content of meal of 6 varieties of flax grown at 3 stations in California, Arizona, and Mexico*

Station and crop year	Acre yield						Test weight						Weight per 1,000 seeds					
	Linota	Redwing	Bison	Rio	Punjab	Abyssinian Yellow	Linota	Redwing	Bison	Rio	Punjab	Abyssinian Yellow	Linota	Redwing	Bison	Rio	Punjab	Abyssinian Yellow
El Centro, Calif. (irrigated):	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*
1929	16.9	14.5	16.9	18.6	26.8	20.9	53.3	53.0	52.0	50.8			3.6	4.1	5.4	6.5		
1931	22.6	20.5	18.5	18.2			53.0	53.5	52.3	50.2			3.7	4.3	4.4	6.4		
1932	[1] 28.0	[1] 26.1	[1] 21.0	27.5	36.5	36.5	53.5	52.9	51.4	50.6			3.9	4.6	5.7	6.1	6.0	4.0
1933	25.2	26.1	30.4	21.1	32.3	23.0	53.4	53.8	52.6	50.5	51.5	51.9	3.8	4.5	5.9	5.4	5.8	3.8
1934	[1] 25.5	33.1	27.8	33.3	33.8	38.7		54.4	53.9	52.5	53.8	53.6	3.6	4.2	5.7	5.2	5.8	4.2
1935	27.2	23.8	27.7	20.5	38.1	27.6							4.3	4.8	6.0	6.9	6.5	4.5
1936	28.7	31.7	40.0	32.5	48.8	33.7									5.2	5.6	6.2	4.1
1937	19.4	18.4	20.2	21.0	32.8	29.3			53.5		54.5	54.0	4.2	4.7	6.0	6.4	6.1	4.3
1938	31.2	31.4	27.4	34.1	51.8	45.4	56.0	56.0	54.5	54.0	55.5	55.0	4.0	4.6	6.1	6.0	6.7	4.7
Average	25.0	25.1	25.5	26.2	37.6	31.9	53.8	53.9	52.9	51.4	53.8	53.6	3.9	4.5	5.6	6.0	6.2	4.2
Mesa, Ariz. (irrigated):[2]																		
1931	16.9	16.2	15.6	13.4			52.5	52.4	51.8	50.5			3.8	4.5	5.8	6.8	6.1	
1932	16.9	15.4	12.0	15.2			51.7	51.9	50.8	50.0			3.8	4.3	5.2	6.0	6.1	
1933	[1] 27.3	[1] 24.5	25.7	25.4			47.6	48.2	48.0	45.6			3.8	4.5	5.6	6.4	6.3	
1934	5.6	8.5	5.7	4.4	16.7		40.0	46.2	47.6	46.0	51.0		3.3	3.7	4.6	4.6	5.8	
1935					30.9	28.8					51.1	49.0					6.0	4.1
1936	13.8		14.2	15.0	26.7	18.2							3.8		5.0	5.6	6.0	4.0
1937					22.4	24.2											6.5	4.0
1938			26.2	14.2	23.3	8.4			47.0	47.0	52.0	49.2			5.4	5.6	6.0	3.9
Average	16.1	16.2	16.6	14.6	25.2	19.9	50.2	49.7	49.0	47.8	51.4	49.1	3.7	4.2	5.3	5.8	6.1	4.0
San Jacinto, Mexico:																		
19		16.9	18.0	23.9										4.3	5.6	6.3		

See footnotes at end of table.

TABLE 8.—*Acre yield, test weight, weight per 1,000 seeds, oil content of seed, iodine number of oil, and crude-protein cont(?)t of meal of 6 varieties of flax grown at 3 stations in California, Arizona, and Mexico*—Continued

Station and crop year	Oil content (basis, 8 percent moisture)						Iodine number of oil (Wijs)						Crude protein in meal [3]					
	Linota	Red-wing	Bison	Rio	Punjab	Abys-sinian Yellow	Linota	Red-wing	Bison	Rio	Punjab	Abys-sinian Yellow	Linota	Red-wing	Bison	Rio	Punjab	Abys-sinian Yellow
El Centro, Calif. (irrigated):	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*							*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
1929	34.4	36.7	36.4	38.8	------	------	193	194	182	179	------	------	------	------	------	------	------	------
1931	35.0	36.1	36.4	39.3	------	------	189	192	183	185	------	------	------	------	------	------	------	------
1932	35.2	36.4	37.8	38.1	39.6	39.4	191	191	181	175	184	197	------	------	------	------	------	------
1933	34.1	36.1	37.3	37.1	40.3	39.5	192	194	181	181	186	196	------	------	------	------	------	------
1934	34.2	36.3	38.1	38.4	37.6	35.5	193	196	185	176	178	192	35.2	34.2	41.2	33.0	------	------
1935	36.3	38.9	38.2	41.6	39.1	39.2	198	197	186	186	190	197	37.2	36.4	37.1	38.7	------	------
1936	------	------	37.0	37.1	39.5	37.0	------	------	176	169	185	192	------	------	39.6	36.5	35.6	33.6
1937	37.1	38.2	40.3	42.0	39.1	38.4	196	196	191	186	188	197	30.9	31.8	33.3	30.4	33.7	29.1
1938	34.7	36.4	38.0	37.3	38.4	37.2	194	194	186	169	188	197	38.2	38.8	42.0	39.0	38.1	27.5
Average	35.1	36.9	37.7	38.8	39.1	38.0	193	194	183	178	186	195	35.4	35.3	38.6	35.5	35.8	33.4
Mesa, Ariz. (irrigated):[2]																		
1931	35.5	37.9	39.2	40.8	42.3	------	189	190	193	176	182	------	------	------	------	------	------	------
1932	35.9	37.3	37.4	38.1	39.2	------	190	192	184	178	182	------	------	------	------	------	------	------
1933	34.5	37.3	38.9	38.7	39.6	------	195	194	188	180	187	------	------	------	------	------	------	------
1934	35.3	36.9	38.4	38.1	41.1	------	196	194	191	185	189	------	------	32.4	35.0	------	------	------
1935	------	------	------	------	39.2	38.5	------	------	------	------	183	196	------	------	------	------	------	------
1936	34.6	------	36.9	38.1	39.6	37.0	186	------	175	176	183	191	33.6	------	38.8	34.7	31.0	33.3
1937	------	------	------	------	39.8	38.1	------	------	------	------	185	196	------	------	------	------	34.2	33.9
1938	------	------	38.0	38.8	40.3	37.3	------	------	180	180	185	192	------	------	39.4	34.8	31.6	32.8
Average	35.2	37.4	38.1	38.8	40.1	37.7	191	192	185	179	184	194	33.6	32.4	37.7	34.8	32.3	33.3
San Jacinto, Mexico:																		
1934	------	36.6	38.5	40.0	------	------	------	189	180	176	------	------	------	------	------	------	------	------

[1] Interpolated yields.
[2] Grown at Sacaton, Ariz., 1935, 1936, and 1938.
[3] Crude protein (N×6.25) in meal, basis of 12 percent moisture and 4.5 percent oil.

Summary of Regional Results

In order to compare the results for the four varieties from the seven different regions, the data from each region are summarized in table 9. The highest average yields were obtained under irrigation in Montana, Idaho, Utah, California, and Arizona. The flax was fall-sown in the two latter States. Low yields were obtained in the northern Great Plains, an area of limited rainfall. In general, there was little or no significant difference in the yield between the four varieties tested except in the Central and Eastern regions, where the earlier varieties, Linota and Redwing, were superior to Bison and Rio, and in southern Texas, where Rio appeared to be superior to the other varieties.

The test weight per bushel and weight per 1,000 seeds averaged the highest in the Canadian and Intermountain regions, where the cooler climate favored the full development of the seed. Drought and repeated high temperatures, wherever they occurred, caused premature ripening and shrunken seed of a low test weight. In general, the small-seeded varieties, Linota and Redwing, showed higher test weights than did Bison and Rio.

In oil content and iodine number of the oil, the highest values were obtained from the Intermountain region, Alaska and Canada, and the Southwestern region. In these areas the flax was grown under relatively cool conditions, due to high altitudes in the Intermountain region, northern latitudes in Canada and Alaska, and to winter cropping in California. Flaxseed grown in these regions contained from 2 to 3 percent more oil, and the iodine number of the oil was some 10 points higher than in seed produced in the Great Plains and Northern Prairie regions. The oil content and iodine number of flaxseed grown in southern Texas were inferior to that grown in California for reasons not entirely clear.

The oil content of the large-seeded varieties, Bison and Rio, was 2 or 3 percent more than that of the small-seeded varieties, Linota and Redwing, whereas the iodine number of the oil was some 10 points lower. Since these relative differences prevailed in all regions and in most localities, it may be assumed that the oil content of flaxseed and the iodine number of oil are definite varietal characteristics. Moreover, these varietal characteristics were relatively constant. However, both oil content and iodine number of the oil were modified greatly by weather conditions, especially temperature and moisture, during the growing season. In the Northern Prairie region (table 9), for example, the average oil content of Linota and Rio was 33.2 and 37.4 percent, respectively, a significant varietal difference of 4.2 percent, whereas the extreme range in oil content, due to seasonal and soil conditions, exceeded 13 percent in each variety. Likewise the iodine number of Linota differed from Rio by 9 points, on the average, whereas the extreme range observed in this region was 48 points for Linota and 45 points for Rio.

TABLE 9.—*Average acre yield, test weight, weight per 1,000 seeds, oil content of seed, iodine number of oil, and crude-protein content of meal of 4 varieties of flax grown in 7 specified regions*

Region	Acre yield				Test weight				Weight per 1,000 seeds				Oil content (basis, 8 percent moisture)				Iodine number of oil (Wijs)				Crude protein in meal [1]			
	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio
Alaska and Canada:	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*					*Pct.*	*Pct.*	*Pct.*	*Pct.*
Number of trials	38	41	39	30	36	39	38	30	38	41	39	30	38	41	39	30	38	41	39	30	19	22	22	15
Highest	20.8	31.3	31.4	27.4	56.2	55.8	[illegible]	54.9	5.4	5.6	6.9	9.0	40.0	41.2	41.6	43.0	206	206	200	196	41.7	43.4	44.6	42.2
Lowest	3.0	3.2	3.3	2.0	51.0	50.0	[illegible]	46.0	3.0	3.6	4.8	5.5	31.6	33.6	35.3	37.0	178	180	169	169	29.9	31.4	32.7	31.4
Average	14.8	15.4	14.4	14.6	54.0	54.0	52.9	52.4	4.1	4.6	6.0	7.1	35.4	36.6	38.2	39.0	192	192	184	183	37.6	38.6	40.4	37.7
Pacific Northwest and Intermountain:																								
Number of trials	52	52	52	51	41	40	41	40	52	50	52	50	52	50	52	50	52	50	52	50	21	22	23	20
Highest	42.1	45.0	43.6	47.1	56.0	56.0	55.8	55.5	5.0	5.5	7.2	8.0	39.4	40.3	41.6	42.9	200	202	199	199	40.0	41.0	43.5	40.0
Lowest	1.8	1.7	2.3	2.1	17.8	50.4	48.6	46.0	3.4	3.9	3.7	4.5	33.5	34.2	36.0	36.3	180	180	166	165	28.9	29.8	31.4	30.6
Average	19.2	18.7	20.4	20.4	53.4	53.6	52.7	52.1	4.1	4.5	5.9	6.7	35.8	37.0	38.4	39.4	189	190	181	181	35.9	37.3	39.1	36.0
Great Plains:																								
Number of trials	52	47	52	52	42	40	42	42	53	47	53	52	53	47	53	52	52	46	52	51	17	13	17	17
Highest	24.4	22.6	25.3	22.3	54.5	54.5	53.5	53.0	4.5	4.8	6.4	7.9	38.9	38.4	39.5	41.1	195	193	186	187	43.1	42.8	44.2	41.8
Lowest	.1	.3	.3	.1	36.0	41.0	43.0	38.0	2.4	2.7	2.8	3.8	26.0	30.4	29.3	27.5	161	162	141	139	32.0	34.9	33.7	30.4
Average	6.1	5.6	6.5	6.0	52.0	52.4	51.5	50.6	3.3	3.8	5.0	5.8	32.7	34.0	36.0	36.5	180	181	169	169	38.7	39.0	40.6	38.3
Northern Prairie:																								
Number of trials	40	41	41	40	35	37	37	35	37	41	41	36	37	41	41	36	37	41	41	36	17	21	21	14
Highest	27.5	23.5	20.0	26.5	56.0	55.8	54.0	54.0	4.5	4.9	6.6	7.9	38.8	37.3	38.6	40.6	193	192	186	186	42.3	42.1	42.9	41.0
Lowest	.2	1.4	.8	.1	30.2	40.3	37.3	32.0	2.1	2.6	2.8	3.2	25.5	26.8	28.1	26.8	145	147	134	141	33.6	35.3	34.7	35.5
Average	13.5	12.6	13.4	15.1	53.4	53.5	52.3	51.4	3.7	4.0	5.3	6.5	33.2	34.3	36.0	37.4	180	180	169	171	39.1	39.5	40.7	38.8
Central and Eastern:																								
Number of trials	36	39	37	29	31	32	30	24	38	40	39	31	38	40	39	31	38	40	39	31	14	16	15	10
Highest	18.3	20.9	17.3	19.9	56.0	55.8	55.0	54.0	4.5	5.1	6.4	8.1	37.6	38.8	38.7	41.2	194	193	183	180	40.1	40.8	41.6	39.1
Lowest	.7	1.1	.9	.9	32.7	37.2	32.4	31.4	2.1	2.8	3.5	3.6	24.2	29.5	27.7	28.4	165	165	150	152	33.8	36.3	37.1	33.2
Average	11.0	11.2	9.8	9.7	51.9	52.2	50.8	49.9	3.7	4.1	5.3	6.1	33.4	34.7	35.9	36.9	180	182	168	170	37.4	38.6	39.6	37.3
South Texas:																								
Number of trials	19	10	18	19	5	3	5	5	18	8	17	19	18	8	17	19	18	8	17	19	12	4	11	13
Highest	23.4	16.7	25.0	33.5	54.1	54.1	53.6	53.6	4.4	4.4	6.0	7.5	36.2	36.9	38.6	39.6	190	189	182	183	40.1	41.8	41.5	41.6
Lowest	0	0	0	0	51.1	50.7	50.8	50.0	3.1	3.2	4.3	4.5	31.6	32.5	34.2	33.4	166	173	155	156	31.0	33.6	34.1	32.6
Average	10.5	10.0	9.7	13.2	53.1	52.8	52.4	51.5	3.7	3.7	5.0	5.9	34.4	34.7	36.7	37.4	183	182	173	173	35.5	37.2	38.4	37.2
Southwestern:																								
Number of trials	14	14	16	16	9	10	12	11	13	13	16	16	13	13	16	16	13	13	16	16	5	5	8	7
Highest	31.2	33.1	40.0	34.1	56.0	56.0	54.5	54.0	4.3	4.8	6.1	6.9	37.1	38.9	40.3	42.0	198	197	193	186	38.2	38.8	42.0	39.0
Lowest	5.6	8.5	5.7	4.4	47.6	46.2	47.0	45.6	3.3	3.7	4.4	4.6	34.1	36.1	36.4	37.1	186	189	175	169	30.9	31.8	33.3	33.0
Average	21.8	21.9	21.7	21.7	52.2	52.2	51.3	49.8	3.8	4.4	5.5	6.0	35.1	37.0	37.9	38.9	192	193	184	178	35.0	34.7	38.3	35.3
Summary of all trials:																								
Number of trials	251	244	255	237	199	201	205	187	249	240	257	234	249	240	257	234	248	239	256	233	105	103	117	96
Highest	42.1	45.0	43.6	47.1	56.2	56.0	55.8	55.5	6.2	5.6	7.2	9.0	40.0	41.2	41.6	43.0	206	206	200	199	43.1	43.4	44.6	42.2
Lowest	0	0	0	0	32.7	37.2	32.4	31.4	2.1	2.6	2.8	3.2	24.2	26.8	27.7	26.8	145	147	134	139	28.9	29.8	31.4	30.4
Average	13.2	13.2	13.3	13.5	52.9	53.1	52.0	51.2	3.8	4.2	5.5	6.3	34.2	35.4	37.0	37.9	185	185	175	175	37.3	38.3	39.8	37.3

[1] Crude protein (N×6.25) in meal, basis of 12 percent moisture and 4.5 percent oil.

The wide range observed in the crude-protein content of the meal under different climatic conditions is not easy to explain. Under generally cool humid conditions, as at Nappan, Nova Scotia (table 2), high acre yields were obtained, the seed was of high oil content, and the iodine number of the oils was high, whereas the protein content was low. The same was true at Aberdeen, Idaho, and at Corvallis, Oreg., in 1936 and 1937 (table 3). On the other hand, a relatively high crude-protein content of the meal was associated with high acre yields, high oil content, and high iodine number in flax grown under irrigation at Bozeman, Mont., and Logan, Utah (table 3). In general, meal of low crude-protein content was obtained from flaxseed grown at El Centro, Calif., and at Mesa, Ariz. (table 8).

CLIMATIC FACTORS

The climatic factors that were tabulated because they appeared to be most closely associated with the yield and intrinsic value of flaxseed were the annual, crop year, June, and July precipitation; the mean

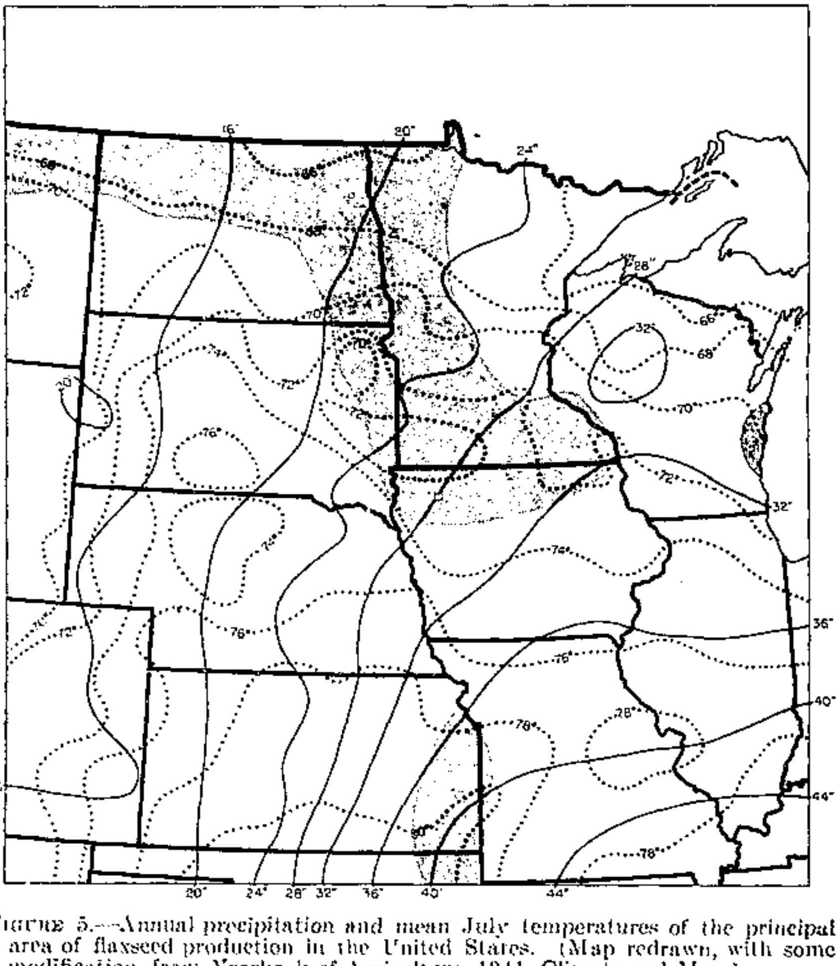

FIGURE 5.—Annual precipitation and mean July temperatures of the principal area of flaxseed production in the United States. (Map redrawn, with some modification, from Yearbook of Agriculture, 1941, Climate and Man.)

and average maximum July temperature; and the "July excess temperature," that is, the total sum in degrees of daily maximum temperatures above 90° F. (See tables 10 to 15.) In the northern flax-producing region July is often the most critical month in flax production, as it usually covers the period from flowering to maturity, which is the critical period in the growth of the flax plant and the development of the seed. In southeastern Kansas, June (mean temperature 75° F.) rather than July may be considered the critical period (fig. 5). In Texas, California, and Arizona, where flax is fall-sown, April is considered the critical seed-growth period.

TABLE 10.—*Climatic and vegetative period data for Alaska and Canada*

Station and year	Precipitation					July temperatures			Date of first bloom	Seeding to ripe	First bloom to ripe
	Annual	Crop year	June	July	June and July	Average mean	Average maximum	Total 90° F. excess			
Fairbanks, Alaska:	*In.*	*In.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F.*		*Days*	*Days*
1929	16.09	15.05	1.77	3.82	5.59	59	[illegible]	0	July 14	110	68
Normal	11.76	11.76	1.32	1.85	3.17	60	72				
Matanuska, Alaska:											
1931	18.93	19.43	.72	1.42	2.14	58	67	0	July 18	120	74
Normal	15.61	15.01	1.06	1.87	2.93	58	67				
Edmonton, Alberta:											
1930	14.58	13.39	2.39	3.28	5.67	63	76	4	July 17	141	65
1931	22.16	20.54	6.60	3.53	10.13	61	73	0	July 16	125	58
1932	14.72	14.68	2.27	2.24	4.51	61	72	0	July 19	116	41
1933	10.48	15.30	3.32	3.03	6.35	60	73	3	July 6	133	72
1934	18.03	21.52	3.04	2.67	5.71	60	72	0	July 5	124	62
1935	26.29	22.49	4.09	1.83	5.92	64	75	7	do	[1] 120	[1] 61
1936	15.77	18.80	1.10	1.52	2.62	65	79	3	July 3	122	70
1937	16.17	16.15	.89	6.20	7.09	63	74	0	June 28	141	60
1938	17.80	18.23	4.19	2.54	6.73	64	76	0	June 29	114	68
Normal	17.11	17.11	3.09	3.28	6.37	61	74		July 8	126	66
Fallis, Alberta:											
1934	18.03	21.52	3.04	2.67	5.71	60	72	0			
1936	15.77	18.80	1.10	1.52	2.62	65	79	3	July 8	112	62
Normal	17.11	17.11	3.09	3.28	6.37	61	74				
Saskatoon, Saskatchewan:											
1930	11.85	10.12	2.83	1.18	4.01	67	80	14	July 8	123	67
1931	13.70	12.75	3.39	1.38	4.77	65	78	10	July 14	99	45
1932	12.27	16.03	3.69	1.40	5.09	64	77	7	July 10	98	38
1933	13.63	10.19	.88	.95	1.83	66	81	24	July 5	82	41
1934	12.83	15.63	4.86	1.22	6.08	65	78	7	July 15	91	35
1935	19.22	17.01	4.65	2.78	7.43	69	82	7	July 12	94	51
1936	11.70	13.21	2.80	.35	3.15	72	86	25	July 8	88	32
1937	11.43	11.25	.55	1.27	1.82	70	84	37	July 6	108	56
1938	18.71	15.50	1.46	1.84	3.30	67	80	6	July 4	87	42
Normal	14.80	14.80	2.51	2.60	5.11	65	77		July 9	97	45
Morden, Manitoba:											
1930	17.93	20.92	4.38	1.91	6.29	70	83	11	June 25	100	66
1931	15.82	14.08	1.08	1.85	2.93	69	82	32	June 20	103	58
1932	19.74	19.46	2.43	2.35	4.78	69	82	27	June 25	85	40
1933	18.79	18.87	.95	.86	1.81	71	86	49	June 23	75	33
1934	13.81	17.31	3.72	1.69	5.41	70	87	35	July 1	87	39
1935	21.59	21.47	5.41	2.80	8.21	74	85	27	do	93	45
1936	13.66	13.65	2.70	.75	3.45	77	94	208	June 29	94	52
1937	25.03	24.11	5.48	6.89	12.37	71	82	14	June 28	114	71
1938	17.00	19.59	2.24	4.26	6.50	70	81	9	do	111	50
Normal	19.53	19.53	3.16	2.79	5.95	69	84		June 27	96	50
Ottawa, Ontario:											
1934	34.13	34.35	3.17	2.94	6.11	70	82	1	June 29	82	35
1935	34.24	34.29	6.00	3.28	9.28	71	81	0	July 2	115	45
1936	38.42	33.70	2.02	4.27	6.29	67	79	8	June 28	96	45
1937	37.33	37.13	3.64	3.99	7.63	70	81	3	July 7	96	45
1938	33.60	36.33	2.43	5.29	7.72	69	80	0	June 20	92	45
Normal	34.34	34.34	3.45	3.69	7.14	69	80		June 29	96	43
Nappan, Nova Scotia:											
1934	38.23	46.06	2.51	1.96	4.47	64	76	0	July 13	111	55
1935	44.09	42.50	3.50	2.96	6.46	65	76	0	July 12	97	42
1936	51.37	44.51	2.70	1.96	4.66	62	73	0	July 20	110	55
1937	35.12	37.40	4.26	1.20	5.46	66	78	0	July 12	92	38
1938	42.17	45.38	3.32	5.67	8.99	65	73	0	July 10	82	31
Normal	36.15	36.15	3.04	2.93	5.97	64	74		July 13	98	44

[1] Interpolated. Flax killed by frost Aug. 16, some 20 days before ripe.

TABLE 11.—*Climatic and vegetative period data for the Pacific Northwest and Intermountain regions*

Station and year	Precipitation					July temperatures			Date of first bloom	Seeding to ripe	First bloom to ripe
	Annual	Crop year	June	July	June and July	Average mean	Average maximum	Total 90° F. excess			
	In.	*In.*	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*		*Days*	*Days*
Corvallis, Oreg.:											
1929	24.45	31.5	1.28	T	1.28	67	80	2	July 2	98	36
1930	23.68	27.2	.94	0	.94	66	81	7	June 30	93	38
1931	39.13	27.2	3.25	T	3.25	69	85	30	June 18	98	44
1932	30.94	41.0	.24	.01	.85	64	76	0	June 12	97	36
1933	42.59	39.6	.84	0	.84	67	82	7	June 18	109	41
1934	35.42	32.0	.24	.26	.50	65	77	1	June 7	97	39
1935	26.35	38.4	.21	.51	.72	66	80	35	June 9	104	45
1936	32.11	35.9	1.70	.30	2.00	67	80	2	June 11	107	47
1937	58.00	40.6	3.58	.08	3.66	68	81	2	June 17	100	46
1938	32.04	44.7	.08	.17	.25	70	86	85	June 10	102	45
Normal	40.27	40.27	1.15	.33	1.48	66	81	-----	June 16	101	41
Union, Oreg. (subirrigated):											
1930	13.51	13.01	1.68	.07	1.75	67	83	13	July 1	115	52
1931	9.68	9.28	1.50	T	1.50	68	86	41	July 3	111	4
1932	11.26	12.31	.57	.22	.79	64	82	7	July 10	106	55
1933	12.69	11.72	1.50	.29	1.79	68	85	31	July 4	129	86
1935	8.04	10.52	.94	.58	1.52	66	83	27	July 10	98	52
1936	9.80	9.86	1.84	.63	2.47	68	85	35	July 4	94	47
1938	11.77	12.19	1.16	.30	1.55	68	85	32	July 5	96	53
Normal	12.14	12.14	1.33	.55	1.88	66	84	-----	do	107	56
Pullman, Wash.:											
1938	14.28	16.20	1.12	.31	1.43	71	84	29	June 15	115	48
Normal	20.49	20.49	1.28	.49	1.77	68	82	-----	-----	-----	
Prosser, Wash. (irrigated):											
1938	7.01	9.38	1.71	.03	1.74	75	93.	146	June 1	106	40
Normal	7.39	7.39	.36	.17	.53	72	91	-----	-----	-----	
Moscow, Idaho:											
1938	16.45	19.91	1.27	.30	1.57	71	85	43	June 10	114	55
Normal	21.84	21.84	1.38	.61	1.99	67	82	-----	-----	-----	
Bozeman, Mont. (irrigated):											
1929	16.01	15.13	2.84	1.42	4.26	66	82	4	July 8	114	52
1930	14.10	12.71	.85	1.64	2.49	66	81	5	July 6	122	51
1931	14.84	15.97	1.46	1.46	2.92	68	83	30	July 1	112	52
1932	17.34	18.03	3.29	1.55	4.84	66	81	3	July 8	123	64
1933	15.89	15.46	1.13	.40	1.53	70	86	23	June 30	90	45
1934	10.54	10.96	2.35	.40	2.75	68	84	21	July 4	96	46
1935	15.46	15.92	1.76	.77	2.53	67	83	8	July 12	95	47
1936	12.78	12.73	2.13	.09	2.22	72	87	26	July 9	100	53
1937	17.99	17.29	3.90	2.16	6.06	67	81	3	July 4	116	66
1938	20.60	19.57	1.82	1.20	3.02	64	78	0	July 12	118	71
Normal	16.74	16.74	2.22	1.40	3.62	66	79	-----	July 6	109	55
Aberdeen, Idaho (irrigated):											
1935	6.36	7.10	.06	0	.06	71	92	92	June 23	120	67
1937	10.13	8.20	.07	1.49	2.46	72	91	93	June 22	108	73
1938	12.09	10.74	.81	.47	1.28	69	86	46	July 4	112	57
Normal	8.83	8.83	.71	.52	1.23	70	89	-----	June 26	113	66
Logan, Utah (irrigated):											
1932	16.42	20.34	1.19	.92	2.11	72	86	8	June 28	96	53
1933	11.93	10.66	.06	.23	.29	76	91	102	June 14	127	67
1934	11.70	10.11	.87	.34	1.21	76	90	76	May 23	129	71
1935	13.47	14.92	.15	0	.15	75	90	38	June 17	136	60
1936	18.31	16.55	.71	.69	1.40	76	90	70	June 4	108	54
1937	20.41	20.33	.49	1.78	2.27	74	88	48	June 17	107	50
Normal	16.53	16.53	.88	.64	1.52	72	86	-----	June 12	117	59
Murray, Utah (irrigated):											
1932	12.14	13.55	2.06	.38	2.44	74	92	80	-----	121	
1933	11.00	11.90	T	.35	.35	80	97	216	-----	112	
1934	11.33	8.31	1.18	1.44	2.62	78	98	236	-----	138	
1935	11.40	14.12	.10	.02	.12	78	96	166	-----	120	
Normal	15.03	15.03	.75	.63	1.38	75	91	-----	-----	123	
Fort Duchesne, Utah (irrigated):											
1931	3.74	4.88	.05	.05	.10	70	90	96	June 5	114	59
1932	6.31	7.29	.25	1.38	1.63	71	89	45	June 10	132	61
1933	4.71	4.28	.09	.39	.48	74	95	161	-----	115	
1934	3.67	4.14	.78	.71	1.49	74	93	124	-----	125	
Normal	6.78	6.78	.37	.50	.87	71	90	-----	-----	122	
Fort Collins, Colo. (irrigated):											
1930	15.17	17.95	1.50	1.00	2.50	70	85	30	-----	-----	
1931	9.88	9.03	1.50	.10	1.60	72	87	44	-----	-----	
1932	12.79	13.82	1.11	2.13	3.24	72	87	11	June 19	112	39
1933	15.65	13.64	.05	.71	.76	72	86	22	June 29	93	36
1934	8.87	11.21	1.25	1.33	2.58	74	90	68	June 13	90	35
Normal	14.70	14.70	1.53	1.66	3.19	71	84		June 20	98	37

TABLE 12.—*Climatic and vegetative period data for the Great Plains region*

Station and year	Precipitation					July temperatures			Date of first bloom	Seeding to ripe	First bloom to ripe
	Annual	Crop year	June	July	June and July	Average mean	Average maximum	Total 90° F. excess			
Havre, Mont.:	*In.*	*In.*	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*		*Days*	*Days*
1930	8.88	9.37	1.64	0.61	2.25	72	88	70	July 5	78	31
1932	15.29	14.91	4.50	1.32	5.82	69	84	30	July 6	79	36
1933	15.16	13.84	2.55	.34	2.89	71	88	85	June 18	84	38
1935	7.72	9.69	.68	1.53	2.21	72	88	46	----	----	----
1938	15.14	14.87	3.99	2.11	6.10	69	82	11	June 28	87	39
Normal	13.30	13.30	2.82	1.76	4.58	69	82	----	June 29	61	35
Moccasin, Mont.:											
1929	13.28	9.54	1.86	.62	2.48	68	85	30	July 12	93	31
1930	12.18	14.40	.91	1.37	2.28	69	84	22	June 25	105	43
1931	10.71	11.06	1.30	2.48	3.78	68	81	40	July 11	106	50
1932	15.59	15.67	3.63	2.12	5.75	66	81	9	July 5	88	31
1933	15.79	16.55	2.43	.29	2.72	69	86	48	June 28	83	31
1934	9.57	9.40	2.70	1.38	4.08	68	84	29	June 19	100	43
1936	10.07	10.09	1.74	.35	2.09	76	92	121	June 24	78	28
Normal	14.94	14.94	2.84	1.68	4.52	66	80	----	July 1	93	37
Dickinson, N. Dak.:											
1928	15.39	18.21	3.39	3.52	6.91	67	79	7	July 3	94	41
1929	17.21	13.48	2.89	.54	3.43	70	87	78	July 5	78	29
1930	13.79	15.29	4.31	.08	4.39	72	89	92	July 7	77	31
1931	16.17	15.32	3.46	2.80	6.26	69	84	103	July 2	93	41
1932	17.24	18.81	5.16	1.02	6.18	70	86	68	June 30	74	31
1933	11.50	12.51	1.26	2.63	3.89	72	88	108	June 24	105	35
1934	7.01	8.96	3.88	.75	4.63	72	88	85	July 13	77	39
1935	15.00	14.70	2.14	2.93	5.07	73	88	66	July 3	80	29
Normal	15.80	15.80	3.37	2.17	5.54	68	83	----	---do---	85	35
Mandan, N. Dak.:											
1929	14.22	11.32	.99	1.20	2.19	73	88	91	July 11	86	46
1930	17.38	15.92	1.60	2.40	3.90	74	89	92	July 4	88	40
1931	17.44	17.33	1.65	4.26	5.91	71	84	82	June 29	96	51
1932	15.76	18.81	3.33	1.90	5.23	71	85	49	June 27	89	44
1933	11.91	12.40	2.18	1.80	3.98	73	87	74	June 21	87	44
1934	8.13	8.86	3.78	1.10	4.88	74	88	64	July 13	76	37
1935	18.30	17.75	2.85	4.71	7.56	75	88	38	July 3	86	38
1937	16.00	15.80	5.65	1.83	7.48	72	85	32	June 24	102	52
1938	14.42	15.13	3.11	2.90	6.01	71	84	13	June 26	92	47
Normal	16.02	16.02	3.29	2.38	5.67	70	83	----	July 1	89	44
Sheridan, Wyo.:											
1930	8.68	11.82	.58	.76	1.34	74	92	133	June 20	82	34
1932	19.27	20.09	2.90	.85	3.75	72	89	76	June 28	81	35
1933	16.25	18.08	1.23	.78	2.01	74	91	121	June 20	82	42
1934	10.40	8.69	1.36	.32	1.68	75	93	152	June 28	88	34
1935	13.03	14.94	1.27	.75	2.02	75	94	143	---do---	83	33
1937	16.97	17.20	2.47	2.97	5.44	71	86	44	July 10	88	36
1938	17.72	18.59	2.00	2.39	4.39	69	85	21	July 5	82	42
Normal	15.18	15.18	2.02	1.39	3.41	72	89	----	July 1	84	37
Newell, S. Dak. (irrigated):											
1928	15.95	15.64	3.38	4.89	8.27	70	83	8	----	88	----
1929	22.35	18.63	3.05	3.23	6.28	73	87	57	July 8	83	35
1930	12.11	16.23	2.18	1.23	3.41	75	90	109	----	81	----
1931	8.80	9.29	1.42	1.31	2.73	75	90	147	----	85	----
1932	19.24	19.28	3.76	1.17	4.93	74	85	80	----	93	----
1933	19.21	10.68	1.22	1.56	2.78	76	91	128	----	----	----
1935	12.10	14.71	1.75	.48	2.23	77	93	115	July 17	97	54
1936	10.36	9.77	.59	1.09	1.68	81	98	269	July 2	89	39
Normal	15.70	15.70	2.51	2.35	4.86	73	87	----	----	88	----
Ardmore, S. Dak.:											
1930	15.71	14.38	1.24	.70	1.94	78	94	188	----	----	----
Normal	15.90	15.90	2.65	2.19	4.84	73	86	----	----	----	----
Hays, Kans.[1]:											
1929	26.57	21.24	3.35	1.54	4.89	71	84	62	June 2	104	32
Normal	23.69	23.69	3.46	4.10	7.56	73	86	----	----	----	----
Woodward, Okla.[1]:											
1934	23.61	19.41	2.02	4.64	6.66	82	95	160	----	----	----
Normal	25.10	25.10	3.37	3.27	6.64	77	90	----	----	----	----
Denton, Tex.[1]:											
1933	29.04	----	5.22	.05	5.27	80	93	130	May 17	90	34
1934	22.36	----	4.24	.23	4.47	85	98	208	May 9	93	36
1935	49.24	----	11.52	5.27	16.79	77	87	166	May 18	108	44
1936	28.85	----	7.77	.02	7.79	82	96	170	May 7	101	43
1937	25.92	----	1.00	4.10	5.10	81	91	94	May 12	102	51
1938	30.76	----	2.34	3.08	5.42	80	91	65	----	----	----
Normal	32.48	32.48	4.11	3.22	7.33	80	91	----	May 13	99	42

[1] May and June precipitations and June temperatures.

TABLE 13.—*Climatic and vegetative period data for the Northern Prairie region*

Station and year	Precipitation					July temperatures			Date of first bloom	Seeding to ripe	First bloom to ripe
	Annual	Crop year	June	July	June and July	Average mean	Average maximum	Total 90° F. excess			
Fargo, N. Dak.:	*In.*	*In.*	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*		*Days*	*Days*
1929	13.89	11.98	0.30	0.94	1.24	72	84	41	June 30	95	47
1930	16.25	17.64	2.70	.48	3.18	74	87	57	do	88	47
1931	19.18	17.97	2.79	5.19	7.08	72	85	64	June 20	95	46
1932	15.05	16.56	2.16	1.36	3.52	72	87	56	June 22	83	37
1933	15.25	15.33	2.13	1.44	3.57	74	86	40	June 18	97	53
1934	13.97	14.42	3.93	.80	4.73	72	85	42	June 26	86	37
1935	19.07	19.85	3.01	2.13	5.14	70	87	28	July 3	86	38
1936	8.87	10.06	.48	.42	.90	80	94	198	June 25	85	37
1937	19.89	18.81	1.89	2.68	4.57	72	84	30	June 29	91	44
1938	16.21	15.76	1.04	1.96	3.00	71	83	15	June 27	88	41
Normal	23.34	23.34	4.05	3.43	7.48	69	81	------	June 26	89	43
Crookston, Minn.:											
1929	14.06	12.51	1.28	2.23	3.51	70	84	32	June 30	97	42
1930	17.13	15.07	2.17	1.69	3.86	72	86	34	June 28	97	43
1931	17.29	17.67	2.64	3.06	5.70	71	84	51	June 27	90	39
1932	15.21	18.23	1.80	1.49	3.29	72	86	53	June 18	85	40
1933	17.49	15.85	3.00	1.50	4.50	72	86	25	June 20	103	47
1934	17.45	17.59	4.95	2.32	7.27	70	84	18	June 26	91	39
1935	18.12	20.90	2.90	4.47	7.37	74	86	6	do	91	39
1937	17.78	19.67	1.41	3.05	5.36	70	82	11	June 29	109	60
1938	15.82	14.94	1.20	2.96	4.16	69	80	4	July 14	80	37
Normal	20.63	20.63	3.35	3.07	6.42	69	78	------	June 28	94	43
Morris, Minn.:											
1930	25.48	23.49	4.67	3.96	8.65	74	87	32	June 23	106	54
1931	19.22	21.25	2.83	2.38	5.21	74	89	104	June 19	84	33
1932	19.70	21.62	1.98	3.32	5.30	72	87	60	June 15	89	40
1933	15.31	17.40	2.79	1.22	4.01	75	90	85	do	97	42
1935	27.68	32.30	4.43	6.52	10.95	77	88	63	June 28	94	44
1936	17.41	14.12	1.85	.34	2.19	78	93	162	July 1	109	45
1937	26.54	28.75	4.45	4.34	8.79	73	85	37	June 24	85	31
1938	23.06	20.39	3.62	2.80	6.42	71	83	2	June 21	88	37
Normal	23.94	23.94	4.04	3.56	7.60	71	82	------	June 22	94	41
St. Paul, Minn.:											
1930	24.16	22.87	6.68	.92	7.60	75	86	43	June 17	104	38
1931	22.03	21.49	4.78	1.12	5.90	77	87	76	June 21	84	27
1932	23.39	26.14	1.56	4.36	5.92	75	85	50	June 14	91	44
1933	23.65	23.21	1.31	2.16	3.47	77	88	39	June 11	81	35
1934	22.73	14.60	2.30	1.40	3.70	76	87	63	June 27	89	38
1935	27.50	30.95	4.82	2.59	7.41	80	90	60	do	95	28
1936	18.47	22.25	2.29	.11	2.40	81	92	162	June 18	75	30
1937	22.59	22.40	3.11	.48	3.59	77	88	49	June 21	83	20
1938	29.75	27.08	2.96	3.36	6.32	74	85	19	June 22	98	43
Normal	27.66	27.66	4.22	3.73	7.95	72	83	------	June 20	89	36
Brookings, S. Dak.:											
1935	17.45	22.33	2.75	1.69	4.41	79	93	104	------	------	------
1936	16.92	15.90	3.13	.20	3.33	82	98	251	June 18	72	27
1937	16.10	15.71	2.39	1.16	3.55	76	90	94	June 27	81	29
1938	17.20	15.99	3.47	2.02	5.49	74	87	20	June 19	84	34
Normal	20.54	20.54	3.91	2.03	6.54	70	83	------	June 21	79	30
Madison, Wis.:											
1938	39.34	35.28	4.24	3.43	7.67	73	81	0	June 15	96	47
Normal	31.10	31.10	3.76	3.88	7.64	72	81	------	------	------	------

TABLE 14.—*Climatic and vegetative period data for the Central and Eastern regions*

Station and year	Precipitation					July temperatures			Date of first bloom	Seeding to ripe	First bloom to ripe
	Annual	Crop year	June	July	June and July	Average mean	Average maximum	Total 90° F. excess			
Lincoln, Nebr.:	*In.*	*In.*	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*		*Days*	*Days*
1933	27.54	22.80	2.33	5.21	7.54	79	91	84			
1934	15.41	16.12	2.12	.36	2.48	88	104	444		93	
1935	26.54	26.58	4.16	3.80	7.96	85	98	237			
1937	19.42	20.44	3.54	3.83	7.37	81	94	160		83	
1938	27.38	24.83	2.35	1.97	4.32	81	96	226		84	
Normal	27.94	27.94	4.32	3.85	8.17	78	89			87	
Manhattan, Kans.[1]:											
1937	21.81	25.86	2.42	3.39	5.81	76	88	121	May 28	90	35
1938	28.87	26.86	7.99	3.27	11.26	74	86	20	May 30	110	37
Normal	32.96	32.96	4.43	4.69	9.12	75	86		May 29	100	36
Moran, Kans.[1]:											
1930	32.87	28.30	4.12	6.03	10.15	73	83	18		119	
1931	32.46	30.99	3.67	3.10	6.77	78	89	67		107	
1932	27.82	31.27	1.64	5.01	6.65	76	86	8		110	
1933	35.91	28.61	5.18	.73	5.91	80	93	150	May 26	109	38
1934	34.59	37.89	5.74	5.11	10.85	80	93	206	do.	112	
1935	49.51	45.64	12.08	7.50	19.58	72	82	0	May 25	132	60
1936	22.31	28.90	4.36	.83	5.19	78	93	153	June 6	88	34
1937	34.04	38.50	5.27	7.07	12.34	76	86	52	June 5	78	35
1938	37.32	35.53	11.62	4.98	16.60	74	85	5	May 18	111	37
Normal	38.10	38.10	4.74	5.28	10.02	75	85		May 28	107	41
Fredonia, Kans.[1]:											
1929	38.85	40.96	9.10	3.39	12.49	74	83	10			
1931	37.93	31.96	4.62	2.97	7.59	77	88	63			
1932	29.61	40.36	2.44	8.49	10.93	76	87	18			
1938	33.93	38.57	7.56	5.12	12.68	74	84	8			
Normal	37.25	37.25	5.02	5.08	10.10	75	85				
Ames, Iowa:											
1932	33.54	47.12	6.16	2.82	8.98	76	88	67			
1933	25.00	24.38	1.02	2.86	3.88	76	89	41			
Normal	31.00	31.00	4.21	3.26	7.47	74	87				
Urbana, Ill.:											
1932	30.49	29.54	3.57	2.41	5.98	77	88	84			
1933	34.47	37.30	1.19	.61	1.80	78	90	68			
1935	37.21	41.57	3.61	4.12	7.76	78	87	21			
1936	35.09	20.10	.47	1.35	1.82	83	96	226			
1937	37.65	42.00	5.43	2.43	7.86	74	84	32			
Normal	35.57	35.57	3.74	3.20	6.94	75	86				
Wooster, Ohio:											
1930	28.78	31.20	2.86	1.71	4.57	74	90	109		101	
1931	35.66	33.99	3.49	2.97	6.46	76	89	53			
1932	34.57	35.77	3.44	3.14	6.58	72	85	20		94	
1933	33.53	28.93	1.67	1.73	3.40	74	88	61		90	
1934	29.90	46.33	4.50	2.55	7.05	76	89	57		77	
Normal	37.78	37.78	3.98	4.56	8.54	72	84			91	
New Brunswick, N. J.[1]:											
1928	45.52	56.14	[illegible]	7.18	9.09	68	78	0			
1929	45.03	39.83	3.93	5.37	9.30	71	83	16			
1930	32.90	37.10	2.54	4.39	6.93	72	84	15			
1931	35.77	38.07	3.24	4.60	7.84	70	82	8	June 6	92	38
1932	43.16	31.20	2.09	4.07	6.16	70	80	0			
1933	46.95	55.09	6.80	2.85	9.65	71	82	10	June 4	94	43
1934	42.40	36.30	4.07	3.92	7.99	73	83	16			
1935	41.37	40.40	2.17	3.62	5.79	69	79	0	June 7	94	44
1936	45.97	47.12	4.33	4.92	9.25	69	80	7	June 5	99	53
1937	42.75	47.19	2.45	3.35	5.80	71	81	2	June 2	87	40
1938	48.67	41.59	3.55	6.03	9.58	68	78	0	June 9	96	40
Normal	45.47	45.47	3.66	3.63	7.34	70	81		June 5	94	43

[1] May and June precipitations and June temperatures.

TABLE 15.—*Climatic and vegetative period data for southern Texas, California, and Arizona*

Station and year	Precipitation					April temperatures			Date of first bloom	Seeding to ripe	First bloom to ripe
	Annual	Crop year	March	April	March and April	Average mean	Average maximum	Total 90° F. excess			
San Antonio, Tex.:	*In.*	*In.*	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*		*Days*	*Days*
1929	20.24	------	2.64	2.58	5.20	72	82	5	Apr. 2	97	45
1930	22.70	------	2.02	2.03	4.05	72	83	7	Apr. 15	116	43
1931	25.00	------	2.93	2.25	5.18	64	82	0	Mar. 26	150	60
1932	35.57	------	1.30	1.41	2.71	70	81	2	Mar. 3	135	50
1933	17.64	------	.54	1.30	1.84	72	83	15	Apr. 30	107	38
1934	27.05	------	2.05	4.56	6.61	71	81	10	Apr. 10	108	52
Normal	27.18	27.18	1.84	3.19	5.03	71	80	------	Apr. 9	118	48
Beeville, Tex.:											
1935	33.20	------	4.75	1.59	6.34	71	82	4	------	------	------
1936	33.72	------	2.50	2.02	4.52	69	83	21	------	------	------
1937	23.30	------	2.26	.30	2.56	72	85	20	------	------	------
1938	21.05	------	.27	3.01	3.28	70	81	1	------	------	------
Normal	30.89	30.89	2.20	2.31	4.51	71	82	------	------	------	------
College Station, Tex.:											
1937	31.30	------	4.28	1.36	5.64	68	80	1	------	------	------
1938	31.91	------	5.41	4.60	10.01	67	77	0	------	------	------
Normal	38.50	38.50	2.75	3.98	6.73	68	79	------	------	------	------
Angleton, Tex.:											
1936	46.06	------	2.31	3.45	5.76	65	77	0	------	------	------
1937	37.98	------	4.86	.71	5.57	66	79	0	------	------	------
1938	41.08	------	1.08	1.46	2.54	68	------	0	------	------	------
Normal	45.85	45.85	3.27	3.56	6.83	68	78	------	------	------	------
Victoria, Tex.:											
1936	46.69	------	2.30	2.27	4.57	67	------	------	------	------	------
1937	25.52	------	2.57	.41	2.98	69	------	------	------	------	------
Normal	35.66	35.66	2.37	3.06	5.43	71	------	------	------	------	------
Orange Grove, Tex.:											
1936	27.58	------	2.82	3.59	6.41	70	------	------	------	------	------
Normal	24.73	24.73	1.42	1.81	3.23	72	------	------	------	------	------
Winter Haven, Tex. (irrigated):											
1938	17.43	------	1.10	.41	1.51	------	------	21	------	------	------
Normal	19.07	19.07	------	------	------	------	------	------	------	------	------
El Centro, Calif.[1]:											
1929	.30	------	0	0	0	67	85	27	------	------	------
1931	4.73	------	0	.93	.93	72	89	50	Feb. 20	167	70
1932	4.63	------	0	0	0	69	86	43	Feb. 10	189	76
1933	2.38	------	0	.79	.79	66	81	15	Feb. 25	179	65
1934	.62	------	.08	0	.08	75	93	129	Feb. 28	183	69
1935	2.87	------	.12	0	.12	70	84	18	Feb. 5	169	68
1936	1.59	------	0	0	0	73	91	120	Feb. 8	191	77
1937	1.70	------	.61	0	.61	69	85	23	Feb. 27	157	46
1938	3.84	------	.59	0	.59	70	87	64	Feb. 10	181	60
Normal	3.21	------	.15	.18	.33	70	86	------	Feb. 16	177	66
Mesa, Ariz.:											
1931	12.53	------	.02	.76	.78	67	83	4	------	167	------
1932	7.41	------	.08	.16	.24	64	82	2	------	155	------
1933	6.41	------	0	.89	.89	59	75	0	------	156	------
1934	6.09	------	.08	.12	.20	70	88	61	------	------	------
1935	9.43	------	1.17	.18	1.35	65	82	3	------	------	------
1936	12.13	------	.55	0	.55	68	87	60	------	164	------
1937	5.30	------	1.78	0	1.78	65	84	15	------	183	------
1938	4.56	------	.77	.02	.79	68	84	45	------	------	------
Normal	8.69	------	.83	.45	1.28	65	82	------	------	165	------

[1] Weather data recorded at Imperial, near El Centro, Calif.

The crop-year precipitation in the Northern States is for the 12 months ending August 31, where July is the critical month. For southern Texas, the calendar-year precipitation is used.

The data were compiled from reports of the United States Weather Bureau or of the cooperating stations. In all cases where possible the normal or long-time average up to and including 1938 is given.

The growing period (seeding to maturity) of spring-sown flax was 96 to 120 days in Alaska, Canada, and the Intermountain region of Montana, Idaho, and Utah; and from 85 to 94 days in the northern Great Plains and in the Northern Prairie region. The length of the growing season varied greatly from year to year at any one station, depending on weather conditions and, to some extent, on the date of seeding.

In southern Texas and in California where flax is fall-sown the length of the growing period depended largely upon the date of seeding, as flax sown in mid-October or in late December tended to ripen at about the same time; that is, in late April or early May. At San Antonio, Tex., the period from seeding to maturity ranged from 97 to 150 days and averaged 118 days. At El Centro, Calif., where the date of seeding was approximately November 15 each season, the growing period ranged from 157 to 191 days and averaged 177 days.

RELATION BETWEEN CLIMATIC FACTORS AND THE YIELD AND COMPOSITION OF FLAXSEED AND LINSEED OIL

The data for the years in which all 4 varieties were grown at the individual stations were used in a statistical analysis of the factors related to the yield and quality of flax and oil. The range and average of the different crop factors are shown in table 9. Data were nearly complete for 154 nonirrigated and 46 irrigated experiments. The test weights were not recorded on all samples and the protein was not determined in the earlier years of the experiments. In the statistical computations of the experiments under irrigation the test weight and the crude-protein content were omitted and the crop factors were not correlated with precipitation. The values for crude protein in the meal were available for correlation studies from only 61 experiments on nonirrigated stations and, of these, test weights were lacking in 11. Test weights from 135 nonirrigated trials were used for correlation computations with all factors other than crude protein in meal.

The statistical computations included correlation coefficients and, in a few cases, regression equations together with the standard error of estimate of the dependent variable.

The following standard methods of statistical calculations were used:

$$\text{Standard deviation} = \sqrt{\frac{\Sigma X^2 - nM_x^2}{n-1}}$$

$$\text{Correlation coefficient} = \frac{\Sigma(XY) - nM_xM_y}{\sqrt{(\Sigma X^2 - nM_x^2)(\Sigma Y^2 - nM_y^2)}}$$

$$\text{Standard error of estimate} = \sqrt{\frac{\Sigma Y^2 - nM_y^2}{n-2}(1-r_{xy}^2)}$$

In practice the regression equations were calculated by the method of least squares, and the correlation coefficients were then calculated as the square root of the product of the regression coefficients. This method is algebraically equivalent to the formula given above. The significance of the values of the correlation coefficients was determined from a table given by Wallace and Snedecor (*22*).

The range, mean, and standard deviation of each of the climatic and crop factors were calculated, but not all are given in detail. The average daily range of temperature in July for all stations was approximately 26° F. The summation of July daily temperatures in excess of 90° was a highly variable characteristic, ranging from 0 to 444, with a mean of 52.6 and a standard deviation of 62.9. The crop-year precipitation also showed a wide range. For 154 crop years at the nonirrigated stations it varied from 8.9 to 56.1 inches and averaged 23.3 inches with a standard deviation of ±11.3. Proportionally, the June and July precipitations were as variable.

Among the 5 crop factors considered (table 16), the test weight per bushel and the oil content of the seed showed the least variability in terms of the mean values. The variability in weight per 1,000 seeds and the iodine number of the oil were greater for the Bison and Rio varieties than for Linota and Redwing. The iodine number of Bison and Rio appeared to be lowered more by adverse climatic conditions than did that of the other 2 varieties. The greatest variability occurred in yield per acre and in iodine number of the oil.

TABLE 16.—*Correlation between weather and crop factors in 4 varieties of flax*

Weather or crop factor	Correlation coefficients for paired factors indicated, in variety—							
	Acre yield (in bushels) of—				Weight per 1,000 seeds (grams) of—			
	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio
Nonirrigated stations (154 tests)								
Precipitation (inches):								
Crop year	+0.24**	+0.25**	+0.23**	+0.20*	+0.35**	+0.35**	+0.25**	+0.15
June	+.17*	+.17**	+.10	+.15	+.08	+.12	+.17*	+.12
July	+.26**	+.26**	+.21**	+.18	+.29**	+.25**	+.40**	+.30**
June and July	+.28**	+.25**	+.19*	+.20*	+.22**	+.22**	+.34**	+.25**
July temperature (° F.):								
Average maximum	−.40**	−.40**	−.38**	−.40**	−.59**	−.57**	−.49**	−.50**
Average minimum	−.03	−.09	−.09	−.11	−.30**	−.31**	−.18*	−.22**
Average mean	−.30**	−.30**	−.30**	−.31**	−.51**	−.50**	−.40**	−.42**
Average daily range	−.26**	−.28**	−.27**	−.27**	−.29**	−.26**	−.31**	−.27**
Total excess	−.43**	−.42**	−.44**	−.46**	−.59**	−.59**	−.53**	−.50**
Weight per 1,000 seeds (gram)	+.68**	+.67**	+.57**	+.57**				
Test weight (pound)[2]	+.43**	+.50**	+.28**	+.39**	+.43**	+.50**	+.28**	+.39**
Oil content (percent)	+.52**	+.51**	+.11	+.51**	+.85**	+.76**	+.61**	+.70**
Iodine number	+.39**	+.10	+.37**	+.35**	+.65**	+.65**	+.44**	+.49**
Crude protein (percent)[3]	−.15	−.24*	−.14	−.23	−.42**	−.45**	.00	−.17
Irrigated stations (56 tests)								
July temperature (° F.):								
Average maximum	−.18	−.21	−.22	−.06	−.28	−.32*	−.29*	−.12
Average minimum	−.43**	−.47**	−.43**	−.34*	−.31*	−.34*	−.29*	−.05
Average mean	−.33*	−.35*	−.34*	−.21	−.32*	−.36*	−.34*	−.12
Average *daily range*	+.03	+.04	+.03	+.13	−.17	−.17	−.13	−.10
Total excess	−.19	−.22	−.20	−.13	−.43**	−.41**	−.45**	−.43**
All stations (200 tests)								
July temperature.								
Average *maximum*	−.20**	−.19**	−.17*	−.14*	−.43**	−.41**	−.35**	−.36**
Average minimum	−.25**	−.27**	−.20**	−.25**	−.33**	−.35**	−.25**	−.21**
Average mean	−.29**	−.29**	−.28**	−.25**	−.46**	−.46**	−.38**	−.35**
Average daily range	+.05	−.07	−.09	−.09	−.13	−.08	−.11	−.14*
Total excess	−.13	−.13	−.22**	−.22**	−.49**	−.47**	−.44**	−.45**
Weight per 1,000 seeds (gram)	+.69**	+.64**	+.66**	+.54**				
Oil content (percent)	+.49**	+.54**	+.52**	+.49**	+.70**	+.76**	+.60**	+.68**
Iodine number	+.44**	+.37**	+.36**	+.35**	+.63**	+.62**	+.41**	+.48**

See footnotes at end of table.

TABLE 16.—*Correlation between weather and crop factors in 4 varieties of flax*—Continued

Weather or crop factor	Correlation coefficients for paired factors indicated, in variety [1]							
	Oil content of seed (percent)				Iodine number of oil (Wijs method)			
	Linota	Redwing	Bison	Rio	Linota	Redwing	Bison	Rio
Nonirrigated stations (154 tests)								
Precipitation (inches):								
Crop year	+0.40**	+0.37**	+0.26**	+0.22**	+0.23**	+0.25**	+0.15	+0.16*
June	+.01	+.05	+.01	+.04	−.07	−.13	−.12	−.11
July	+.09	+.06	+.08	+.13	.00	−.02	−.07	+.02
June and July	+.20*	+.08	+.05	+.10	−.04	−.10	−.12	+.00
July temperature (°F.):								
Average maximum	−.63**	−.58**	−.58**	−.51**	−.60**	−.66**	−.68**	−.61**
Average minimum	−.41**	−.41**	−.63**	−.41**	−.54**	−.50**	−.62**	−.57**
Average mean	−.59**	−.56**	−.58**	−.51**	−.70**	−.66**	−.74**	−.69**
Average daily range	−.22**	−.17*	−.15	−.37**	−.17*	−.17*	−.11	−.08
Total excess	−.63**	−.59**	−.56**	−.55**	−.65**	−.62**	−.65**	−.60**
Test weight (pound)[2]	+.44**	+.44**	+.34**	+.57**	+.35**	+.34**	+.33**	+.43**
Iodine number	+.82**	+.78**	+.75**	+.75**				
Crude protein (percent)[3]	−.49**	−.61**	−.68**	−.26**	−.48**	−.52**	−.47**	−.37**
Irrigated stations (46 tests)								
July temperature (°F.):								
Average maximum	−.08	+.06	−.21	−.07	−.45**	−.25	−.26	−.27
Average minimum	−.25	−.42**	−.38**	−.23	−.69**	−.49**	−.51**	−.35*
Average mean	−.19	−.35*	−.35*	−.22	−.67**	−.46**	−.42**	−.39**
Average daily range	+.03	+.09	−.01	+.12	+.18	+.22	+.15	−.50**
Total excess	−.33*	−.37*	−.43**	−.35*	−.45**	−.27	−.25	−.36*
All stations (200 tests)								
July temperature (°F.):								
Average maximum	−.41**	−.41**	−.41**	−.37**	−.56**	−.51**	−.53**	−.52**
Average minimum	−.38**	−.43**	−.45**	−.39**	−.56**	−.51**	−.60**	−.53**
Average mean	−.47**	−.50**	−.51**	−.47**	−.65**	−.60**	−.66**	−.62**
Average daily range	−.06	+.01	.00	−.02	−.01	−.03	−.01	−.05
Total excess	−.49**	−.47**	−.47**	−.46**	−.55**	−.52**	−.55**	−.53**
Iodine number	+.75**	+.77**	+.72**	+.74**				
	Test weight per bushel (pounds)[2]				Crude protein in meal (percent)[3]			
Nonirrigated stations								
Precipitation (inches):								
Crop year	+0.21*	+0.20*	+0.07	+0.11	−0.43**	−0.08	−0.38**	−0.31*
June	−.02	−.04	−.07	+.09	−.15	−.22	−.11	−.25
July	+.11	+.12	−.03	−.02	+.02	−.08	+.08	−.05
June and July	+.05	+.01	−.09	−.07	−.08	−.18	−.03	−.18
July temperature (°F.):								
Average maximum	−.23**	−.24**	−.16	−.25**	+.51**	+.56**	+.44**	+.14
Average minimum	+.01	−.06	−.09	−.14	+.34**	+.34**	+.31*	+.28*
Average mean	−.13	−.16	−.16	−.23**	+.50**	+.53**	+.44**	+.41**
Average daily range	−.23**	−.22*	−.06	−.10	+.22	+.29*	+.18	+.15
Total excess	−.27**	−.28**	−.27**	−.30**	+.33**	+.41**	+.26*	+.27*
Crude protein (percent)[4]	.04	−.09	−.04	−.07				

[1] *=significant; ** = highly significant. [2] 135 tests. [3] 61 tests. [4] 50 tests.

In the nonirrigated tests, the crop-year precipitation was positively correlated (in most cases significantly) with acre yield of seed, test weight per bushel, weight per 1,000 seeds, oil content of seed, and iodine number of oil and was negatively correlated with crude-protein content of the meal. The correlation between crop-year precipitation and iodine number was rather small. July precipitation was positively correlated with acre yield and weight per 1,000 seeds and with the test weight of the Linota and Redwing varieties, but showed no significant correlation with oil content, iodine number, or protein content. June precipitation showed small and, in some cases, significant positive correlations with acre yield and weight per 1,000 seeds and small but not significant negative correlations with iodine number and protein content. June precipitation was not correlated with test weight or oil content.

High July temperatures in the nonirrigated tests tended to be negatively correlated with acre yield, test weight, weight per 1,000 seeds, oil content, and iodine number, but were positively correlated with the protein content of the meal. The lowest correlations with July temperature were with test weight and acre yield. Among the different measures of July temperature, average maximum, average mean, and total excess above 90° F., in general, gave correlation coefficients of similar magnitude. Excess temperature showed highly significant negative correlations with yield in the nonirrigated tests and small nonsignificant correlations in the irrigated tests. The average minimum temperature was correlated with acre yield in the irrigated tests but not in the nonirrigated tests, and the correlation of minimum temperature with the other crop factors was less than that for the other temperature measures just mentioned. Average minimum temperature was not correlated with test weight. All of the correlation coefficients between the average daily range in July temperature and the various crop factors were small, but in some cases they were significant.

The correlation coefficient involving the crop factors of acre yield, test weight, seed weight, oil content, and iodine number were all positive and, with a few exceptions, were highly significant. This shows that these factors are closely interrelated and that weather conditions favorable for a high yield of flaxseed result in the development of plump seeds containing a high percentage of oil of high iodine number. Within each variety the highest correlations were between oil content and either iodine number or weight per 1,000 seeds. The relation between acre yield and seed size is shown graphically in figure 6.

The size and plumpness of the seed is considered by flaxseed buyers as an indication of the oil content. The data show a close relationship between seed size and oil content with correlation coefficients of +0.64 to +0.85. These correlations are sufficiently high to warrant the consideration of seed size and plumpness in judging the value of different samples of flaxseed of a known variety. The graphic illustration of this relationship (fig. 7), however, shows that the figures are too variable to be used for accurate prediction purposes. The correlation coefficients for oil content and iodine number in a given variety ranged from +0.74 to +0.82. This relationship is shown graphically in figure 8. Within a variety there is a definite general relation between oil content and iodine number, but this is subject to considerable variability, as is evident from the graph. Among the four varieties, the relation between oil content and iodine number is strikingly different. Thus, in Linota seed with an oil content of 35 percent, the oil might reasonably be expected to have an iodine number of approximately 187 on the average, whereas in Bison seed of 35 percent oil content the iodine number would be only about 165. Consequently, as between these two varieties, grown under the same conditions, the iodine number tends to be negatively associated with oil content and seed size.

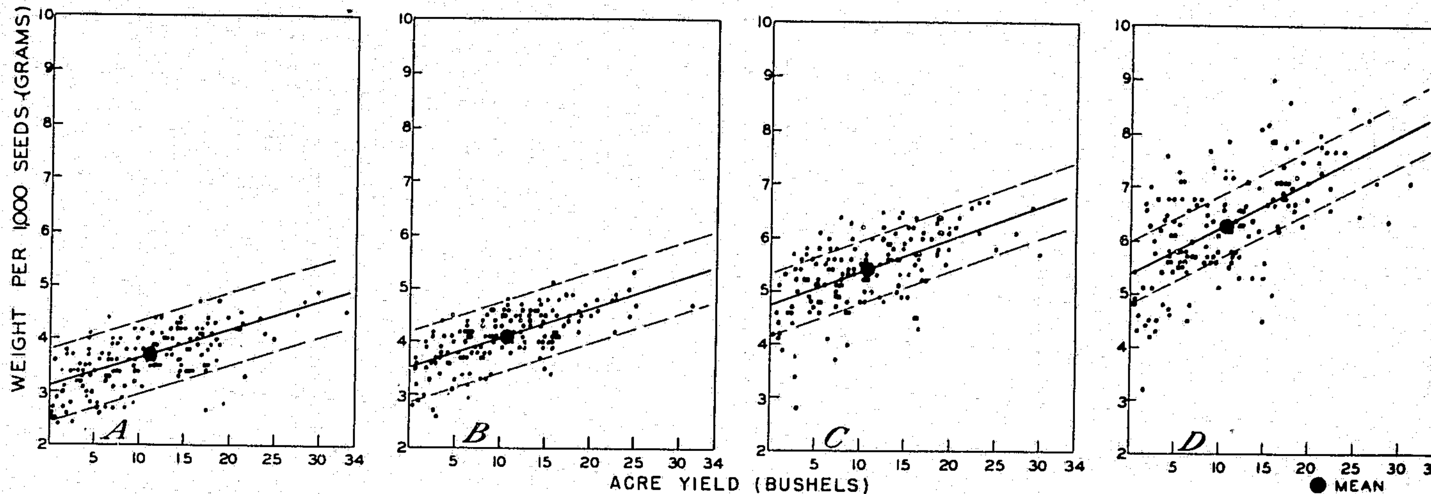

FIGURE 6.—Relation between acre yield of flaxseed and weight per 1,000 seeds of *A*, Linota; *B*, Redwing; *C*, Bison; *D*, Rio.

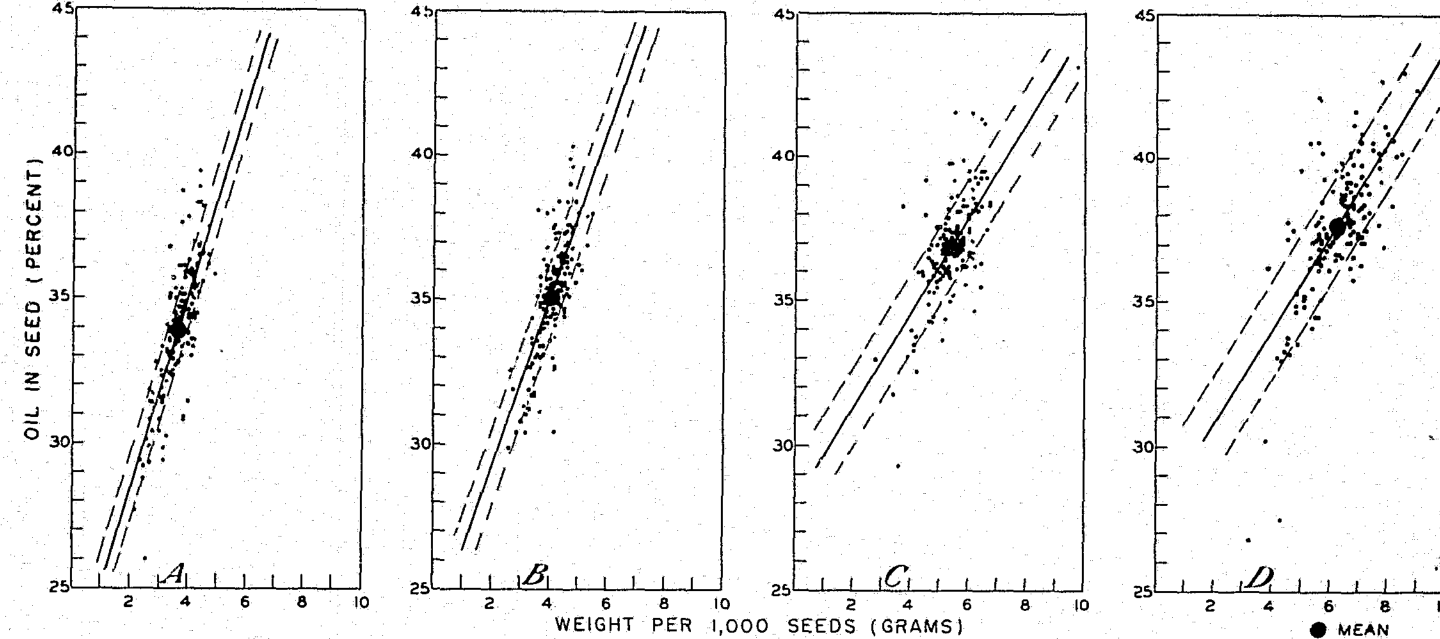

FIGURE 7.—Relation between weight per 1,000 seeds and oil content of flaxseed of four varieties of flax: *A*, Linota; *B*, Redwing; *C*, Bison; *D*, Rio.

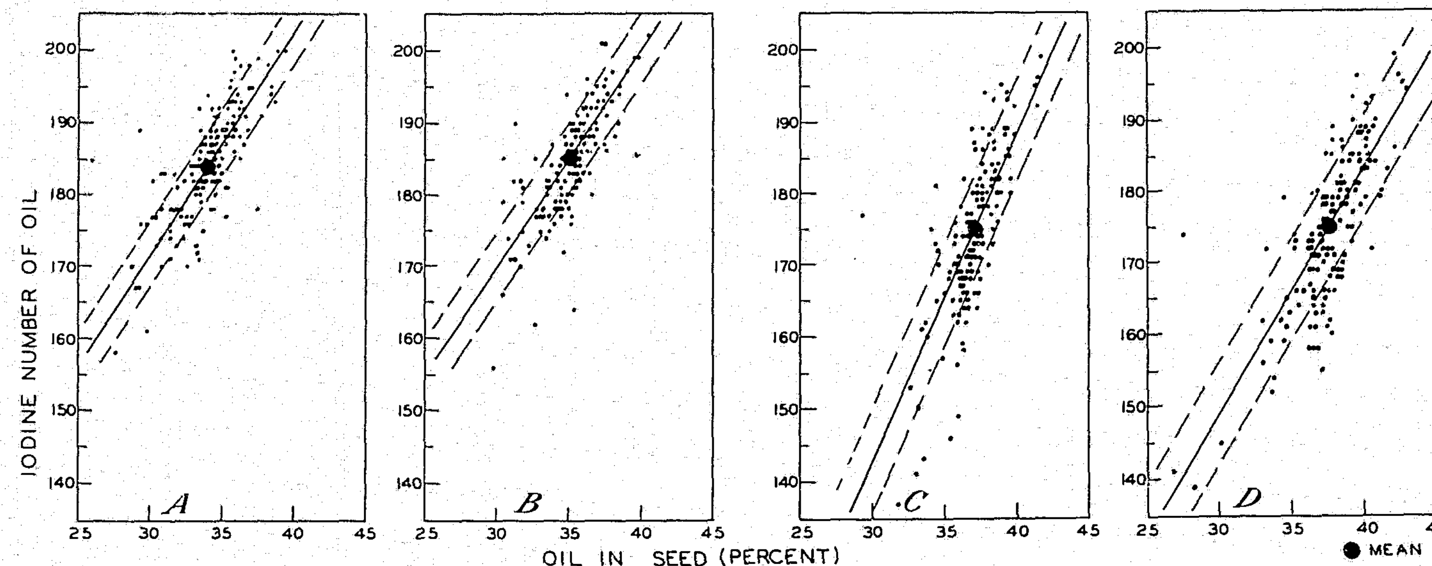

FIGURE 8.—Relation between the oil content of flaxseed and the iodine number of the oil in four varieties of flax: *A*, Linota; *B*, Redwing; *C*, Bison; *D*, Rio.

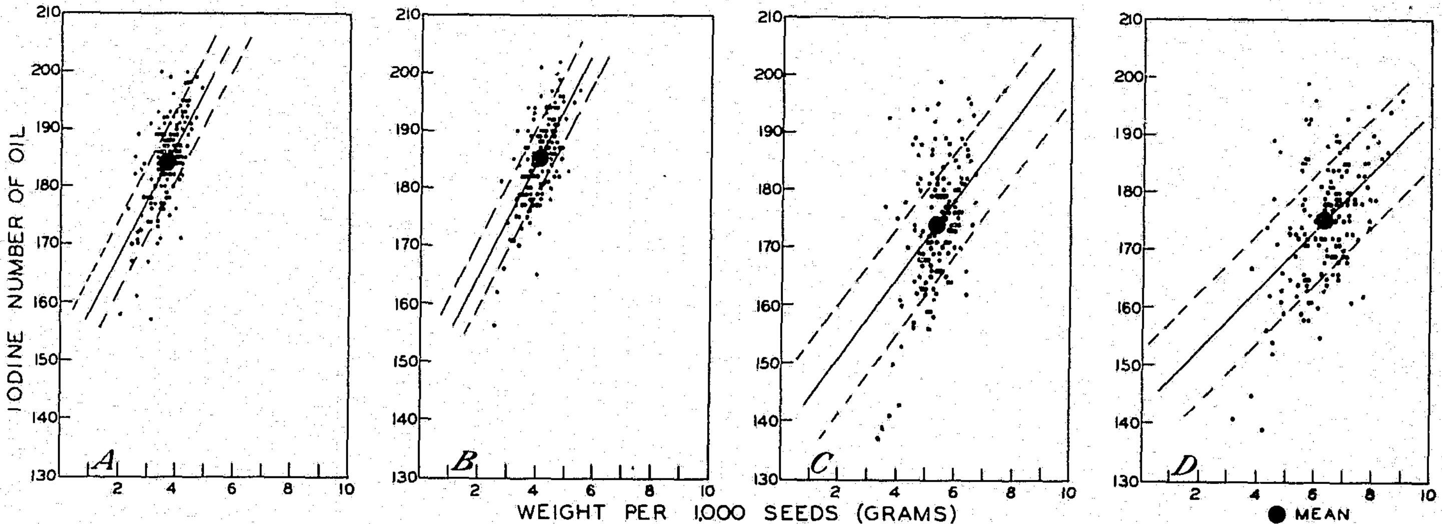

FIGURE 9.—Relation between the weight per 1,000 seeds and the iodine number of the oil in four varieties of flax: *A*, Linota; *B*, Red wing; *C*, Bison; *D*, Rio.

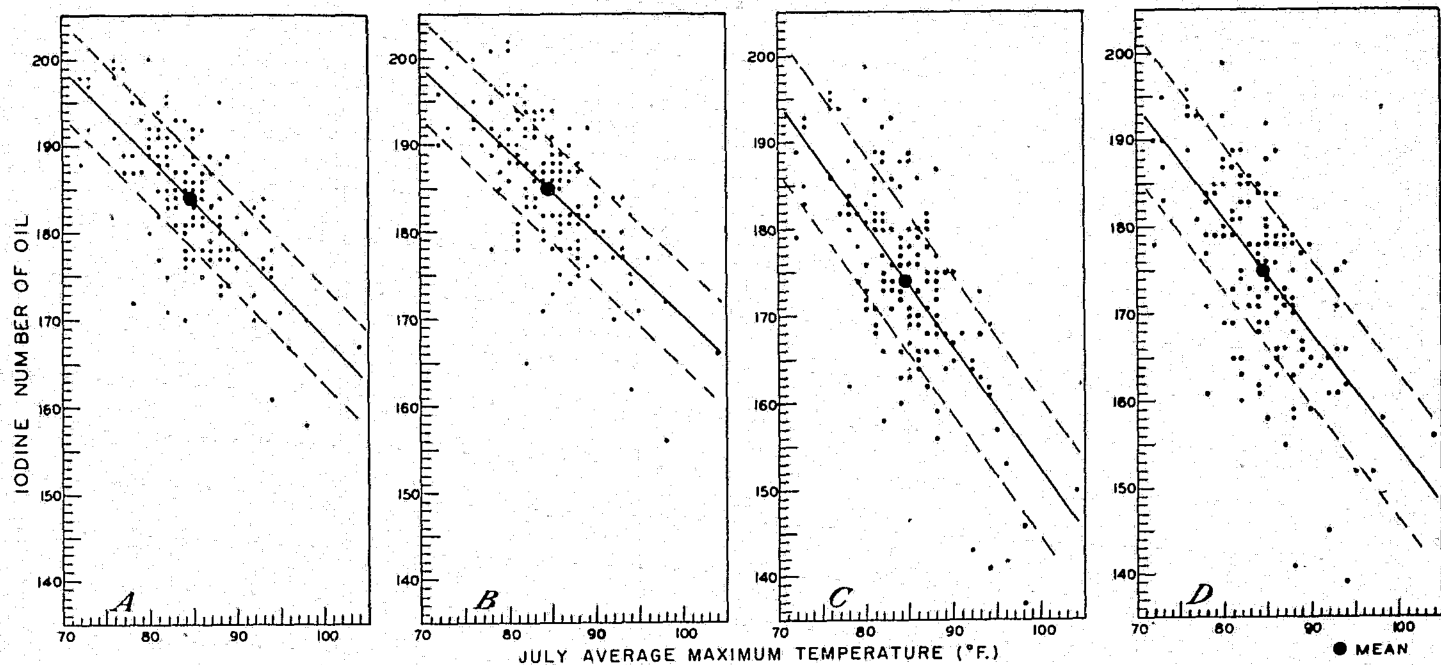

FIGURE 10.—Relation between the average maximum temperature for July and the iodine number of the oil of four varieties of flax: *A*, Linota; *B*, Redwing; *C*, Bison; *D*, Rio.

The correlation coefficients involving iodine number and weight per 1,000 seeds ranged from +0.44 in Bison to +0.65 in Linota and Redwing (fig. 9).

The crude-protein content of the meal in most cases is negatively correlated with acre yield, weight per 1,000 seeds, oil content, and iodine number, but shows little or no association with test weight.

In general, the relationships between weather and crop factors were similar for all four varieties. However, in the large-seeded varieties, Bison and Rio, the correlation between weight per 1,000 seeds and either acre yield, test weight, oil content, iodine number, or protein content was less than in the small-seeded Linota and Redwing varieties. The iodine number of the oil from Bison and Rio was more variable than that from Linota and Redwing and, since differences in iodine number are associated with temperature, it appears (fig. 10) that the iodine number of Bison and Rio oil is more responsive to temperature differences than that from Linota and Redwing.

LONG-TIME RECORDS AT FARGO, N. DAK.

The seasonal variability in weather at a given location and its effect upon flax is well demonstrated by the record at Fargo, N. Dak., for the 22-year period, 1917–1938. During this time the Agronomy Department of the North Dakota Agricultural Experiment Station conducted flax varietal trials, which were continuous for the variety N. D. R. 114[3] and included Linota, Redwing, Bison, and Rio for shorter periods (table 17).

During this period the precipitation for the crop year ending August 31 varied from 10.1 to 26.0 inches, being above the long-time normal of 23.4 inches only in 1927 and 1928. Precipitation during the growing season (April to August, inclusive) varied from 3.8 to 18.5 inches and the July precipitation from 0.4 to 7.2 inches. The driest year on record at the station was 1936. Approximately 75 percent of the annual precipitation occurs during the 6 months, April to September, inclusive, and crop production is largely dependent on the amount and distribution of precipitation during this period.

The yearly variation in July temperature during the 22-year period ranged from 66.0° to 80.2° F. for the mean, 76.3° to 94.0° for the mean maximum, and 54.9° to 66.4° for the mean minimum. The total daily excess temperature above 90° for July varied from 0° to 198°.

[3] North Dakota Resistant No. 114, formerly an important commercial variety developed by H. L. Bolley, North Dakota Agricultural Experiment Station, and first distributed about 1912.

TABLE 17.—*Acre yields and other characteristics of certain flax varieties*

Character and variety	1917	1918	1919	1920	1921	1922	1923	1924	1925
Yield per acre in bushels:									
N. D. R. 114	16.8	21.2	18.9	15.9	7.7	15.4	11.6	14.2	12.4
Linota					12.0	25.6	19.3	20.4	14.6
Redwing									13.1
Bison									
Rio								20.4	17.0
Average					9.9	20.5	15.5	18.3	14.3
Date of full bloom:									
N. D. R. 114	July 3	June 30	June 27	June 25	June 22	June 24	June 26	July 13	July 3
Linota					June 23	do	do	do	do
Redwing									do
Bison									
Rio								July 10	June 27
Average	July 3	June 30	June 27	June 25	June 22	June 24	June 26	July 11	July 2
Days seeding to ripening (number):									
N. D. R. 114	90	101	78	89	81	92	84	90	103
Linota					79	97	88	95	104
Redwing									103
Bison									
Rio								100	122
Average					80	95	86	95	108
Days full bloom to ripening (number):									
N. D. R. 114	34	43	36	38	37	42	34	36	43
Linota					34	47	38	41	44
Redwing									43
Bison									
Rio									47
Average					36	45	36	39	44
Weight per 1,000 seeds (gm.):									
N. D. R. 114	3.7	4.3	3.9			4.2	3.7	3.8	4.2
Linota						4.6	4.0	4.0	4.4
Redwing									4.6
Bison									
Rio									8.4
Average									5.4
Oil content of seed (percent, calculated on a basis of 8 percent moisture in the seed):									
N. D. R. 114	32.8	33.5	33.5			34.0	32.9	34.2	34.7
Linota						33.8	33.1	33.5	35.2
Redwing									35.4
Bison									
Rio									40.1
Average									36.4
Iodine number of oil (Wijs):									
N. D. R. 114	177	184	185			185	181	182	190
Linota						183	181	184	190
Redwing									190
Bison									
Rio									187
Average									192
Precipitation (inches):									
Crop year (Sept. 1 to Aug. 31)	11.52	18.71	22.86	20.24	21.65	19.61	20.49	16.87	21.78
Apr. 1 to Aug. 31	5.38	14.72	16.96	13.52	12.77	11.11	15.03	13.40	14.19
July	.81	2.68	5.66	2.92	3.08	1.65	2.34	1.25	4.35
Temperatures in July (°F.):									
Mean maximum	85.7	80.0	84.2	81.0	81.2	78.3	82.9	78.3	80.4
Mean mean	72.5	67.7	71.0	68.9	70.4	67.3	72.5	66.6	68.2
Mean minimum	59.3	55.4	59.8	56.9	59.7	56.3	62.1	54.9	56.1
Total excess above 90°	55	13	24	0	25	2	9	0	21

compared with weather conditions at Fargo, N. Dak., during the period 1917–38

1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938
17.7	13.3	17.0	15.1	13.0	17.7	15.4	14.9	13.6	16.6	1.4	13.0	16.9
22.8	18.3	21.3	17.5	13.4	18.9	17.1	17.8	15.1	19.4	1.3	17.2	20.7
19.5	12.4	21.1	15.8	12.0	18.7	16.5	15.0	14.9	17.0	1.5	15.4	19.0
25.1	17.0	20.6	16.0	16.9	20.5	16.7	18.8	15.3	19.5	.8	17.2	19.8
25.6	20.6	20.7	19.9	17.1	17.5	16.5	18.0	13.5	22.1	.1	19.1	23.8
22.1	16.3	20.1	16.9	14.7	18.7	16.4	16.9	14.5	18.9	1.0	16.6	20.0
July 3	July 16	July 2	July 5	July 4	June 25	June 26	June 22	June 30	July 7	June 28	July 3	July 2
July 4	July 18	July 3	July 6	do.	do.	do.	June 23	do.	do.	June 27	do.	July 3
July 2	July 15	July 2	July 4	July 3	June 24	June 24	June 21	June 20	July 6	do.	July 2	July 1
July 6	July 18	July 4	July 7	July 6	June 27	June 27	June 24	June 30	July 8	June 30	July 4	July 3
July 7	July 19	July 6	June 28	July 4	June 21	June 28	June 20	July 3	July 7	July 2	do.	June 28
July 4	July 17	July 3	July 4	July 4	June 24	June 26	June 22	June 30	July 7	June 29	July 3	July 1
92	92	101	92	88	94	82	97	84	84	82	87	87
95	93	104	94	86	94	83	97	85	86	82	92	88
93	92	101	92	86	93	80	95	83	84	82	87	86
98	97	107	97	87	94	83	97	85	86	84	92	88
112	103	102	95	92	98	87	99	89	90	90	92	89
98	95	103	94	88	95	83	97	85	86	84	90	88
38	47	48	39	43	40	32	49	31	32	31	36	35
40	46	50	40	41	40	33	48	32	34	32	41	35
40	48	48	40	42	40	32	48	31	33	32	37	35
41	50	52	42	40	38	32	47	32	33	31	40	35
54	55	45	49	47	48	35	53	33	38	35	40	41
43	49	49	42	43	41	33	49	32	34	32	39	36
3.8	4.2	4.2	3.5	3.7	3.9	3.7	4.0	3.5	3.7	2.3	3.5	4.1
3.7	4.3	4.4	3.5	3.7	3.9	3.5	4.1	3.3	3.8	2.2	3.4	4.2
4.2	4.7	4.7	4.0	4.0	4.2	4.1	4.5	3.8	4.3	2.6	4.0	4.5
6.1	6.4	6.7	5.5	5.2	6.2	5.4	6.1	5.2	5.5	3.0	5.2	6.4
7.5	7.0	7.4	7.1	6.7	7.1	6.2	7.0	5.7	6.6	------	6.3	7.7
5.1	5.5	5.5	4.7	4.7	5.1	4.6	5.1	4.3	4.8	2.5	4.5	5.4
35.1	34.8	33.5	34.2	33.8	31.6	33.6	34.5	33.8	35.1	27.1	34.9	36.8
33.3	33.9	34.1	32.8	33.7	30.8	32.5	33.6	32.8	34.1	25.5	33.9	35.9
34.4	35.0	35.5	34.0	34.7	32.5	35.1	34.7	34.0	35.3	26.8	35.1	37.3
35.6	37.4	38.0	37.1	36.5	34.7	35.8	36.5	35.9	37.0	28.1	37.2	39.2
36.5	38.4	39.2	38.3	37.8	36.3	37.1	37.3	35.4	38.0	------	37.6	39.7
35.0	35.9	36.1	35.3	35.3	33.2	34.8	35.3	34.4	35.9	26.9	35.8	37.8
183	185	187	179	183	181	177	188	178	181	148	186	193
185	190	188	177	183	183	177	187	178	178	145	185	194
184	193	188	179	182	185	177	188	179	181	147	186	192
175	182	179	166	171	170	162	176	161	166	134	178	184
177	192	182	168	172	173	155	170	158	166	------	177	185
181	188	185	174	178	178	170	182	171	174	142	182	190
16.08	25.55	20.03	11.98	17.64	17.07	16.50	15.33	14.20	19.85	10.06	18.81	15.76
8.85	13.47	18.55	5.11	8.94	12.24	9.11	8.91	8.70	14.00	3.82	14.22	11.20
2.02	1.01	7.17	.94	.48	5.19	1.36	1.44	.80	2.13	.42	2.68	1.98
82.2	76.3	79.3	84.1	88.6	84.6	84.7	86.1	85.3	80.8	94.0	83.5	82.7
70.2	66.0	69.3	71.5	73.6	72.5	72.1	73.7	72.5	75.6	80.2	72.1	71.2
58.1	55.8	59.3	58.9	60.6	60.4	59.5	61.3	59.7	64.4	66.4	60.7	59.6
19	0	0	41	57	64	56	49	42	28	198	30	15

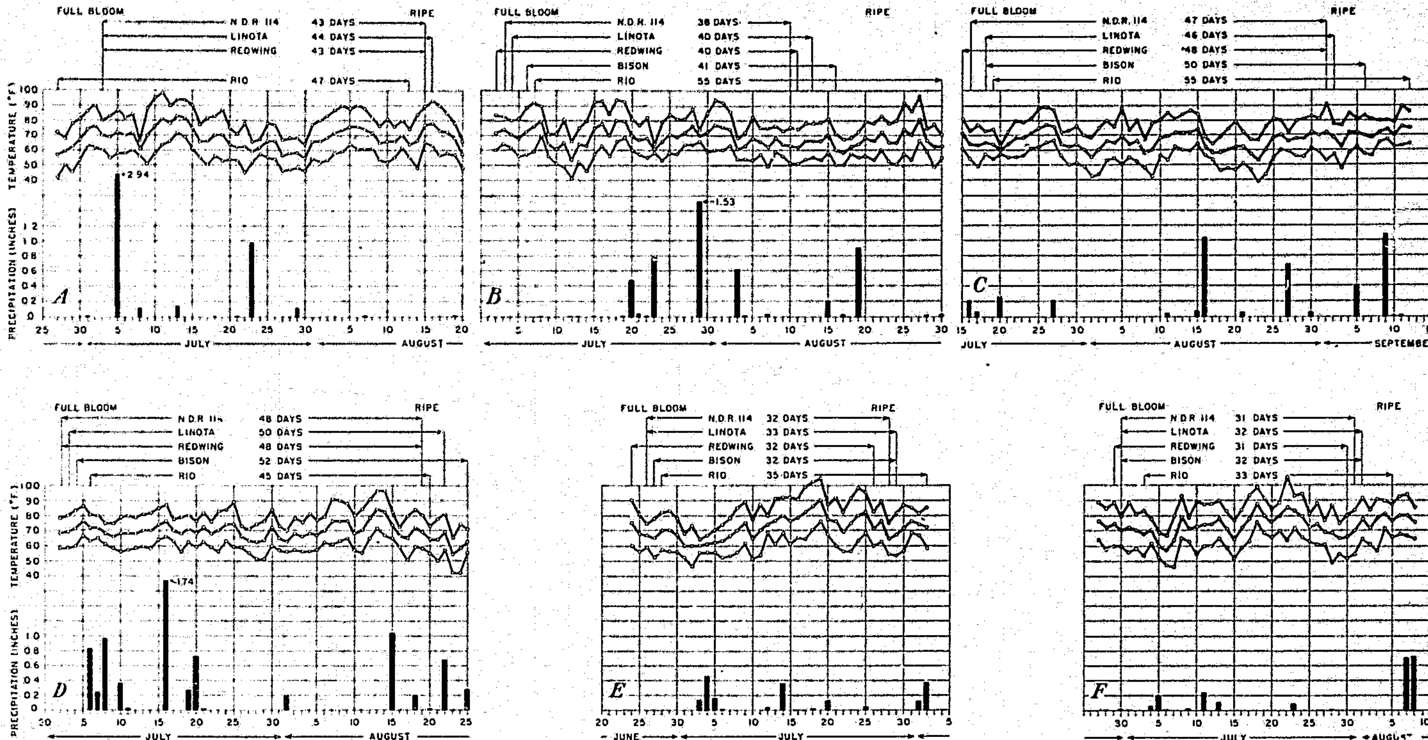

Figure 11.—Daily temperature and precipitation records during the period from full bloom to ripening of flax varieties in six distinctive seasons at Fargo, N. Dak.: *A*, 1925; *B*, 1926; *C*, 1927; *D*, 1928; *E*, 1932; *F*, 1934.

The varietal experiments were conducted during the entire period under the supervision of T. E. Stoa, to whom the authors are indebted for the agronomic data reported in table 17. As the field-plot experiments were conducted under exceptionally uniform soil conditions, variations in length of the vegetative and fruiting periods, yield of seed, and quality of oil can be attributed largely to variations in weather.

The yields of N. D. R. 114 varied from 1.4 to 21.2 bushels an acre. The date of full bloom varied from June 22 to July 16. The number of days from seeding to ripening varied from 82 to 103, and the period from full bloom to ripening from 31 to 49 days. The variations in the length of the vegetative period are undoubtedly influenced by soil moisture supply as well as by date of seeding and consequent differences in photoperiod and temperature.

The ranges in seed characteristics in N. D. R. 114 were from 2.3 to 4.3 gm. in weight per 1,000 seeds, from 27.1 to 36.8 in percentage of oil in seed, and from 148 to 196 in iodine number of oil.

Similar variations occurred in the other four varieties. In general, deficient precipitation and high temperatures reduced the yield, shortened the vegetative and fruiting periods, and lowered the weight of the seeds, the oil content of seed, and the iodine number of the oil.

The daily maximum, mean, and minimum temperatures and the daily precipitation for the period from full bloom to ripening of the five varieties during certain distinctive seasons at Fargo are shown in figure 11. The average iodine numbers of the oils in 1925 and 1927 were 192 and 188, respectively. There was ample precipitation during both seasons. During the bloom-to-ripe period of growth there were no temperatures above 100° F. There was a 6-day period with maximum temperatures of 90° or above soon after blooming in 1925, which followed heavy precipitation. In 1925, when the highest iodine numbers were observed, the maximum temperatures were below 80° during the latter part of the period of most rapid oil formation. In 1927, when the maximum temperatures were somewhat higher in this latter period, the iodine numbers were somewhat lower.

The highest average yield of the 5 varieties at Fargo was in 1926 (table 17) and the next highest in 1928. The average iodine numbers of the oils in these 2 years were 181 and 185, respectively, which are somewhat lower than the averages for 1925 and 1927. There were 6 days during the period of most rapid oil formation with maximum temperatures above 90° F. in 1926, but none in 1928.

The seasons of 1932 and 1934 were deficient in moisture, and the average iodine number of the oils was 170 and 171, respectively. During July, precipitation was low and temperature high in both years. Maximum temperatures above 100° F. were reached in both seasons during the latter part of the period of oil formation, 20 to 25 days after flowering.

FATTY ACID ANALYSIS OF LINSEED OIL

The iodine number may give only a relative indication of the drying quality of an oil, as it is only a measure of total unsaturation. Linseed oil consists of glycerides of saturated acids, together with the unsaturated acids, oleic, linoleic, and linolenic. Oleic will absorb two, linoleic four, and linolenic six iodine atoms per molecule of fatty acid.

The iodine number of a sample of oil does not indicate in what proportions these unsaturated fatty acids occur. Two oils having the same iodine number may have different proportions of fatty acids [4] and for that reason may have quite different drying properties.

For these reasons the oils from the seed of a series of plot tests of the seasons of 1929, 1930, and 1931 were analyzed for the estimation of the constituent fatty acids. The flaxseed was grown under a wide range of climatic conditions in different places in the United States and Canada.

For the estimation of the constituent fatty acids the Wijs iodine numbers, the Kaufmann thiocyanogen numbers, and the percentages of saturated acids were determined for the cold-pressed oils from the samples of flaxseed. The Twitchell lead-salt-alcohol method was used for the determination of the saturated acids. This procedure is now known to give slightly low values. In making the calculations for the data presented in this bulletin, the saturated acids were assumed to be of equal parts of palmitic and stearic acids. The unsaponifiable matter in the oil was not determined, but was arbitrarily taken as 1 percent in all samples. Recent investigations have shown that the use of theoretical thiocyanogen values, as proposed by Kaufmann for the fatty acids, lead to serious errors in calculating the percentages of fatty acids in oils. Riemenschneider, Swift, and Sando (*19*) have summarized the results reported by recent investigators and suggest that, when 0.1N thiocyanogen solutions are used, thiocyanogen values of 89.4 for oleic acid, 93.9 for linoleic acid, and 162.0 for linolenic acid be tentatively used. These values were used in the present calculations. Somewhat higher values were suggested (*19*) when 0.2N thiocyanogen solutions are used. In reporting the results, the percentages of the individual acids are expressed as triglycerides in the oils. It is recognized that there has been considerable study of and improvement in the methods of determining thiocyanogen values and saturated acids since the present results (1929–31) were obtained.

A considerable number of analyses of linseed oil for the percentages of the several fatty acids based on the use of theoretical thiocyanogen values are reported in the literature. These analyses show considerable variation in the percentages of each fatty acid. However, the authors have not found any references to the effects of variety and weather on the percentage of the several fatty acids except those that might be inferred from the variations and causes of variation in iodine number of the oil.

The percentages of the different acids were calculated in the oil of 4 standard varieties grown in a total of 40 crop-year tests at 19 widely scattered stations. The oil content of the seed, and the acid, iodine, and thiocyanogen numbers of the oils are given in table 18. The percentages of the individual acids expressed as triglycerides in the

[4] This is shown in a recent article by ROSE, W. G., and JAMIESON, G. S. THE COMPOSITION OF SEVEN AMERICAN LINSEED OILS. Oil and Soap 18: 173. 1941.

oils are given in table 19. The high acid number of the oils from seed grown at El Centro, Calif., in 1930 are due to exposure to damp conditions in the field after maturity and before threshing. The iodine number among all the different samples varied from 156.5 to 197.5, and the thiocyanogen number varied from 97.4 to 123.7. Wide variations in the calculated percentages of the individual fatty acids were found. The saturated acids varied from 3.3 to 12.1 percent, oleic acid from 9.4 to 37.3 percent, linoleic acid from 2.3 to 39.6 percent, and linolenic acid from 30.5 to 58.7 percent.

The average composition of the 140 samples analyzed was 7.8 percent saturated acids, 23.2 percent oleic, 19.9 percent linoleic, and 48.1 percent linolenic acids as triglycerides. Apparently some abnormal oils were produced in the trials. These same samples of seed were used in the general study of the effect of climate, the climatic conditions during the growth period being given in tables 10 to 15, inclusive.

As the climatic data tabulated gives average temperatures, it does not indicate the magnitude and duration of extremes in temperature that might influence the nature of the oil laid down in the seed. It is probable that the time of occurrence of high temperatures during the seed-forming period is of great importance in influencing the quality of the oil, or there may be a critical stage in the early ripening period when excessive temperatures are most detrimental. This is indicated by the variations in the reaction of the four varieties as shown by the percentages of the several acids. All four varieties differ somewhat in vegetative characteristics. Linota and Redwing are early varieties; Bison is midseason in maturity and has remarkable vegetative vigor; and Rio is normally a late variety having a long period of flowering.

Oil composition appears to be related somewhat to variety. The oils of Bison and Rio averaged 175 in iodine number and those of Linota and Redwing 185 (table 9). The average iodine numbers for the oils from the samples of these varieties analyzed for fatty acids were about the same as those cited (table 18). The oils from the seed of the Rio variety averaged distinctly higher in saturated acids than those of the three other varieties. Those from the seed of the Bison variety averaged higher in oleic acid. The average percentage of the linoleic acid for the four varieties varied approximately one unit. The oils from the Bison and Rio varieties averaged about the same in percentage of linolenic acid and were distinctly lower than those of the Linota and Redwing varieties. This varietal relationship was similar to that for iodine number. The differences in the fatty acids of the oils throw some light on the differences in iodine number but does not explain why the varieties react differently.

The analyses were complete for the fatty acids as triglycerides in the oils from the seed of the 4 varieties for 22 crop years at 14 stations (table 19). The correlation coefficients for the relations between the specified temperature factors, the percentages of the individual fatty acids for the 4 varieties, and the averages of the varieties are given in table 20.

TABLE 18.—*Oil content of flaxseed and the acid, iodine, and thiocyanogen numbers of the oils from the seed grown under different climatic conditions and used for fatty acid analysis*

Station and crop year	Oil content (basis, 8 percent moisture)					Acid number					Iodine number (Wijs)					Thiocyanogen number				
	Linota	Redwing	Bison	Rio	Average	Linota	Redwing	Bison	Rio	Average	Linota	Redwing	Bison	Rio	Average	Linota	Redwing	Bison	Rio	Average
Edmonton, Alberta:	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*															
1930	36.0	36.0	38.3	40.7	37.8	1.22	0.99	1.41	1.33	1.24	191.4	192.4	185.7	188.6	189.5	116.8	116.6	114.7	115.4	115.9
1931	35.8	36.9	39.3	40.2	38.0	1.91	1.31	2.73	3.29	2.31	192.0	195.9	191.8	187.1	191.7	123.7	118.6	117.7	115.1	118.8
Saskatoon, Saskatchewan:																				
1930	34.2	35.0	37.2	38.8	36.3	1.11	1.55	.99	.77	1.10	189.8	186.4	172.7	179.9	182.2	114.6	114.3	111.9	113.0	113.4
1931	35.5	36.5	38.3	39.4	37.4	1.24	.85	.80	.69	.90	196.4	197.5	187.8	188.0	192.4	120.2	120.6	118.2	115.0	118.5
Morden, Manitoba:																				
1930	33.3	35.1	37.0	37.1	35.6	4.11	2.33	1.55	1.33	2.33	181.5	183.2	175.6	173.5	178.4	108.7	115.6	113.4	112.9	112.6
1931	32.9	34.1	36.7	37.0	35.2	1.16	1.05	1.05	.90	1.04	183.6	185.1	174.6	173.8	179.3	116.1	116.4	113.0	110.3	114.0
Corvallis, Oreg.:																				
1929			39.8	40.6				.88	.99				191.6	189.7				114.2	113.6	
1930	38.2	36.1	38.2	39.8	38.1	3.59	5.70	7.45	3.43	5.04	194.5	195.6	189.0	189.5	192.2	119.6	119.9	116.6	111.1	116.8
1931		36.3	37.6	39.0			.55	.58	.63			191.7	188.5	188.1			116.3	115.3	114.2	
Union, Oreg.:																				
1930	36.5	37.6	38.6			1.22	1.11	1.22			187.2	190.7	179.9			116.6	116.1	115.5		
1931		37.6	38.9	40.9			.91	.88	1.29			187.1	180.3	184.2			113.3	110.9	113.6	
Bozeman, Mont.:																				
1929	34.8	36.2	39.2	38.1	37.1	1.06	1.36	1.51	2.27	1.55	189.9	190.6	182.5	178.9	185.5	118.7	119.2	116.8	114.3	117.2
1930	34.7	35.8	37.4	38.9	36.7	1.43	1.66	1.55	1.77	1.60	187.1	183.2	174.0	177.9	181.8	114.9	110.4	110.2	109.6	111.3
1931		36.5	38.8	40.0			.81	.74	.86			185.1	178.2	179.6			116.4	113.2	113.5	
Moccasin, Mont.:																				
1929	30.1	32.7	35.7			1.66	2.61	2.01			181.9	178.1	173.6			110.4	109.7	113.6		
1930	34.2	35.9	37.2	38.4	36.4	1.22	1.11	1.22	1.22	1.19	186.8	188.3	173.7	178.0	183.0	117.1	117.3	108.1	105.6	112.0
Dickinson, N. Dak.:																				
1929	32.1	33.4	36.7	37.4	34.9	.99	1.20	1.11	.93	1.06	177.4	174.2	170.3	171.8	173.4	109.9	110.4	107.6	107.7	108.2
1930	31.5	37.4	38.5	39.4	36.7	1.44	1.66	1.77	1.44	1.58	172.4	189.5	181.1	179.4	180.6	108.4	115.3	112.4	105.5	109.9
Mandan, N. Dak.:																				
1929	30.8	31.9	36.8	36.6	34.0	1.26	1.32	1.21	1.32	1.28	174.4	175.4	172.1	170.9	173.2	107.9	111.2	107.1	109.4	108.9
1931	32.1	34.5	36.1	38.1	35.2	1.13	1.45	1.56	1.76	1.48	178.8	179.3	168.4	171.5	174.0	112.5	110.4	104.6	105.2	108.2
Newell, S. Dak.:																				
1929	33.4	34.0	37.1	36.8	35.3	1.32	2.81	1.21	1.22	1.64	188.3	176.1	171.5	168.7	176.2	112.6	113.2	114.2	105.8	111.4
1930	35.7	36.6	37.6	39.7	37.4	1.44	1.38	1.33	.99	1.25	184.3	189.3	180.3	176.5	182.6	116.9	114.6	110.3	107.8	112.4
1931		34.7	36.1	36.3			1.32	1.31	1.66			166.5	162.6	163.4			108.8	103.0	102.0	
Fargo, N. Dak.:																				
1929	33.7	34.1	36.4	37.0	35.5	1.28	1.21	1.65	1.36	1.38	176.9	180.3	167.6	170.0	173.7	113.6	115.2	108.0	108.5	111.3
1930	33.8	34.0	36.2	37.2	35.3	1.44	1.33	1.44	1.55	1.44	180.2	182.5	170.1	169.2	175.5	116.8	113.5	107.6	106.1	111.0
Crookston, Minn.:																				
1929	33.6	35.6		39.1		1.30	.89		.89		183.8	184.9		175.3		114.8	115.8		112.4	
1930		35.0	37.1	39.4			1.41	1.55	1.22			186.6	174.4	181.9			114.2	109.9	113.5	
1931		34.8	35.9	36.0			.86	1.22	.94			180.6	172.7	167.4			109.7	108.1	105.9	

Morris, Minn.:																				
1930	35.2	35.7	37.5	39.1	36.9	2.77	1.44	1.55	1.22	1.74	186.5	182.4	174.3	173.2	179.1	118.0	117.7	114.4	113.6	115.9
1931		36.0	37.5	39.2			1.86	1.33	1.38			189.2	176.4	179.5			113.7	109.0	108.8	
St. Paul, Minn.:																				
1930	33.6	35.4	35.5	37.7	35.6	3.33	1.55	1.22	1.21	1.83	182.2	181.9	165.3	162.5	173.0	112.1	111.6	104.2	103.3	107.8
Moran, Kans.:																				
1930	35.5		37.6	39.8		1.33		1.22	1.77		182.8		180.7	173.5		112.9		112.8	107.2	
1931		35.0	35.8	36.9			.89	1.12	.90			177.1	156.5	157.8			109.9	99.7	97.4	
Fredonia, Kans.:																				
1929	35.0	36.4	37.3	38.0	36.7	1.16	.99	1.77	1.21	1.28	182.8	183.2	171.2	171.1	177.1	113.1	115.7	109.4	107.4	111.4
Wooster, Ohio:																				
1930	32.3	34.3	34.4	34.5	33.9	.99	1.77	.99	1.22	1.24	181.6	183.5	165.2	159.3	172.4	114.9	117.1	116.6	117.0	116.4
San Antonio, Tex.:																				
1929	33.7		36.2	36.7		2.57		4.54	3.18		175.4		166.0	163.0		114.5		108.3	104.5	
1930	33.3		36.1			1.99		2.22			169.1		158.6			116.8		117.4		
1931	35.7		37.4	38.5		.99		1.54	1.30		186.1		176.4	177.5		116.8		113.4	113.0	
El Centro, Calif.:																				
1929	34.4	36.6	36.4	38.8	36.6	.76	.99	.88	1.09	.93	197.3	194.4	181.6	179.1	188.1	118.1	118.1	111.8	110.4	114.6
1930	31.9	33.4	30.3	32.4	32.0	23.10	19.77	22.88	19.33	21.27	181.8	181.6	172.6	168.1	176.0	109.7	112.2	104.3	103.7	107.5
1931		36.0	36.4	39.3			.83	.69	98			193.6	183.0	182.9			114.5	111.7	111.4	
Average[1]	34.0	35.2	36.9	38.0	36.0	[2] 1.62	[2] 1.61	[2] 1.65	[2] 1.40	[2] 1.58	184.9	185.7	175.9	175.3	180.4	114.6	115.2	111.4	109.7	112.7
Highest	38.2	37.6	39.8	40.9	40.9	[2] 4.11	[2] 5.70	[2] 7.45	[2] 3.43	[2] 7.45	197.3	197.5	194.0	189.7	197.5	123.7	120.6	118.2	115.4	123.7
Lowest	30.1	31.9	30.3	32.4	30.1	.76	.55	.58	.63	.55	169.1	166.5	156.5	159.3	159.3	106.4	108.8	99.7	97.4	97.4
Average of all samples	34.0	35.4	37.0	38.2	36.3	[2] 1.61	[2] 1.46	[2] 1.56	[2] 1.39	[2] 1.50	184.0	185.2	175.6	175.5	179.8	114.7	114.5	111.2	109.6	112.3

[1] Average for 24 stations growing all 4 varieties.
[2] Omitting 1930 samples from El Centro, Calif.

TABLE 19.—*Percentages of saturated, oleic, linoleic, and linolenic acids expressed as triglycerides in oils from flaxseed grown under different climatic conditions*

Station and crop year	Saturated acids					Oleic acid					Linoleic acid					Linolenic acid				
	Linota	Redwing	Bison	Rio	Average	Linota	Redwing	Bison	Rio	Average	Linota	Redwing	Bison	Rio	Average	Linota	Redwing	Bison	Rio	Average
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Edmonton, Alberta:																				
1930	7.5	6.9	7.6	11.2	8.3	17.3	16.1	20.7	16.1	17.6	19.9	23.0	19.3	14.6	19.2	54.3	53.0	51.4	57.1	54.0
1931		5.6	4.9	8.5			15.9	19.9	19.1			23.0	21.9	18.3			51.4	52.3	53.1	
Saskatoon, Saskatchewan:																				
1930	7.4	7.9	8.4	10.2	8.5	15.7	19.0	31.5	23.4	22.4	25.4	21.0	10.2	12.9	17.4	50.6	51.1	48.9	52.5	50.8
1931	5.3	6.4	6.5	8.2	6.6	18.2	16.8	24.7	18.0	19.4	18.9	17.3	12.3	20.3	17.2	56.6	58.5	55.5	52.5	55.8
Morden, Manitoba:																				
1930	8.5	8.2	7.6	10.7	8.8	15.3	24.9	31.0	30.8	25.5	32.2	11.9	10.4	4.0	14.6	43.0	51.0	50.0	53.5	50.1
1931	7.9	7.6	7.6	8.9	8.0	25.4	21.3	31.5	27.2	27.1	11.4	12.8	10.3	16.0	12.6	54.3	51.3	49.6	46.9	51.3
Corvallis, Oreg.:																				
1929			6.0	5.5				9.9	15.3				36.3	31.7				47.8	46.5	
1930	7.1	7.3	7.7	8.5	7.7	18.4	17.4	19.1	9.4	16.1	15.4	15.6	17.7	34.6	20.8	58.1	58.7	54.5	46.5	54.5
1931		6.5	6.6	7.7			16.7	18.9	19.3			23.7	22.7	21.4			52.1	50.8	50.0	
Union, Oreg.:																				
1930	7.6	8.8	6.9			22.0	16.2	20.6			15.0	19.1	10.2			54.4	51.9	52.3		
1931		7.0	7.7	9.4			21.1	21.0	19.5			21.9	24.6	17.6			49.0	45.7	52.5	
Bozeman, Mont.:																				
1929	6.1	6.2	7.1	8.6	7.0	23.2	23.1	28.5	27.8	25.7	14.1	13.2	9.0	10.0	11.6	55.6	56.5	54.4	52.6	54.8
1930	5.3	6.0	7.3	8.4	6.8	20.8	11.5	27.8	21.3	20.4	24.4	30.6	19.3	21.6	27.0	48.5	41.9	44.6	44.7	44.9
1931		7.4	6.9	8.3			21.4	27.9	25.8			13.1	15.6	14.0			51.1	48.6	50.9	
Moccasin, Mont.:																				
1929	6.3	6.8	7.0			19.0	22.2	34.1			30.8	27.3	8.1			42.9	42.7	49.8		
1930	7.9	7.5	8.5	10.9	8.7	23.2	21.9	17.7	12.9	18.9	12.2	14.2	30.5	33.7	22.7	55.7	55.4	42.3	41.5	48.7
Dickinson, N. Dak.:																				
1929	6.3	7.4	8.4	10.1	8.1	18.7	27.8	27.2	24.5	24.6	30.5	18.8	21.2	20.0	24.1	37.5	45.0	42.2	44.4	42.3
1930	8.0	8.6	6.0	10.9	8.4	23.0	16.4	23.5	11.0	18.5	28.7	20.6	23.5	35.9	27.2	39.3	53.4	46.0	41.2	45.0
Mandan, N. Dak.:																				
1929	6.8	7.7	7.6	10.6	8.2	23.7	27.5	24.8	28.2	26.1	28.4	17.2	26.7	12.3	21.2	40.1	46.6	39.9	47.9	43.6
1931	7.5	7.8	8.6	9.9	8.5	25.6	21.2	26.9	20.9	23.1	17.7	21.8	25.8	28.2	24.1	48.2	45.2	37.7	40.0	42.8
Newell, S. Dak.:																				
1929	6.3	7.4	7.6	10.0	7.8	14.8	30.1	37.3	25.2	26.9	31.9	12.0	2.3	22.4	17.2	46.0	49.5	51.8	41.4	47.2
1930	6.2	5.9	7.2	11.5	7.7	27.0	17.2	20.3	18.0	20.6	12.6	27.3	27.5	23.4	22.7	53.2	48.6	44.0	46.1	48.0
1931		8.3	9.2	10.1			34.0	28.6	25.4			12.5	25.0	27.9			44.2	36.2	35.6	
Fargo, N. Dak.:																				
1929	7.7	7.3	8.7	10.6	8.6	29.6	28.3	31.1	27.7	29.2	11.2	11.0	15.9	14.1	13.1	50.5	52.4	43.3	46.6	48.2
1930	6.8	7.5	6.8	11.0	8.0	31.5	22.7	28.5	24.5	26.8	6.4	19.3	23.7	20.4	17.5	54.3	49.5	40.0	43.1	46.7
Crookston, Minn.:																				
1929	6.1	9.6		6.9		24.2	22.3		30.1		19.0	11.2		14.5		49.7	55.9		47.5	
1930		7.1	8.0	9.8			19.1	26.3	22.0			22.9	19.7	14.4			49.9	45.0	52.8	
1931		8.2	8.2	10.1			18.3	25.3	26.9			28.1	23.1	20.2			44.4	42.4	41.8	

Morris, Minn.:																				
1930	5.9	6.2	8.0	6.9	6.8	26.3	30.6	34.0	34.7	31.4	12.2	7.4	4.7	7.7	8.0	54.6	54.8	52.3	49.7	52.9
1931	-----	7.7	7.9	10.1	-----	-----	14.7	22.4	16.9	-----	-----	27.0	25.4	26.5	-----	-----	49.6	43.3	45.5	-----
St. Paul, Minn.:																				
1930	4.4	7.3	7.9	10.0	7.4	22.7	20.4	28.1	28.7	25.0	28.7	25.1	26.8	22.6	25.8	43.2	46.2	36.2	37.7	40.8
Moran, Kans.:																				
1930	7.3		6.9	10.5	-----	21.4	-----	24.1	21.4	-----	21.9	-----	20.2	23.2	-----	48.4	-----	47.8	43.9	-----
1931	-----	7.8	8.6	10.4	-----	-----	23.1	30.9	24.4	-----	-----	23.5	29.0	35.3	-----	-----	44.6	30.5	28.9	-----
Fredonia, Kans.:																				
1929	6.7	7.0	8.1	9.9	7.9	22.2	25.8	29.4	25.0	25.6	22.3	13.8	17.0	20.4	18.4	47.8	52.4	44.5	43.7	47.1
Wooster, Ohio:																				
1930	8.6	7.8	-----	-----	-----	25.4	27.3	-----	-----	-----	11.6	8.1	-----	-----	-----	53.4	55.8	-----	-----	-----
San Antonio, Tex.:																				
1929	7.6	-----	6.8	10.5	-----	33.0	-----	34.8	29.8	-----	6.4	-----	16.1	18.4	-----	52.0	-----	41.3	40.3	-----
1931	6.3	-----	6.3	8.7	-----	24.6	-----	30.8	27.3	-----	15.1	-----	13.6	12.3	-----	53.0	-----	48.3	50.7	-----
El Centro, Calif.:																				
1929	5.1	3.7	3.3	9.1	5.3	13.7	18.1	23.6	20.7	19.0	27.4	26.1	30.8	22.3	26.7	52.8	51.1	41.3	46.9	48.0
1930	6.9	7.1	7.6	12.1	8.4	17.6	21.0	19.5	21.1	20.0	31.9	23.0	36.6	25.0	29.1	42.6	47.0	35.3	40.8	41.4
1921	-----	7.0	7.4	9.5	-----	-----	11.0	19.1	17.5	-----	-----	31.3	26.0	23.3	-----	-----	49.7	46.5	48.7	-----
Averages [1]	6.7	7.0	7.5	9.9	7.8	21.5	22.0	26.7	22.6	23.2	21.4	18.9	19.2	20.2	19.9	49.4	51.1	45.7	46.2	48.1
Highest	8.6	9.6	9.2	12.1	-----	33.0	34.0	37.3	34.7	-----	36.5	39.6	36.6	35.9	-----	58.1	58.7	55.5	57.1	-----
Lowest	4.4	3.7	3.3	5.5	-----	13.7	11.0	9.9	9.4	-----	6.4	7.4	2.3	4.0	-----	37.5	41.9	30.5	28.9	-----
Average all samples	6.8	7.2	7.4	9.6	-----	22.2	21.4	26.1	22.6	-----	20.3	19.7	19.9	20.7	-----	49.7	50.7	45.6	46.1	-----

[1] Average for 22 stations growing all 4 varieties.

TABLE 20.—*Correlation between percentages of fatty acids calculated as triglycerides in the oils and July temperatures for 4 varieties of flaxseed grown in 22 field tests*

July temperature and flax variety	Saturated [1]	Oleic [1]	Linoleic [1]	Linolenic [1]
Average maximum (° F.):				
Linota	−0.080	+0.328	+0.158	−0.475*
Redwing	+.083	+.353	−.031	−.369
Bison	+.085	+.040	−.318	−.490*
Rio	+.288	+.167	+.172	−.570**
Averages	+.071	+.284	+.260	−.581**
Average minimum (° F.):				
Linota	−.142	+.449*	−.144	−.131
Redwing	+.250	+.408	−.200	−.055
Bison	+.304	+.373	−.110	−.105
Rio	+.050	+.403	−.129	−.311
Averages	+.153	+.536**	−.239	−.217
Average mean (° F.):				
Linota	−.047	+.505*	+.026	−.428*
Redwing	+.240	+.528*	−.185	−.355
Bison	+.210	+.273	+.169	−.521*
Rio	+.301	+.399	+.015	−.609**
Averages	+.241	+.556**	+.025	−.587**
Total excess temperature:				
Linota	+.062	+.360	+.168	−.531**
Redwing	+.227	+.192	+.148	−.502*
Bison	+.013	+.120	+.438*	−.537**
Rio	+.479*	−.038	+.227	−.515*
Averages	+.263	+.113	+.381	−.639**

[1] *=significant; **=highly significant.

The coefficients are in no case sufficiently high for safe prediction purposes, but the trend is very significant in relation to the effect of high temperatures during the oil-development period of the growth of the flaxseed.

The coefficients for temperature and percentage of saturated acids are generally positive, but in only one case is the value significant. All but one of the coefficients for temperature and percentage of oleic acid are positive.

The correlations between temperature and percentage of linoleic acid are not significant; some of the correlation coefficients are negative and some are positive.

The effect of temperature on the percentage of linolenic acid was more pronounced. The 20 correlation coefficients computed were all negative: 7 of them were highly significant, and 6 were significant.

These correlation data further emphasize the importance of temperature during the period of oil formation in the plant as a factor determining the iodine number. High temperatures appear to increase the proportion of oleic acid and of the more saturated acids and reduce the proportion of linolenic acid, resulting in an oil of low iodine number.

DISCUSSION

The exact process of oil formation in flaxseed and other oil-bearing seeds and fruits is not well understood. Little is known of the characteristics of the individual lipases that function in the metabolic processes by which fatty acids and glycerides are synthesized in the seed. The kinds and relative proportions of fatty acids in the oils of different seeds are characteristic of each species. However, the relative percentages of the fatty acids may be modified by selection of varieties within a species and by conditions of growth; that is, by climatic or weather conditions.

Sergius Ivanov (*12*) observed that oils containing glycerides of unsaturated acids with one double bond (oleic, erucic, or ricinic acid) are little affected by climatic changes, whereas, in oils having fatty acids with three double bonds (linolenic acid), the iodine numbers decrease with increase of temperature, that is, with growth of the plant in warmer regions; and oils with two double bonds (linoleic type) are intermediate in response to temperature.

Theis, Long, and Beal (*20, p. 770*) found a marked increase in the iodine number of the oil in flaxseed from 10 to 20 days after flowering, when at the same time there was a marked increase in linolenic acid (three double bonds) and a marked decrease in oleic acid (one double bond). In regard to the progressive changes in the fatty acids these authors state:

> When the curves are inspected together, it is observed that as the degree of unsaturation increases the percentages of linoleic and linolenic [acids] increase and those of oleic and stearic decrease. This suggests that as the seeds mature, desaturation proceeds through the stages stearic, oleic, linoleic, to linolenic.

They observed, also, that enzymatic activity of the seeds decreased as the percentage of oil increased, with a marked decrease immediately after the period of rapid oil formation.

The growth of flaxseed from flowering to maturity has been studied by Dillman (*6*), Johnson (*16*), and Lehberg et al. (*17*), who have shown that the deposition of the oil occurs most rapidly from about the fifth to the twenty-fifth day after flowering, although the total oil content continues to increase until the maximum dry weight of the seed is reached at 30 to 35 days. The final ripening process is chiefly a matter of dehydration, or loss of moisture from the seed, the rapidity of drying depending on weather conditions. In hot, dry weather the whole period of growth and ripening of the seed may not exceed 30 days, whereas in cool weather, with adequate soil moisture, the period from first bloom to ripening may extend 50 days or more. If a period of hot, dry weather occurs during the critical period of seed growth and oil formation, it results in the production of shrunken seed of low oil content and a low iodine number of the oil. The data presented here confirm this interpretation.

Ivanov (*14*) suggests that in mild climates, where there is little range in day and night temperatures, the "main product of the oil building process is oleic acid; in the rough northern climate, with sharp changes in the temperature of the day and night, unsaturated acids are created. Such changes * * * produce more linolenic acid." The authors can hardly agree to this interpretation. It seems more likely that high temperatures and partial or severe drought tend to shorten the growth period of the seed and force early ripening, thus limiting the period of oil synthesis and adversely affecting the enzymatic processes by which the more highly unsaturated acids, particularly linolenic acid, are synthesized. At Fairbanks and Matanuska, Alaska; Edmonton, Alberta; Bozeman, Mont.; and Nappan, Nova Scotia, temperatures of 90° F. rarely occur during the growing season, and uniformly high iodine numbers in oils are obtained from flaxseed produced at those stations. The mean maximum temperature for July is 67° at Matanuska, 72° at Fairbanks, 74° at Edmonton and Nappan, and 79° at Bozeman. The average daily range at these stations is relatively narrow, that is, from 18° to 25° in July. The prevailing mean temperature during the critical period of seed growth appears to be a more important factor than daily range of temperature in relation to iodine number of the oil.

On the other hand, in the Great Plains and in the North Central States, where hot, dry seasons were frequent during the period of these experiments, oils of low iodine numbers were produced. In these areas the mean maximum temperatures during July ranged from 80° to 90° F., and daily maximum temperatures exceeding 100° were of frequent occurrence.

Drought appears to have the same effect as high temperatures in reducing the oil content and lowering the iodine number. Indeed, drought and high temperatures are commonly associated, and it is not easy to determine the injurious effect of each separately. The data indicate that, in seasons when the annual precipitation is less than 18 inches and when daily temperatures exceeding 90° F. are frequent, flax production is hazardous both from the standpoint of profitable acre yields and quality of oil.

N. N. Ivanov (*9*) found relatively little variation in the protein content of flaxseed grown under different environments as compared with that of wheat grown under the same conditions. In the present investigations the crude protein ranged from 28.9 to 44.6 percent in the linseed meals of four varieties. A part of this range was due to variety, as the meal of the Bison variety was about 2 percent higher in protein than that of the other three varieties. In general, high protein values were associated with low yields due to deficient precipitation and high temperatures.

SUMMARY

Agronomic and chemical data on 4 varieties of flax—Linota, Redwing, Bison, and Rio—covering a period of 1 to 10 crop seasons at each of 54 field stations in North America are presented. The geographical location of these stations ranged from about 19° to 65° north latitude and from 64° to 149° west longitude. The elevation ranged from 53 feet below sea level to 8,000 feet above sea level. The annual precipitation ranged from 8.9 to 56.1 inches for the crops grown under natural rainfall. The average mean temperatures for July, the critical period of seed and oil formation at the northern stations, ranged from 52° to 88° F., with the mean maximum temperatures ranging up to 104°.

The various factors, the relations of which were studied statistically, were acre yield, test weight per bushel, weight of 1,000 seeds, oil content of seed, iodine number of oil, and crude-protein content of the meal; crop-year and June and July precipitation; the average maximum, minimum, and mean temperatures; the daily range in temperature, and the "excess" temperature during July.

There was no significant difference in the acre yield of the four varieties based on the average yield at all stations. A yield of approximately 11 bushels per acre was indicated for an annual precipitation of 23 inches. Variations in environmental conditions resulted in yields from less than 1 bushel to 20 bushels or more per acre for the crops grown under natural rainfall, and up to 40 bushels or more under irrigation. The acre yield is positively correlated with crop-year precipitation and negatively correlated with July temperatures.

The combination of climatic or weather factors, mainly deficient precipitation and excessive July temperatures, which reduced the yield

per acre, also caused a decrease in seed size, test weight per bushel, oil content of seed, and iodine number of the oil, but an increase in the crude-protein content of the meal. With the exception of crude protein in meal, these factors were positively correlated with crop-year precipitation and negatively correlated with the average maximum, average mean, and July "excess" temperature. July precipitation appeared to influence materially only the acre yield and the seed size. The crude protein in meal was negatively correlated with the crop-year precipitation and positively correlated with July temperatures. As a consequence of these common influences, positive, and in most cases highly significant, correlations were found between acre yield, weight per 1,000 seeds, oil content of seed, iodine number of oil, and test weight per bushel. The crude-protein content of meal was negatively correlated with the other factors, except test weight per bushel, though not so significantly.

The oil content of the large-seeded varieties, Bison and Rio, was 2 or 3 percent higher than that of the small-seeded varieties, Linota and Redwing. The correlation between seed size and oil content, due to environmental conditions, was highly significant for all varieties, the coefficients ranging from +0.64 to +0.85 for each variety. Seed size and plumpness of seed appear to be the best indication of oil content. As an average of all tests, the weight of Linota was 3.8 gm. per 1,000 seeds, Redwing 4.2 gm., Bison 5.5 gm., and Rio 6.3 gm.

In general, the small-seeded varieties yield oils of higher iodine numbers than the large-seeded varieties. As an average of all tests, the iodine number of the oils of Linota and Redwing was 185 and of Bison and Rio, 175. It appeared that the earlier varieties, Redwing and Linota, were less affected by unfavorable weather conditions, especially by high temperatures and drought, than the later varieties, Bison and Rio. However, within each variety there was a positive correlation between seed size and iodine number. The coefficients were 0.65 for Redwing, 0.62 for Linota, 0.49 for Rio, and 0.41 for Bison.

As the three measures of July temperature—the mean, maximum, and total excess above 90° F.—are related measures of excessive temperature, they gave, in general, correlation coefficients of similar magnitude. It is felt that the total excess temperatures above 90° F. during the seed-filling period should reflect most accurately the injurious effect of extremely high temperature on the yield and quality of flaxseed. Excess temperature showed high negative correlations (−0.42 to −0.46) with yield in the experiments conducted under irrigation at Newell, S. Dak., where soil moisture was not a limiting factor.

The 22-year record (1917–1938) of flax tests at Fargo, N. Dak., shows, in general, correlations between the several weather and crop factors similar to those covering all stations. In addition it shows that, over a period of years, climatic factors may vary extremely in a given area.

The correlations between the percentages of the different fatty acids in the oils and July temperatures show that temperatures during the oil-formation period are negatively correlated with linolenic acid and positively correlated with the saturated and oleic acids. The coefficients were small, but they consistently showed the influence of temperature.

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