NORTH DAKOTA AGRICULTURAL COLLEGE

Government Agricultural

Experiment Station

FOR

NORTH DAKOTA

Bulletin No. 71

FLAX CULTURE

By H. L. BOLLEY

Any farmer, teacher or student in the State may have this Bulletin mailed to his address, free of charge, upon application

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FARGO, NORTH DAKOTA, U. S. A.
October, 1906

The European investigations reported upon in this Bulletin were conducted in co-operation with the Bureau of Plant Industry of the U. S. Department of Agriculture.

The Government report has been issued as "Farmer's Bulletin No. 274" and may be had by addressing the Department of Agriculture, Washington, D. C.

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FLAX CULTURE

By HENRY L. BOLLEY

Culture Conditions in the United States: Flax culture in America from its introduction to the present time has been along primitive lines. The farm methods have been crude and unintelligent and the results have been very irregular, such that, at the present time, the crop has no permanent place in the Agriculture of the country. Unlike other farm crops, though often very remunerative, it has never fixed for itself a home in any particular farming community, nor have the farmers made any intelligent effort to have it stay with them as a yearly crop. In each new locality in which it has been introduced, it has, at first, yielded bounteously in seed or fibre, according to type, and with profit to the producer, but later gradually failed until the producer has actually met with loss, when the crop has been dropped for good. No effective effort seems to have been made to improve the strain, get better seed or new varieties. It has been looked upon as a short-lived crop suited only to new lands; and little, if any, attention has ever been given to attempts to improve the race or strain of seed at hand. Any seed which would germinate has been the criterion. No grower has thought it of importance to grow his own seed. For one reason or another each community has given up the culture quite satisfied that the crop is "exhausting" to soil and unremunerative on old lands. Thus the crop has moved westward, from place to place and from state to state, so rapidly that it has been impossible to build up any permanent industry about it. Even the simple machinery of tow mills cannot be moved from place to place with sufficient rapidity to keep pace with such a nomad crop; and, of course, have not been and can not be expected to persist as paying institutions.

The crop has been kept in existence only because of its two very valuable products which are always in demand, oil and fibre. The unstability of the crop has perhaps prevented American mechanical ingenuity from coming to the aid

of the fibre industry and it has about gone to the wall as against the competition of the cheap labor of foreign countries and the cotton industry of our own country. There remains only the knowledge that we once produced good flax fibre in this country, and the present use of the crop in the production of seed for oil purposes. This is hardly to be placed under the heading of flax farming or culture. Scarcely any of the elements of careful farm methods enter the work. The crop is largely used as a reducer of wild lands or as a side issue, a crop to sow after it is too late to hope for success with other of the regular farm crops.

Along with this irregularity and uncertainty as a permanent general crop has come a great secondary evil. Valuable as the seed end of the industry has always been, neither oil mills or seed markets can exist locally. This makes it easy for a few men to gain control of the seed and oil markets. Indeed, it now appears to be practically in the hands of a single firm or trust. This, in itself, is sufficient to greatly injure the development of any crop or farming interest. Market competition is a necessity of development.

Students of special agricultural problems have also given slight attention to this neglected crop. Until late years, scientific investigation has come to the aid of special industries only upon direct demand of the people. The producers of flaxseed have apparently considered the flax crop beyond help and have never demanded any aid. They have always contended that it is "hard" and "exhausting" upon land, and the soil soon becomes "flax-sick" or "flax-tired," that is, takes on a condition in which further successful cropping to flax is impossible. Many contend that it also affects the soil injuriously with reference to the production of other crops. The attitude of one North Dakota farmer well illustrates this point. The writer wished to rent some flax-sick land of him, upon which to conduct some special flax experiments. The owner refused in these words: "The flax business is played out. I do not want to have anything to do with the crop nor do I want my neighbors to see any more of it on my farm. I don't want them to think me a plain fool."

Original Work at the North Dakota Experiment Station: During a number of years study and experiment the Botanical Department of the North Dakota Experiment Sta-

tion has fully established the fact that this firmly grounded general belief or prejudice of farmers against the flax crop is well founded. It is found, however, that the whole trouble is due to parasitism, not to soil exhaustion or to the accumulation of deleterious chemical substances in the soil. The details of these experiments and studies need not be restated at this time. They are recorded in various reports and bulletins* of the North Dakota Experiment Station. It is sufficient to state that flax sick soil is occasioned by the presence of a fungus, *Fusarium lini*, Bolley, which may be introduced to new soil areas by way of the seed flax, and when once in the soil propagates with rapidity. Flax plants are destroyed by it at all ages of growth from seed time to maturiy. About four years cropping to flax suffices to destroy the usefulness of the soil for the growth of the crop, if desease bearing seed is used. The flax crop has also been found to be subject to the attack of other destructive parasitic plants, but this one alone was found to be wide-spread in its distribution and sufficiently destructive to fully account for the disappearance of flax as a general crop in all but a few of the northwestern states.** The common practice of seed exchange and the further fact that no seed varieties of special merit have ever been generally recognized, have, in themselves, been elements sufficiently potent to account for the general distribution of the disease, even though it were not aided by wind, water and other natural agencies.

This, in rough, is the outline of the past and present of flax culture in America. The people seem to be awakening to the fact that a valuable crop and its associated industries is about to slip from their control. Enough has been done by a few persons to show that this not only is unnecessary, but that the crop may with slight effort be made to become of the greatest importance both to the farming public and to the commercial and manufacturing inerests of the nation.*** Under the present farming status the outlook for the crop is a gloomy one indeed. It is only when the author

*North Dakota Agricultural Experiment Station: Annual Reports for 1900, 1901, 1903, and 1904, bulletins 50 and 55.

**North Dakota Agricultural Experiment Station Bulletin No. 55, page 187. See also the various annual reports of the N. D. Expr. Station.

***See bulletins 50 and 55 of the North Dakota Agricultural College Experiment Station.

sees the possible future crop through the aid given by the enlightening results of late investigations that any permanent future can be claimed for it.

The Importance of the Crop: The importance of the crop need not be argued in detail to those who have had experience with it under conditions of successful growth, but the American farmer, once having dropped a non-paying crop, does not take it up again except upon evident proof of worth. The flax crop is now making its last stand upon American soil, unless intelligent agricultural methods restore it to a condition of regular productiveness throughout a large area. The question back of the studies upon which this report is based is: Is there a reasonable prospect that this may be done? The answer, looking to past history of seed and fibre industry and to the present demand and sources of supply, may easily be in the affirmative. There is a large area of the eastern and central states in which the crop was once successfully grown, and the presence and use everywhere of products of less merit stand as guarantee of a large future consumption of really meritorious flax products. The American people do not wear cheap clothing or make use of cheap substitutes for any purpose, when conditions are such as to allow selection of merit or quality. Would one wear cotton, could he have woolen and linen clothing of first quality? What are the merits of cotton crash, bagging, canvas, thread, twine, rope, kerchiefs, shirting, etc. as contrasted with the linen products? What could the farmer and stockraiser do with more linseed products, oil-cake and oil? One has only to ask himself such questions to reach the assurance that there would be a demand for the products of a real flax industry. America has never been a great producer of fibre, but enough has been done to show that the area of possible successful cultivation of the flax crop is extensive. Previous to 1870, the growth of the crop for seed and fibre was wide-spread throughout the different states. In the early years following the Revolution, it is well known that fine types of fibre were made throughout all of the original eastern states. Later Pennsylvania, Tennessee and Kentucky were noted for the fine quality of flax fibre which could be produced there.

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*See Eleventh Census, Bulletin No. 117, also Dodge on "Useful Fibre Plants of the World," Report, No. 9, U. S. Department of Agr. page 228, and Flaxseed Production, Commerce and Manufacture in U. S. Year Book of Dept. of Agriculture 1902—page 421.

The following table *shows the product for seven decennial years since 1849. Between 1860 and 1880 the states

Table No. 1. Flax Products of Decennial Years.

Year	Bushels of Seed.	Pounds of Fibre.
1849	562,312	7,709,676
1859	566,867	1,720,145
1869	1,730,444	27,133,031
1879	7,170,951	1,565,546
1889	10,250,410	241,389
1899	19,979,492	

chiefly concerned in the production of flax were Illinois, Michigan, Ohio, Virginia, New York, Kentucky, Tennessee, Wisconsin and Iowa. Other western states have come into marked prominence since, through the production of heavy seed crops. Since 1870 the fibre industry has died out except at a few local points. The acreage of the crop for seed production has been increased to such extent in the newly broken lands of the Northwest that the annual value of the seed crop of North Dakota alone exceeds by nearly or quite double that of all the states for any year previous to 1890. This statement alone suffices to show the great value of this crop if it could but be fixed as a standard crop. The annual yield of seed in the state of North Dakota may be conservatively placed at 15,000,000 bushels. For the year 1905 it is placed at 15,743,184 bushels. With Americans, well painted buildings and apparatus etc. are a matter of natural pride, but not a small fraction of linseed oil is now used to that which would be used, were the market of that product under those conditions which are characteristic of a general crop and normal manufacturing. Furthermore, American beef and dairy interests may be said to be almost strangers to the immense feeding value of this crop. The exports of oil-cake only indicate, in a promisory sort of way, the usefulness of this unstable crop, if it were converted into a stable one. Most European stockmen rate oil-cake very highly as a cattle food, and this by-product is looked upon as one of the most staple of stockfoods. For reasons not clearly understood, American cattlemen do not fully realize the value of this product when used with courser stockfoods. European farmers also highly prize the effect of barnyard manures from oil-cake fed stock. It is probable that eighty to ninety percent of all oil-cake produced in the U. S. is exported. It is contracted for by brokers at crushing mills at prices ranging from $10.00 to $15.00 per ton.

The American farmer is thus disposing of much soil fertility at a paltry price which could be saved to the land, were it fed to dairy and beef cattle on the farms of the country.

Statistical authorities are so much at variance in figures that it is difficult to procure wholly reliable data concerning the crop in America, but one may gain some conception of its importance, even as at present grown, by a consideration of the followng statements and tables which have been compiled from various sources as fairly representative of present conditions. Could the crop be more generally grown and its worth more generally appreciated, the uses made of its products would speedily multiply.*

During the season of 1904, the entire acreage in flax in the U. S. was approximately 3,200,000 acres, in 1903 it aproximated 3,700,000 acres. In 1903 the yield of seed was sufficient to produce approximately 70,000,000 gallons of linseed oil. This would have made about 500,000 tons of oil-cake. Most of this valuable by-product is exported to the cattle countries of north and west Europe. The same regions use up most of the oil-cake of the large crushing plants of Russia. Linseed oil usually sells upon the market at approximately sixty cents per galion. This estimate for the oil alone would place the crop of 1903 at approximately $42,000,000. Fully fifty per cent. of that crop was grown in the single state of North Dakota. This last fact is emphasized simply to show that there would be great value in extending the cultivation of the crop or rather in returning to its culture in the older states if this may be accomplished and it is the more evident that Dakotans should make every effort to save the crop to the state.

It is estimated that the flaxseed crop of the United States for 1901, 1902, 1903 and 1904 was approximately 103,985,000 bushels. Of this yield of seed North Dakota produced fifty per cent. or 54,825,000 bushels. The average per capita production for the state for the same period was thus seen to be, in farm values, approximately $38.86.** The approximate yield of flaxseed per acre in North Dakota, for the year 1903, was 13 bushels, and approximately 16,863,494 bushels were produced. The following tables compiled from

*Those who wish detailed figures concerning the crop production by states, or figures showing exports and imports, should consult the Year Book of Agriculture, Div. of Statistics.

**Official Statistics Department of Agriculture and Labor, Bismarck, N. D.

Plate 1. Pulling and sorting fibre flax in the Courtrai district of Belgium.

Plate 2. Removing the seed by the mallet method at Courtrai, Belgium.

computations by Orange Judd Farmer, though perhaps not more than approximately correct as to actual figures, are very conservative, yet give a fair idea of the status of the seed crop in the United States and its distribution as to states.

Table No. 2. Acreage—Yield per acre and Total Product in U. S.

Year.	Acres.	Per Acre	Total in Bushels.
1896	1,145,000	11.3	17,402,000
1897	1,130,000	9.6	10,891,000
1898	1,553,000	11.1	17,217,000
1899	1,679,000	12.0	20,086,000
1900	2,595,000	9.0	23,412,000
1901	3,050,000	9.5	29,079,000
1903	3,159,000	8 4	26,639,000
1904	2,275,000	9.8	22,190,000

NOTE.—In 1905 the total seed production of the United States was estimated at 28,477,753, of which North Dakota produced 54.3 per cent.

Table No. 3. Crop by States in 1901.

State.	Acres.	Yield per Acre.	Total Bushels.
Wisconsin	47,000	12	564,000
Minnesota	636,000	10.5	6,668,000
Iowa	108,000	9.5	1,026,000
Missouri	62,000	4.5	279,000
Kansas	161,000	5.5	886,000
Nebraska	17,000	6.0	102,000
North Dakota	1,452,000	10.3	14,956,000
South Dakota	493,000	7.5	3,568,000
Idaho and Montana	75,000	12.0	900,000

Table No. 4 is taken from the Year Book of the United States Department of Agriculture, and is especially interesting in this connection as showing the probable acreage, yield per acre, total bushels, and value of the crop by states for the year 1904.

Table No. 4. Yield and Value of Crop by States in 1904.

States.	Ackreage	Average Yield Per Acre	Production	Average Farm Price Dec. 1	Average Value Per Acre Dec. 1.	Farm Value Dec. 1.
	Acrea	Bushels	Bushels	Cents	Dollars	Dollars
Wisconsin	25,442	12.2	310,392	112	13.66	347,639
Minnesota	537,356	10.8	5,803,445	101	10.91	5,861,479
Iowa	65,037	10.5	682,888	98	10.29	669,230
Missouri	24,342	6.0	146,052	97	5.82	141,670
Kansas	95,055	6.0	570,330	93	5.58	530,407
Nebraska	12,327	7.0	86,289	100	7.00	86,289
South Dakota	207,256	10.0	2,072,560	98	9.80	2,031,109
North Dakota	1,233,792	10.6	13,078,195	99	10.49	12,947,413
Montana	9,334	8.0	74,672	95	7.60	70,938
Idaho	23,729	10.7	253,900	85	9.09	215,815
Oregon	2,231	12.0	26,772	122	14.64	32,662
California	1,022	12.5	12,775	106	13.25	13,542
Oklahoma	20,402	12.0	244,824	99	11.88	242,376
Indian Territory	6,240	6.0	37,440	102	6.12	38,189
United States	2,263,565	10.3	23,400,534	99.3	10.26	23,228,758

*NOTE.—Orange Judd's estimate for crop of 1905 is placed at 30,000,000 bushels.

I quote further statistics as compiled by the Commisioner of Agriculture and Labor, Bismarck, N. D., for the year of 1903, in order to show the value of the flaxseed crop as compared to the crops of wheat, oats and barley. Only six counties are here given. For data on other counties, persons interested should consult the statistical map published by the state Department of Agriculture for the year of 1903 and 1904. By consulting the prices, as indicated in Table No. 4, or the Daily Market quotations, it will be seen that the flax crop of North Dakota easily stands second in importance.

Table No. 5. Comparative Crop in bushels in six representative counties of North Dakota, crops of 1902.

County.	(bu.) Wheat.	(bu.) Flax.	(bu.) Oats.	(bu.) Barley.
Barnes	2,416,732	677,812	1,825,627	609,029
Bottineau	1,493,461	599,319	1,108,979	223,896
Grand Forks	2,863,812	1,171,385	1,611,634	660,251
Ramsey	929,669	1,339,321	975,787	451,541
Walsh	3,504,342	1,164,286	1,766,056	719,470
Ward	148,246	406,406	488,569	488,825

As studied by counties or districts in the seed producing state of Minnesota and the Dakotas, statistics of yields by years do not indicate a falling off either in total bushels or in average yields per acre. By inspection, it is found that this is almost wholly to be accounted for in the large acreage of new lands which are yet being broken and seeded to this crop. A study of statistical tables, kindly allowed me by the Accounting Departments of the Great Northern and by Chicago and Milwaukee railroads, makes this point quite evident. The yearly haul of flaxseed from stations and points long under flax culture show a gradual falling off while large and increasing hauls are made from those points near which there is yet much virgin soil. Though some states which could produce the seed crop may not need it as a rotation crop, there are others of more northern location which can ill afford to lose it from their rather short seried rotation. In the entire northern tier of states, short seasons make a rather limited series of crop open to general cropping. This is especially true of Montana, the Dakotas and Minnesota. They are naturally, both as to soil and climate, suited to the producton of linseed, and, for a time, it has been a well recognized product of this region. It is a short season crop of great value. Its loss from the list of crops which can be seeded upon an extensive plain will be keenly felt. And the industries which now depend upon it, if lost to this country, will entail an expense upon all classes of people in the way of necesssaries which then must be imported. Of these, the following raw products and manufactured products are evident as to their value to our people when simply listed: Linseed oil used as the basis of all paints; oil cloths, linoleums, etc.; oil-cake, one of the best of stock foods; tow, used extensively in all uphostelry and harness manufacturies, the making of coarse towelings, twine crash cloths, bagging, etc.; paper pulp for best linen papers; linen fibre used in manufacturing all types of twine, rope and best linen stuffs, as table linen, shirting, etc. It is easy to appreciate the value of this crop to our country when one consideres the simple fact that 20,000,000 bushels of seed, a low estimate for the average annual crop of the U. S., will produce approximately 50,000,000 gallons of oil and 372,500 tons of oil-cake.

Studies at the North Dakota Experiment Station and the investigations made while in the flax growing areas of

Europe, assure me, I think, in predicting that it is not necessary that the crop shall be lost. I also feel safe in stating that its culture can again be resumed in other states in which it once succeeded, but now fails. Our experiments at this Experiment Station also show that the Northwest can produce the fibre crop in as long, fine and strong form as any country in the world. (See plates 20 and 22.)

The seed crop in areas new to cultivation has always been a paying one, though all else of the crop has been allowed to go to waste or has been burned. Millions of tons of straw have been burned each year, much of which, in quality and length for the production of fibre, far excells the average straw from which the Russian peasant makes the fibre which chiefly supplies the linen fabrics of the world.

There are now prospects of better things and, if the farmers can but hold the crop to present productiveness so that the industries now established, oil mills, tow mills, paper pulp mills, binder twine plants, crash toweling and bagging factories, etc., need not cease operation, there is yet hope that a large part of the straw value may yet fall to the farmer. Tow mills with a capacity of ten to twenty tons per day are being operated at various points in the Northwest. The mills pay for the ordinary straw from the threshing machines from $2.00 to $3.00 per ton. The farmers about these points must see to it that all possible is done to keep up the productiveness in straw, as from or about these mills must come the first development of a real fibre industry.

The Purposes of the European Explorations and Investigations: Studies conducted at the North Dakota Agricultural Experiment Station made the following points stand out clearly:

(1.) The chief reason for the disappearance of the flax crop from old cultivated lands is the introduction of the flax-wilt organism, *Fusarium lini*, Bolley, and to careless culture affecting the seeding operations; allowing the entrance of associate diseases.

(2) The chief cause of the rapid distribution of disease to new fields and districts, and of the rapid occupation of entire areas, is due to the fact that farmers follow the practice of procuring seed from elevators and often exchange seed. In other words, they have not tried to keep or improve their own seed flax. They have held to the theory

that since the crop is raised only for fibre or for oil purposes, it makes slight difference about the seed, if only that used is reasonably sure to sprout. Many hardly seem to appreciate what should be the real color and form of flaxseed. That found upon the market and in elevators, generally, is more or less injured by moisture, is never graded to a regularity of form or size, is often shriveled and scaly, and, it is quite commonly believed that it is necessarily impossible to remove the common weed seeds. Naturally when such a belief exists there is not liable to be any pure bred flax, but the general crop must of necessity produce a mixture weak in vitality and of little character. I find that this treatment of the flax crop is not alone characteristic of our Northwestern farmers. The belief is general among flax growers that there exists no strains or varieties of flax which may be said to have special merit. Wherever I have gone, whether in Europe or America, and have asked what is the best variety of flax for fibre, the reply has almost universally been; "Common Blue Blossom is the best. It is all alike or will become alike if given the same conditions." With fibre growers there exists a persistent belief that flax deteriorates because of a lack of change of soil and climate; and most of those who grow it for the seed, act on the belief that variety or quality of seed has little or nothing to do with the crop grown. They believe that flax is a good crop with which to subdue new or wild lands, and when this is done they feel sure that the yield will quickly fall to a minimum and, therefore, they use the crop with the expectation of reaping a few good yields while the land is new, then abandon it altogether. There seems to be little thought that there could be merit in seed improvement and proper cultivation.

The result of all this negative influence is that the crop is reduced to a mixture of varieties and strains, and the yield to a minimum of productiveness both with regard to quality of fibre when grown for that purpose and of oil when the seed is placed upon the market. The mixture of seed strains brings about unevenness of ripening, unevenness in height and periods of development, which are followed by many consequent evils all of which tend to weaken the seed value. Generally our farmers take pride in producing stock, whether of cattle or grain, as soon as convinced that the productiveness is due to breed. Pure breeds, varieties, or races furnish a strong stimulus to provide proper sur-

roundings and culture, especially proper care for the types which are to be used for breeding purposes. Much, therefore would be gained to the flax growing interests if we could introduce new varieties or strains of such special merit and of such noticeable qualities that they would become of interest and be recognized by the grower as something worthy of special care. It is obvious that the crop has a wide area of distribution and, for this reason, it is probable that strains of particular merit may be found for the different large areas of our country which vary greatly in climate and soil characteristics. Our observations also lead to the belief, that, because of the persistent culture of the flax crop by the peasants of Russia and other European districts, one might be able to find strains of flax not only variable in capabilities as to growth for differences in soil and climate, but which should possess greater resisting capabilities to the known diseases which affect flax culture.

In short, in order to stimulate the development of the crop throughout the widely varyng areas of soil and climate, pure varities or strains of seeds more or less suited to these varying conditions are needed, disease free or resistent types, better yielders of seed, better yielders of fibre, drought resistent types, short seasoned crops, etc. These points were held in mind in our explorations and, in looking for seed samples, it was also kept in mind that, even though we should fail to find any or a part of those needed types in pure form, that is to say, in sufficient quantity to allow of purchasing and distributing the same in bulk, yet the samples of seed obtained, even of mixed types, would enable our plant breeders at the different Experiment Stations and elsewhere to gain the proper types by the work of testing, crossing and selection. To provide these samples it was recognized that a wide range of seed collection from widely varying climatic and soil areas is needed. In making the explorations, the samples of seed available in each region were, therefor, taken, even though individually of poor grade. It was particularly desired to find samples which were worthy of note because of the long time during which they had maintained their usefulness and had been cultivated in the district in which they were found. The known variability of the flax plant under different soil and climatic influence indicates that much may be hoped to be gained from this method of selection, regardless of the truth that methods of culture throughout the world evidence very

much the same general carelessness with regard to the handling of the seed and, therefor, naturally tend toward the disappearance or obliteration of distinction with regard to variety or types.

Aside from the procuring of the samples of seeds for the purposes above indicated, the question of the proper methods of cultivation in order to procure a maximum yield, under the conditions in which the crop was being observed, was kept constantly in mind in order that we might more probably arrive at conclusions as to what methods should be recommended for the cultivation of the crop in the different climatic and soil regions of America.

As we had learned in our investigations in Minnesota and North Dakota that the chief cause for the disappearance of the flax crop under cultivation, that is its short life upon particular soil, was usually, if not wholly, due to the existence of fungus diseases, notes were taken upon the existence of such diseases under all of the different crop and soil environments of the different regions of Russia and other countries visited.

In the further discussions of this report, such variations as we observed in the characteristics of the crop, the methods of culture and the existence of diseases in the different countries visited will be considered under general headings according as they fit into the purposes of the report.

Flax Districts and Regions Visited: The following outline of the trip of explorations will indicate the regions which were visited and the opportunities we had for observing methods of culture, soil characteristics, methods of handling the crop, etc.: Holland, north of Rotterdam, and Amsterdam, the Gronigen and Friesland fibre districts in North Holland, the chief fibre districts of the Islands of Zeeland, the chief fibre districts of Flanders about Ostberg and Ghent, the Courtrai district of Belgium, the River Lys, the greatest of fibre manufacturing districts, then southeastward through Belgium. In our stay in Holland and Belgium we studied the experiments located at the Experiment Stations of Gronigen, Wageningen and at Gembloux. In Germany studies were made in the Barvarian flax country about Munich. Through the courtesy of the Directors, we were enabled to conduct studies in the Botanical Gardens of the University of Munich and the University of Amsterdam, and to make use of

the noted Herbaria at these institutions for observation upon the flax plant. Stops were made at Berlin and observations made upon the flax districts of Northeast Prussia. In Russia, practically all the districts which are noted for the production of fibre or seed were visited. Careful studies were made in the following fibre districts: The Baltic provinces of Kurland, Liefland, Kovno, Pskoff, and Novgorod. Extended investigations were made at Riga, St. Petersburg, Moscow, Saratov, Kharkov, Odessa and Novorossisk in regard to the seed trade.

Extended field studies were made about Riga, Pskoff and the governments of Smolensk, Vologda, Yaraslav, Kostroma, Nishni-Novgorod, Kasan, Perm, Orenberg, Ufa, Samara, Saratov, in the provinces of the Don, Kuban, Crimea, Besserabia, in the regions about Odessa, Kharkov, Kursk, Tambov, Tula and Orel. Some stops and studies were made in regard to seed and fibre manufacture in Austria, about Buda Pest and Vienna; and studies were made in regard to the fibre and seed trade in the region of North France. Two weeks were spent in studying in the Herbarium located at Kew Gardens, London, with reference to the flax diseases as recorded by extensive and world wide plant collections made by that institution during many years.

Relation of the Crop to Climate: The regions in which the flax crop has been successfully grown, either for fibre or for seed, cover a wide latitude and are found upon various large tracts within the tenth and sixty-fifth parallels of north latitude. New culture areas in southern latitudes also show the crop successfully grown under similar climatic conditions. As at present cultivated, the limitations as to climate are quite sharply defined. These are probably matters more of variety and strain which have become properly established because of unintelligent cultivation, than because of any definite attempts which growers have made to attain new and suited strains or varieties. That is to say, I find by my observations that the type of the crop which is to be found in any particular region, whether it be a fibre producing region or a seed producing region, is there chiefly because of the results of natural survival, and because of ordinary crop performance. The limitations northward seem fixed chiefly by the shortness of the season. In Russia the actual limit for fibre production, which is grown from seed raised upon the ground, may be placed practically on the isotherm through the city of Vo-

Plate 3. A scene on the River Lys. Retting grounds shownig fibre flax in stacks, empty retting crates and fibre straw in the bundle ready for retting.

Plate No. 4. Filling the retting crates on the River Lys.

Plate 6. Stooking the fibre straw after removal from the River. The drying process.

logda while the seed crop fails toward the southern limitations, apparently for want of varieties or strains which may insure productiveness in the presence of high summer temperatures and irregularly occuring drought visitations. Here, also, the crop of Southern Russia, as elsewhere in southern regions, comes into competition with other crops which demand less rigorous types of labor for equivalent cash returns. Thus, in Russia, the finest, largest growths of fibre plants are obtained in the governments of Vologda and Archangel on a line almost directly northward from Vologda, where the peasant farmers practically make no attempt to ripen flaxseed for seeding purposes, almost always sending for it to the more southern governments of Viatka, Yaraslav and Pskoff. This, of course, has been found by them to be a practical necessity, due probably largely to their careless methods of farming and to their belief that flax is not quite capable of reaching proper maturity with them. This, as in the case of the Hollanders and Irish people, is probably only an imaginary necessity. It may be the cheapest source of obtaining seed, but it is certainly a bad principle in farming to assume that it is impossible to properly develop the seed of a standard crop in a region in which it is being grown. When this assumption is once made by the farmers of a particular region, that crop is sure to be a more or less irregular one, and the farmers gain no advantage from natural soil and climatic selection, which is undoubtedly the most important feature connected with the proper development of an agricultural crop. In America the progress of the flax crop practically reverses the relation of climate as compared to that which is noticed in Eastern Europe. There the farmers raise seed flax in the more southern districts, here the yield seems to be heavier as the crop is grown farther and farther northward until the regular annual coming of the autumn frosts cuts short the certainty of maturing. Parallels of latitude are, of course, not true gauges of the range of a crop. Temperature associated with rainfall, atmospheric humidity and soil type, directly govern plant distribution. Generally speaking, the crop may be said to grow best on the cold side of the temperate region. From a general survey of the different general regions in which it is cultivated, as, for example, Northwest Russia, Northwest Holland, North and East Ireland, the northwestern states of the United States, and Southern Argentine, it can hardly be doubted that "common flax"

is at present bred to fit cool growth conditions within moderate extremes as to heat and drought. Roughly, as far as the growth of the seed crop is concerned, its culture may be placed as co-existent with successful spring wheat regions, while the fibre crop is produced in regions of heavier rainfall and somewhat cooler and more cloudy skies than spring wheat is usually successfully grown. The crop may also be said to possess either general capabilities or varieties and strains, which allow of the production of fair crops of seed flax at least to the southern limits of winter wheat producing regions.

Whether grown for seed or fibre purposes, the flax crop of the northern hemisphere is quite generally found between the limits of the July isotherms of sixty and eighty degrees Fahrenheit. Roughly drawn, these lines run as follows: That of July 60 degrees passes approximately thro San Francisco northward along the coast range to the Arctic circle in Alaska, thence southward and eastward thro Winnipeg and north New England, thro north Ireland, Hull, Christinan, Archangel, Michaelovka, Verkhoynsk, Siberia and north Saghalien. That of July 80 degrees passes approximately through Gulf of California, Pierre, South Dakota, Des Moines, Charleston, South Carolina, Gibraltar, Tripoli, Constantinople, Bokhara, Pekin and Nagisaki. A rough study of isothermal lines, as now mapped, indicates that the various flax areas of the world fall quite naturally in temperature belts of great similarity according to the type of flax that is grown, thus the seed flax areas for the production of oil are found under temperature conditions very similar as to the mean temperatures of the growing months. It is also found that the even climatic conditions of Brussels, St. Petersburg, and the North Pacific Coast of Oregon and Washington, North Michigan, and Wisconsin, furnish about equal qualities of the better types of fibre flax. The only point of variation seems to be that the seed producing areas of our northwestern plains reach a higher July and August mean temperature than most of the flaxseed producing areas of Europe and Asia attain.

It is necessary, however, in contrasting isotherms to consider not those of a single month alone, but those of the properly contrasting growth periods, as for example, the periods of blossoming and boll formation. These periods of growth, it will be found, do not strike the same calendar months in the different flax districts of the world, but, when

examined separately with reference to each other, are found to be very similar as to the temperature, rainfall, humidity and cloudiness of sky, etc., under which they are produced. Under the present methods of cropping, it is found that the soil characteristics of successful flax culture are also very similar. This is especially true of the crop when cultivated for fibre. For example, the similarities of conditions in the very successful fibre districts known as the Baltic districts of Russia, and the Courtrai, Flanders and Groningen districts of the Low Countries are quite remarkable to any observer, and must be taken to mean something when considering the chances of succeeding with the crop, under the methods of culture now pursued; that is to say, we need not expect to make marked success with this crop for fibre purposes in regions which differ greatly from those named as to climatic and soil characteristics, unless varieties or selected strains varying quite markedly from the ordinary type are procured. (See discussion of this matter under Breeding and Selection.)

The culture of the crop for seed purposes is of considerably wider range than that of its culture for fibre production. Even the best fibre districts produce a rather high average yield of seed. Good crops of seed flax for oil purposes are obtained at varying points starting at almost the northern limits as in Russia and northwest America, extending to the various southern limits as represented in the Caucasian regions, Turkestan and India. The following points may be named as indicative of regions in which flaxseed is grown for oil purposes with marked success: Winnipeg, Manitoba and northwestward, Minot, N. D. and southward through the Dakotas; Smolensk and Tambov and Perm, Central and Northern Russia; Samara, Oufa and Orenberg of Southeastern Russia; Odessa, the Crimea, Novorossisk, and the Kuban region of the Caucasus, in Southern Russia. It will be remembered that the out-put of flaxseed for India is second only to that of the crops of United States and Russia. Nearly all of these regions, in which the highest seed production and finest types of oil producing seed are obtained, indicate conditions of climate and soil which demand considerable powers of drought resistance on the part of the crop. This contrast between the successful growth of the crop for fibre and the successful production of oil producing seed flax is particularly marked, for the crop for fibre purposes is not only confined within

those temperate boundaries previously mentioned, but to those regions in which there is a relatively, even, high, atmospheric humidity and rather even, low temperature growth season, as for exaample, east coast of Ireland, west coast of Bigium, Flanders, and Holland, northeast coast of Russia, west coast or Baltic provinces of Russia, and the north provinces of Russia represented by the heavy, woody, and rather swampy cool areas of that country. The areas in which the really fine flax fibre has been successfully grown for long periods under common and comparatively ignorant mehods of culture are similar ones and well marked out by a great sameness (likeness) of atmospheric conditions during the growth season. Compare, for example, the meteorlogical conditions, temperature, rainfall, humidity, etc., of these regions during the respective growth seasons of each. They are found to be much the same. It will be seen that these regions named are the flax fibre regions of note. Their names are synonymous with the culture of the crop for fibre purposes.

For a proper comprehension of these meteorological features, extensive yearly and monthly tables are necessary Those interested will do well to refer to the government or district statistics of the regions in which they may be interested. Such tables of temperature and rainfall of two dispart, portray a climatic region. Thus, the rainfall of two districts may vary much as to amount, yet the results as to soil and atmospheric plant environment remain essentially similar. The less measurable features of sunshine, cloudiness, fogginess, general atmospheric humidity, etc., are matters which vitally affect plant growth. This is especially noteworthy as affecting the flax crop. For the production of fine, long fibre of even quality, the plant must have an even rather slow development with few, if any, sudden checks. The cloudy sky and cool, humid air with an even, but not too great soil moisture throughout the period of growth is a feature of all fibre districts, and accounts for fineness, length and strength of fibre.

There is even a greater sameness in the characteristics of the climatic conditions of the flaxseed producing areas of the different countries than would at first be thought. While large crops of seed are produced in regions approximating closely the boundaries of the fibre districts, as, for example, in the governments of Smolensk and Tambov, Russia, yet the larger yields per acre and the finer type and

quality of oil producing seed are found generally in regions of much more harsh influence as affecting the growth period, as, for example, less regularity of rainfall, more dry winds, hotter sun and greater variation with reference to falling temperature at times approaching sudden frosts, as in north and west Dakota, South and east Russia, especially the regions directly east and south from Samara. One Russian authority, Mr. C. Tretiakov of Poltavia, kindly furnished the following interesting figures upon this point: Russian grown flaxseed produces 33 to 36 percent of oil; Russian seed grown in western Europe produces 30 to 32 percent of oil; Argentine grown flaxseed produces 37 percent of oil; Indian grown flaxseed produces 38 percent of oil; while our northwestern grown flaxseed approximates an average oil production of 30 percent. There can be no doubt that the hotter climates produce a higher percentage of oil, while the northern grown plant grows more markedly to foliage and fibre. In part, this is undoubtedly a matter of variety and strain, which may, perhaps, be corrected thro breeding.

In the general farming of these different regions, there may be found many types or varieties in the type of the flax plant but seldom any evenness or sureness of purity in type. Indeed, the author believes that as fibre strains almost always have been paramount in the minds of those who have been most successful in the proper culture and development of the flax plant, the seed strains, being secondary, have suffered. While the boundary lines for the culture of the two types of crop are more or less definitely marked, it is also true, in the peasant districts of the large flax growing areas, that these types grade almost insensibly, the one into the other, and the type or strain found growing in a given locality, as for example a point in any of the great Russian districts, may be said to have become established there chiefly because unintelligent cultivation, especially with reference to seed selection, has acquiesced in the usual results or crop performances rather than attempt in any manner the attainment of true types or varieties more suited to the conditions.

The foregoing facts and considerations lead me to the thought that a slight, well directed experimental effort may easily lead us to the attainment of more hardy and more oil productive varieties of flax both for fibre and seed purposes. It seems quite probable that the fibre strains are

farthest away from the normal type of the plant, for the reason that more intelligent attention has been given to that culture. With persistent care of the seed and selection aiming toward a proper separation of the types and towards securing strains of each which are suited to the climatic conditions in which they are to be grown, there is every reason to believe that the range of productive culture can be greatly extended, especially in this country. For, while the limits with reference to climatic conditions seem to be quite well marked, there is perhaps no other cultivated plant which is successfully and economically grown over so wide a range. And there is certainly no type of cultivated plant which has had so slight intelligent culture with reference to selection and saving of the diverse types or strains.

Relation of the Crop to Soil Quality and Conditions: Our observations and studies of soil relations of the flax crop lead to the belief that the question of soil type and soil fertility as affecting the successful culture of this crop is one of far less importance than has usually been supposed. Nearly all writers on flax culture have thought it necessary to state that flax demands a very fertile soil. My observations in America, Holland, Belgium, Russia and Austria do not confirm the belief of these writers. The lighter soils of Ward and Ramsey Counties, North Dakota, readily equal or excel the most fertile soils of the Northwest in flaxseed production; and the light, sandy, very poor forest or scrub lands of Viatka, Vologda, Kostroma, and Yaraslav, Russia, easily produce the grandest types of fibre flax when the system of culture is at all intelligent. Indeed, in the last named government, I found the peasantry continuing the culture of flax upon soils naturally light and so impoverished from the long continued ruinous "three crop" rotation that oats and rye were no longer a possible consideration. This was a surprising confirmation of our previous conclusions drawn from work done at the North Dakota Experiment Station. (See North Dakota Experiment Station Bulletins No. 50 and 55, also the Annual Reports of the Experiment Station for 1900, 1902, 1903 and 1904, in which it has been clearly shown that the flax crop as such is not more exhausting to land than other ordinary farm crops when continued upon the soil for a number of years.) Indeed, it has been shown by the experiments of our Chemist and Agriculturist, and by my own biological ex-

periments that the flax plant is less radical in its draft upon the soil than wheat, corn or oats. In Holland and Flanders, the best and most healthy growths of flax from which is made the finest fibre in the world, I observed, were grown not upon the heaviest and most fertile lands, but upon a type of soil, apparently bearing very little humus, the most characteristic features of which are its compactness and the presence of a fine type of rather light colored sea-sand.

I am under obligations to B. Sjollema, Director of the Agricultural Experiment Station at Groningen, Holland, for the following data with regard to the chemical nature of this type of soil:

Table No. 6. Showing the General Chemical Constituents as found in the first twelve inches of rather sandy, old, but very good flax soils of North Groningen, Holland.

Nitrogen	0.14 %
Potassium, Soluble in Boiling—5 % HCl	0.18 %
Potassium, Total	1.4 %
Phosphoric Acid, Soluble in Boiling—11 % H N O	0.1 %
Sodium, Total	4.5 %
Fe. O_3, Total	2. %
Al, O_3, Total	3.5 %

Prof. Sjollema informs me that in most of the sandy lands where flax was grown, the percentage of sand reaches as high as 80 percent of the first twelve inches of the soil. It will be noted that no $CaCO_3$ is given in this table. Prof. Sjollema writes: "The old grounds (polders) have lost all their $CaCo_3$ in the upper layers." "The new polder grounds contain most $CaCo_3$ approximately 5 percent.*"

Again, it was found that the soils of those north Russian provinces, where the finest grades of fibre flax are grown, are characteristically poor and weak. Even in the far famed fibre producing provinces of Pskoff, the soil is wretchedly poor. Each of these northern countries is very deficient in nitrogen, potash. and phosphoric acid. The peasants call it "luda," and say that "where there is luda, there is want." However, they never give up the culture of their loved flax plant which furnished them their cloth-

*The new polder lands are those latest reclaimed from the sea.

ing and some extra kopecks. I saw reasonably good crops of flax on soils in that region where the winter rye and oats did not exceed ten inches in height at date of maturing.

The Russian seed crop, as grown for oil purposes only, is, in chief part, confined to the "Chernoziom," the black soil regions which are located southward and southeastward from Moscow and Kharkov. The seed crop is not, however, wholly confined to the black soil areas, as very good crops of seed were seen in the white soil regions of Northeast Smolensk and Kursk, and in other non-Chernoziom regions, especially in the lighter soil areas northward of the Caspian sea. Climatic considerations and crop methods govern the type of the crop whether seed or fibre, in these two important regions. I would not be understood to argue the reverse, that good flax cannot be grown most easily upon the more fertile soils. It is only wished to show that preconceived farm opinions which have been gained by the people in general from long "experience," are not always proper guides to farm methods and, that the beliefs that flax must have very strong soil, that it is a gross feeder, and especially destructive soil impoverisher, are not well founded.

Table No. 7 shows the chemical composition of the flax plant as computed by Snyder* to show the approximate amount of plant foods re-moved by average flax crop per acre.

Table No. 7. Showing Pounds of Plant Food Removed By an Acre of Flax.

Soil Constituents.	In 900 lbs. Flaxseed.	In 1,800 lbs. Flax straw.	Total.
Potash (K_2O)	8.5	18.7	27.2
Soda (Na_2O)	.4	2.4	2.8
Lime (CaO)	3.2	13.5	16.7
Magnesia (MgO)	5.3	6.4	11.7
Iron Oxide (Fe_2O_3)	.4	1.8	2.2
Phosphoric Anhydrid (P_2O_5)	14.6	3.4	18.0
Sulphuric Anhydrid (SO_3)	.8	1.9	2.7
Silica (SiO_2)	.3	3.3	3.6
Undetermined	.1	2.2	2.3
Total	33.6	53.6	87.2
Total Nitrogen	39	15	54

*See Minnesota Experiment Station Bulletin No. 47, page 4.

Plate 6. Stooking the fibre straw after removal from the River. The drying process.

Plate 7. Preparing the bundles for the second retting, River Lys district, Belgium.

It will readily be observed, when this table of soil constituents is contrasted with similar analyses for other farm crops, that the draft of the flax upon the soil is, comparatively speaking, light. This may be well seen by an examination of Table No. 8, which shows the draft of an ordinary flaxseed crop upon the soil, stated in total pounds removed, contrasted with similar analyses of wheat, barley, oats, corn, peas, mangles and potatoes. The yields assumed for this table approach closely the average yields for these crops in Minnesota and the Dakotas.

Table No. 8. Showing Comparative Draft upon Soils by Different Crops. *

CROP		Nitrogen lbs.	Phosphoric Acid lb.	Potach lbs.	Lime lbs.	Silicon lbs.	Ash lb.
Wheat	20 bu.	35	20	35	8	116	210
Barley	40 bu.	40	20	38	9	72	216
Oats	50 bu.	50	18	45	11	75	205
Corn	65 bu.	75	20	60	12	90	200
Peas	30 bu.		25	60	75	10	240
Mangles	10 tons	75	35	150	30	10	350
Potatoes	150 bu.	40	26	75	25	4	125
Flax	15 bu.	54	18	27	16	3.5	87

Experiments conducted in the Botanical Department and in large plots on the Experiment Station farm of the North Dakota Agricultural Experiment Station, definitely illustrate that the flax is not particularly destructive upon the soil. We have often found in the Red River Valley that the soil is too fertile for the growth of a flax crop when atmospheric and soil moisture is at the normal. The farmers of the Valley often put flax upon summer-fallowed lands thinking that such lands are too strong for the wheat crop; and very often the flax crop falls down and produces a poorer yield of inferior seed because of this extra fertility. In the case of droughty seasons, the flax crop has shown itself able to stand on very fertile lands but often it is almost worthless when anything more than an ordinary rainfall occurs.

The North Dakota Experiment Station has demonstrated quite clearly that considerably better crops of wheat may be raised after flax than after wheat.**

*Compiled from analyses by Snyder, 1. c. page 5.

**North Dakota Experiment Station Bulletin No. 39, page 451.

Through the kindness of Prof. Tretiakov of Poltova, I am able to give some very interesting figures from the Experiment Station at that point upon this same feature. In the Experimental fields located at Poltova, it was found that the draft of flax upon the soluble plant food was less than the draft made by wheat. Thus, by analysis, it was found that in 100 kilograms of field soil, there remained more soluble matter after the removal of a crop of flax than after the removal of spring wheat. The table given being as follows:

Table No. 9.	Mineral Matter.	Soluble Nitrogen.	Soluble Phosphates.
After Wheat	22.8 grm.	0.199 grm.	0.170 grm.
After Flax	23.6 grm.	0.209 grm.	0.298 grm.

Mr. Tretiakov, in part, accounts for the favorable influence exerted by flax upon the growth of the following wheat crop by the fact that flax withdraws less moisture, saying that: "The favorable influence of the flax crop upon the following spring wheat crop, as seen in our experiments, is in direct relationship to the greater soil moisture under flax than under wheat," Experiments were made at Poltova to determine this point upon a layer of soil of 12 vershocks depth (21 inches.) Under flax there was 14.30 percent of moisture remaining the following spring, while under spring wheat there remained 13.94 per cent. This test indicates the same point as the previous table, viz., that the actual draft on the soil is less for flax than for wheat, even when the matter of water evaporated is under consideration and is directly opposed to the belief often expressed by many North Dakota farmers.

By considering the foregoing and similar tables contrasting the chemical composition of farm crops, and by considering extremely various types of soil upon which fine crops of flax fibre and flaxseed have been grown, it is evident that the theory of the destructive nature of flax upon the soil is not well founded and should be abandoned. The chemical analyses of the soils of some of the noted Russian flax producing districts bear out this statement.

Table No. 10, Showing the General Characteristics of the Soils of Several of the Most Noted of Flax Producing Districts of Russia* follows:

Dry Soil Content	Nishni Novgorod	Tambov	Ufa.	Saratov	Smolensk	Grodno
Humus	10.76	7.84	9.61	7.36		
Combined Water	6.02	4.89	3.67	4.11		
Lost by Ignition	16.78	12.73	13.28	11.47	5.65	21.05
Mineral Substances	83.22	87.27	86.72	88.53	94.35	78.95
Silica	17.09	13.01	9.22	17.05	4.68	3.97
Alumina	6.59	7.02	7.48	11.17	4.64	0.84
Iron Oxide	4.06	3.15				0.31
Oxide Manganese	0.01	0.012	.	0.11	0.11	0.04
Lime	1.68	1.08	0.65	1.07	0.22	0.32
Magnesia	1.10	0.37	0.85	0.60	0.33	0.03
Potash	1.00	0.51	0.51	0.85	0.20	0.07
Soda	0.17	0.04	0.07	0.09	0.04	0.05
Phosphoric Acid	0.25	0.19	0.24	0.15	0.12	0.12
Sulphuric Acid	0.02	0.02	0.01	0.03	0.01	Trace
Clay and Sand	51.25	61.71	54.35	56.84	83.68	73.31
Carbonate of Lime						

This table of soil analyses is given to illustrate some of the types of Russian soil where, under proper methods of agriculture, good crops of flax are raised. It is unnecessary to compile similar tables for other flax districts in Europe and America as such are to be found in almost all government publications. The study of these and other similar soil analyses will aid any one to the understanding of the Russian peasant's saying: "Not the earth but the sky produces the harvest." The land of the origin of this simple proverb, I think, in original and general fertility and conditions for the production of cereals, perhaps, discounts that of any equally large area in the world, but the peasantry are often acquainted with the spectre of want in a degree hardly known elsewhere. Agricultural uniformity in the method of doing things and habit rule there. They do not seem to know how to circumvent by cultivation, selection or breeding any of the ordinary troubles which beset agriculture; and the very best soils are soon impoverished. The lesson for American farmers is that, so far as flax is concerned, soil quality is rather a secondary consideration. The strains of seed used, climatic and atmospheric conditions seem to be first in order of importance. I believe we shall learn that, as in the case of corn, soil culture, seed selection, and breeding will enable our farmers to circumvent the chief evils associated with the elements of soil and climate. Our local experiments and foreign observations teach that the flax plant is a very variable one. It would seem possible to form or model it into the type we

* Industries of Russia, Agriculture and Forestry. Vol. III, P. A. Kostychev.

wish, into such types as would serve the practical purposes demanded; and fit it to any soil and climate in which the other cereals usually thrive.

Distribution of the Crop and Chief Manufacture: Except in the case of America, it may be said that the flax fibre producing industry has been comparatively stable and permanently located in certain and rather definite regions, while the seed producing crop has been migratory and rather unstably located, invading new fields or soil areas, and failing as a successful crop with the disappearance of virgin lands. It may be said that the growth of the crop for fibre purposes never really reached a stable condition in any American community though there are some publications and statisctics* which indicate that a fair growth was, at times, made in that direction previous to the great development of the cotton crop and its consequent cheapening of all textile fabrics. The statistics which are available are difficult to interpret and are, perhaps, hardly very accurate as to the elements in detail. In a general way, those most valuable show a wonderfully slow growth and regularity of fibre production and decline, associated with a similar regularity of rise and fall in the demand and consumption of linen products which hardly warrant one in the belief that the demand for flax fibre products may be suddenly or even greatly increased in the near future. However, statistics are simply an array of facts or approximate facts, and are of very little use in any predictions unless one is able to consider them in the light of non-associated facts and conditions which, in themselves, are not available because conditions and demands change with great rapidity in reference to each other.

The tables and notes in this report, compiled from various sources, will help the reader to roughly locate the sources and points of manufactury of the various flax products; and also to indicate the countries and regions which, at present, are the chief producers of this crop. I think that a careful study of these tables will also help one to understand why it may prove profitable for our people to take a renewed interest in the proper culture of the crop and development of its products.

Table No. 1 in a way, shows the rise and decline of the

*See Dodge on "Useful Fibre Plants of the World." Report No. 9, U. S. Dept. of Agriculture, and various other publications in the Department of Agriculture.

fibre industry in the United States with the associated rise of the seed or oil crop. It should be noticed that the fibre crop reached its highest development during the period from 1859 to 1869, when the cotton crop began to become of great importance.

Table No. 4 indicates quite clearly the great value to the people of this country to which the seed or oil crop has attained, and gives the present location of the flax crop in the United States. In connection with this table, it should be noted that the chief seed producing states of the list, the northwestern states, possess a land comparatively new to cultivation. If the Crop Reports of the Department of Agriculture are studied, it will be noted that Montana, Idaho, Oregon, California, Oklahoma and the Indian Territory are new names to the record of the flax crop.

Tables Nos. 11 and 12 give, at a glance, the comparative values of the three chief fibres of the world's commerce.

Table No. 11. Cotton, Wool and Flax Fibres Used in Factories in Europe and the United States in 1840 and 1894*

IN TONS.

Year.	Cotton.	Wool.	Flax.	Total.
1840	380,000	340,000	590,000	1,310,000
1894	2,226,000	1,068,000	1,544,000	4,838,000

Table No. 12, Showing Consumption of Cotton, Wool and Flax Fiber in Great Britain.*

IN TONS.

Year.	Cotton.	Wool.	Flax.
1799-1801	20,900	50,300	54,300
1829-1831	121,600	74,600	96,900
1859-1861	511,250	130,250	106,000
1869-1871	369,900	156,000	152,650
1879-1881	664,200	237,750	124,150
1889-1891	802,250	223,300	109,750
1898-1900	797,000	248,300	107,350

It will be noted from Table No. 12 that the use of flax

*J. L. Watkins in Year Book of the Department of Agriculture, 1901, p. 193.

fibre in the factories of Great Britain increased quite gradually and rapidly from the date of 1800 to 1869, since which time there has been a gradual falling away. While it is probable that the increased use of cotton and wool fibres, in part, accounts for the shrinkage in the use of flax fibres, observations while in European countries and other information which is available lead me to the conclusion that the diminishing manufactury from flax fibre is chiefly due to the diminishing supply of the fibre.

Table No. 13 gives, at a glance, the chief countries and regions of seed and fibre production, and the crop for the three years shown gives a fair idea of what may be expected from the annual output. In this table, under the fibre column, only long type commercial fibre is considered. For this reason, only European countries are accredited with the production of fibre. While there is considerable use made of the flax straw in the production of upholstering tow, for paper pulp, etc., especially in the United States where many hundreds of tons are so used, this sort of product is not rated as fibre. If the reader, however, will take into account the average annual value of flaxseed per bushel, and the marked demand there is for flax fibre of the best quality, it is evident that the flaxseed and fibre crop of the world is of no mean importance. Persons wishing to gain a fair understanding of the average price of flaxseed per bushel, year by year, month by month, should consult the United States Department of Agriculture Year Books, under the Division of Statistics of flax crops.

Table No. 13. Annual Flaxseed and Flax Fiber Crop Listed by Countries.*

IN TONS

Country	SEED			FIBRE		
	1901	1902	1903	1901	1902	1902
	Bushels	Bushels	Bushels	Pounds	Pounds	Pounds
United States	25,000,000	29,285,000	27,301,000			
Manitoba	275,000	582,000	583,000			
Mexico	165,000	152,000	150,000			
Argentina	15,352,000	14,371,000	30,076,000			
Ireland				29,736,000	25,182,000	19,327,000
Sweden	60,000	60,000	60,000	3,162,000	3,162,000	3,162,000
Netherlands	389,000	384,000	362,000	18,387,000	19,234,000	18,497,000
Belgium	280,000	266,000	272,000	25,538,000	24,280,000	24,790,000
France	611,000	450,000	500,000	54,683,000	39,624,000	47,000,000
Italy				41,917,000	41,917,000	41,917,000
Austria	1,131,000	1,034,000	1,120,000	122,267,000	113,508,000	103,848,000
Hungary	162,000	173,000	170,000	18,461,000	18,533,000	15,000,000
Croatia-Slavonia	23,000	26,000	24,000	8,684,000	8,803,000	8,000,000
Roumania	554,000	1,005,000	2,064,000	1,433,000	4,484,000	12,267,000
Bulgaria	23,000	23,000	23,000	2,116,000	2,116,000	2,116,000
Servia	11,000	11,000	11,000	832,000	2,847,000	1,861,000
Russia	15,227,000	20,173,000	17,997,000	728,044,000	1,165,098,000	1,003,641,000
British India	13,041,000	14,077,000	19,263,000			
Algeria	10,000	10,000	10,000			
Total	72,314,000	82,082,000	99,985,000	1,050,260,000	1,468,788,000	1,301,426,000

*Compiled from Year Book of the Department of Agriculture, 1904, page 690.

As indicated in Table No. 12, Great Britain is not only the greatest user of flax fibre, but is also the greatest importer of flaxseed for oil purposes. It will, perhaps, be interesting to merchants and the future producers of this seed crop to take note of the countries which produce the seed and those which are the greatest importers and crushers of this product.

The four chief flax producing regions of the world may be listed in order of their importance as United States, Argentina, Russia and British India. For a long time Russia has held the chief place in the production of flaxseed for oil purposes but Argentina and United States have rapidly forged to the front through the opening up of virgin sod to this crop, and probably, in part, because of the introduction of a high class American harvesting machinery.

Table No. 14 is interesting in this connection because it shows the net import of flaxseed into the various important linseed oil producing countries of Europe, thus giving an insight into what becomes of the flaxseed of the world and the location of the chief oil factories.

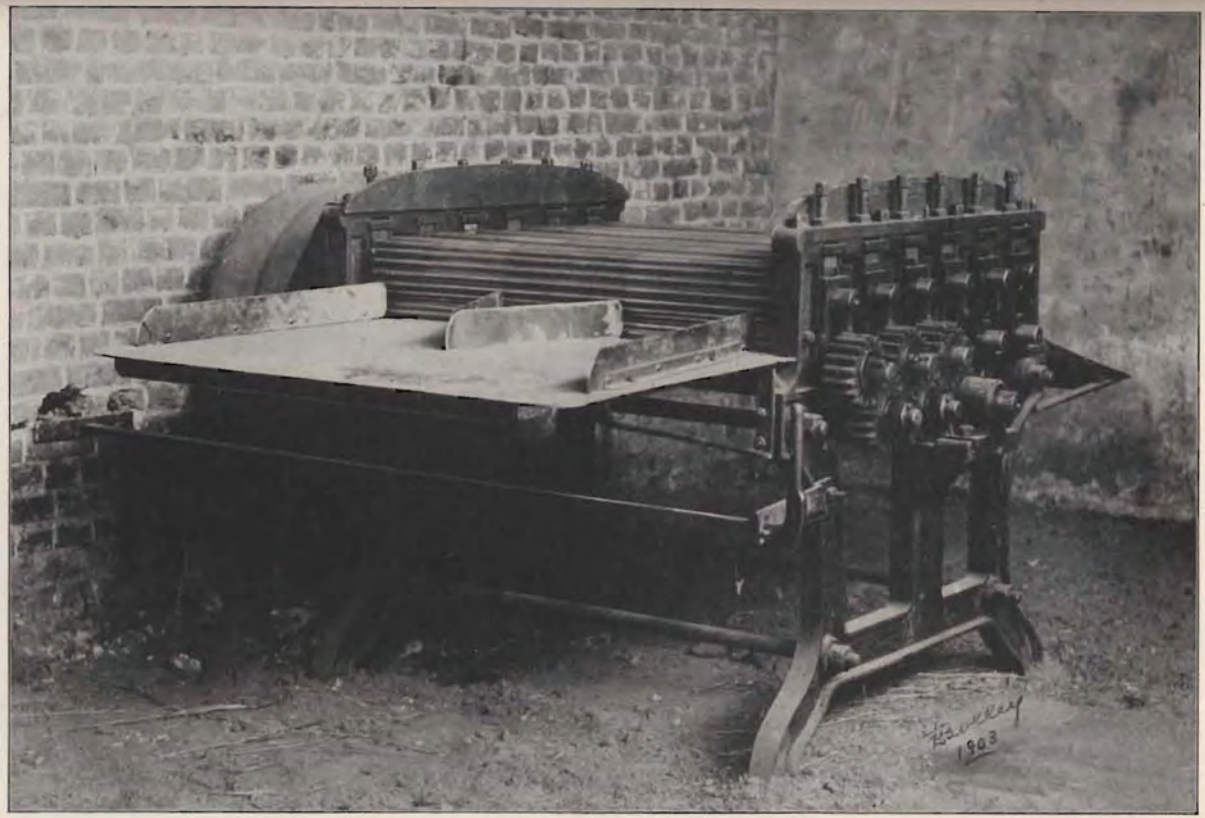

Plate 8. Typical flax fibre breaking machine.

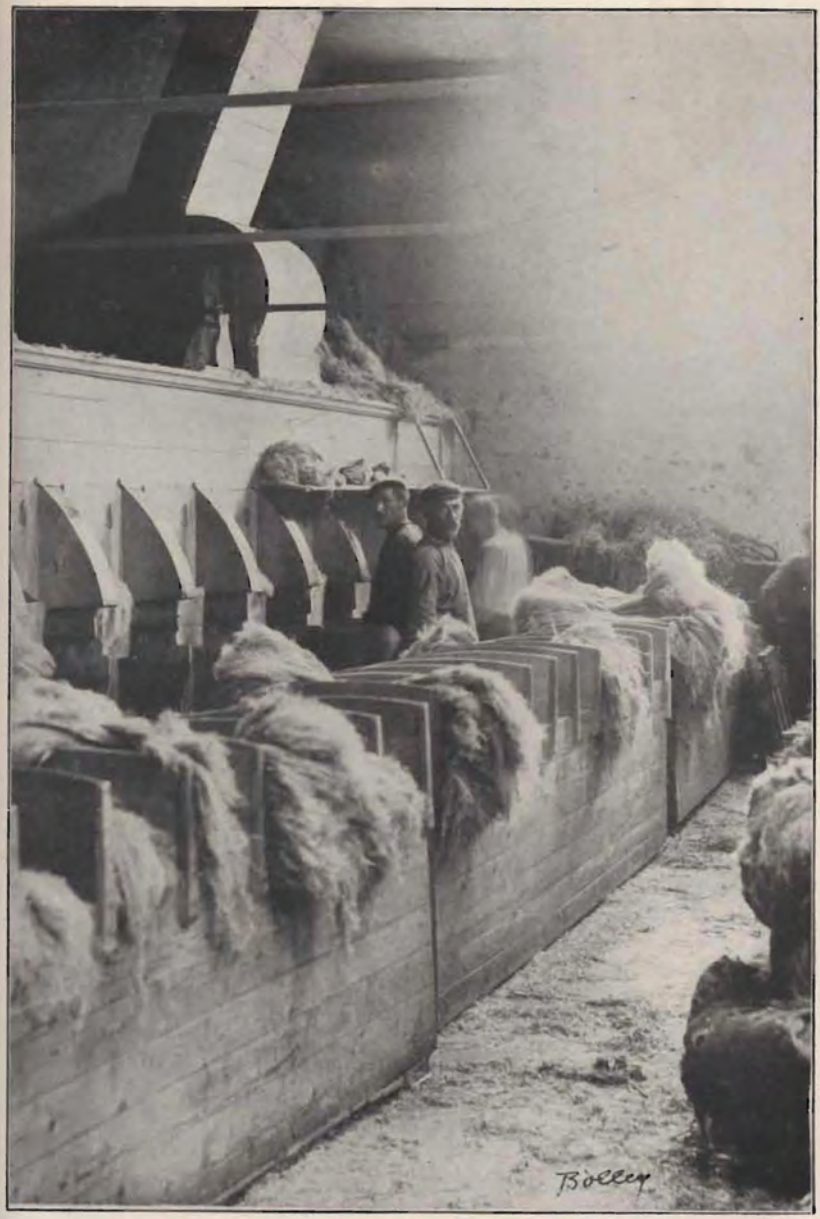

Plate 9. A Belgium scutching mill showing position of the laborer with reference to scutching wheels and the sorting stalls.

Plate 10. Fig. *a*, types of Russian labor or peasantry of the most noted flax fibre region of Russia, government of Pskoff. Fig. *b*, a portion of a typical peasant village in the fibre district of Pskoff, Russia.

Table No. 14.* Net Imports of Flaxseed By Years Into The Various Countries Named.

IN TONS.

Countries	1902	1901	1900	1899	1898	1897
United Kingdom	744,305,408	678,502,272	68*,793,536	766,620,288	693,119,616	818,514,816
France	225,549,464	240,545,536	321,086,800	281,210,440	246,177,344	313,016,088
Germany	542,248,616	522,340,896	589,893,752	586,471,536	595,129,528	578,171,384
Holland	434,497,224	384,637,904	407,634,480	472,736,944	488,596,304	513,740,024
Denmark	31,569,872	28,360,132	32,709,543	34,604,685	35,329,767	39,982,320

*Compiled from Report by Mr. Chas. M. Dougherty of the Bureau of Statistics, U. S. Dept. of Agr. for 1903, pages 409-426.

As yet the United States is not a great exporter of flaxseed. Its important crushing mills located at Buffalo, Minneapolis, New York, and Chicago are able to practically take care of the seed crop. It is estimated that from seventy to eighty percent of the oil seed which is crushed in the United States is taken care of by four great mills in the above points. There were some forty odd mills in operation in the United States during the fall of 1902, having a combined crushing capacity approximating 30,000,000 of bushels. They were thus capable of producing approximately from sixty to seventy million gallons of oil.

Mr. Charles M. Dougherty of the Division of statistics, U. S. Department of Agriculture* has estimated that annually these mills make use of approximately twenty-two millions of bushels of seed. This would leave something less than one-fifth of the annual crop for export purposes, and practically accounts for the fact that the United States no longer imports flaxseed to any material extent. This can only be made necessary now by crop failure. Even the Eastern mills, located at Buffalo and New York, now draw upon the Northwestern states for their supply of seed. It devolves upon the northwestern farmer to perfect his methods of culture to such extent that he may be able to hold this important market. The demand of this growing country for paint and its essential mixer oil, will always insure the oil crushing industry, if the farmers can provide the seed. The oil product is mostly used in this country, but the important by-product known as oil-cake goes annually to the various stockfeeding countries of Europe, furnishing a valuable element of export trade. Statistics** of the Department of Agriculture for 1901 and 1902 estimate that practically eighty percent of this valuable by-product is sent to foreign countries. The amount exported during that period being 582,886,775 pounds. The chief users of this product are listed as United Kingdom, Denmark, Holland, Belgium, France and Germany. These cattle and dairy countries not only make use of the product from their own crushing mills but feed all this imported material, including nearly the entire cotton seed oil-cake product of the United States, and practically all of the oil-cake from

*Last Citation, page 432.

**Year Book of Dept. of Agriculture, 1902, page 431.

flax seed, sunflower seed, and other oil-producing seeds, produced in the great crushing mills of Russia. This oil-cake is not only a valuable stockfood, being highly nutritious, the chief food ingredient of which is albuminoid in nature, possessing, in a condensed form the finest type of flesh and milk forming properties, but is a product which, if annually sold away from the farm lands, is a sure means of impoverishing the soil unless the farmers make proper provision to replace the fertility by the use of other means. Perhaps, if this is done in a judicious manner, suitable cheap fertilizers may be obtained to take the place of this loss. Our farmers and cattlemen will do well to learn as quickly as possible that such by-products should be fed at home, thus keeping the fertility of the soil up to its proper standard.

Table No. 13 indicates in a general way the countries of the world which are interested in the production of fibre, also the ones which are concerned in the manufactury of the linen products. Practically every European country which produces any flax fibre uses a large amount of it in the home production of linen fabrics. The peasantry, especially of Russia, make use of a large amount of homespun cloth. Indeed the Russian export of fibre represents a low percentage of the entire amount of fibre produced. Coarse linen cloth is made at home in a small way by peasant manufacturing processes for every conceiveable kind of domestic use. Indeed, in some districts, the Russian peasant is clothed entirely from his home-grown flax products, from the closewoven shirt and feet-wrappings to a heavy and closely woven overcoat. (See plates 10 and 18.) So common is the use of this product that, in purchasing small samples of seed of peasants, the purchased amounts were often brought to the writer in small home-made linen bags of the finest strength and texture. Home-made linen twine and thread are in common use. In the larger Russian manufacturing establishments, sail canvas of the heaviest and finest quality, waterproof bagging and heavy twines are made and are articles of general consumption by the people. It is impossible to get any reliable statistical knowledge regarding these home manufacturies, the extent of home consumption, or of the actual export trade, but the observations of the writer are such that he feels certain that home consumption of flax fibre is not only of vital importance to the Russian people but accounts for the use of a very large proportion of the flax fibre of that country. One Russian statistician

estimates this home consumption as, at least, one half the actual annual product.

Through the kindness of United States Counsul Heenan of Odessa, I was enabled to obtain from a Russian official source the following export figures for the years 1901 and 1902:

Table No. 15. Russian Export of Flax Products.

IN TONS

Year.	Fibre.	Tow.	Seed.	Oilcake.
1901	215,060	25,500	123,510	145,260
1902	279,579	33,150	160,561	188,838

The oil crushing plants are scattered throughout European Russia, the chief ones of which are located at St. Petersburg Ribinsk, Smolensk, Riga, Odessa, Saratov, Samara, Kharkov, Rostoff-on-Don, Tiflis and Ekaterinodar. Some of the very largest of these flaxseed crushing mills are located in northern Russia, and draw their crush almost entirely from the fibre grown seed.

Of the mills located at St. Petersburg there are two; Riga, four; Ribinsk four; Smolensk one. These, alone, have an annual output of oil somewhat in excess of 7000 tons. The Russian peasants not only produce the chief bulk of the flax fibre of commerce, but take, on the average, a fair crop of seed. The production of fibre in Russia is almost wholly in the hands of the peasants, or in the hands of small land-owners. The larger estate owners have practically ceased to raise flax for fibre purposes, claiming that they are unable to stand for the cost of labor. This fibre producing area of Russia lies chiefly northward of the east and west line drawn through the city of Moscow. Very little of the work of fibre production is done in fibre mills. Only the crudest hand processes are to be seen in operation throughout the country. With the exception of some mills located on the estates of certain noblemen and run by the Russian Department of Agriculture for the encouragement of the flax fibre industry, there are practically no fibre mills in Russia. Mills, of the order just named, are in operation at some five or six points. I visited three of these plants, one at Goroditch in the government of Kostroma; one on

the estate of Leonard Sakowicz at the village of Diriny Gorke near the city of Porchoff, in the government of Pskoff; and on the estate of Princess Galitzin at the village of Novo-Duginsky, in the government of Smolensk. These mills are located in the greatest centers of peasant activity in the production of flax fibre. An Agricultural expert was in charge for the purpose of making demonstrations in proper methods of fibre production, including the growth of the crop. I found, at these stations named, a high order of experimental and educational work being conducted. The interest with which the peasants were supporting these plants, which were run on a sort of cooperative plan, and the results which were being obtained and produced by the peasants in the immediate vicinity of the mills were sufficient to convince me that the Russian people with slightly further aid from their Government along these and similar lines will easily be able to monopolize the flax fibre industry of the world. At present, the product of such mills may only be looked upon as sample or model work, illustrating the proper methods for such countries. The great fibre output of Russia, upon which the linen mills of the world depend, is produced in the most crude and unenlightened manner by countless numbers of individual peasants scattered throughout the whole area of European Russia. It is thus a product of great variety as to quality. The same assertion may be made of the status of the industry in other fibre producing countries of Southern Europe, including the important fields of Austria, Hungaria, and Roumania. Mills for the proper separation of fibre are found principally in North France, Belgium, Holland and Ireland. The most important of these are located along the River Lys, in what is known as the Courtrai district of Belgium.

The work of retting occupies the available space on the River Lys for a distance of perhaps ten or fifteen miles above and below the city of Courtrai. Extensive fibre plants are packed along the river bank and large area of ground are used for the various processes of preparing the straw previous to breaking. The whole process as I was informed by Mr. Arthur Vannieuwenhuyse, one of the most extensive fibre producers of the city, furnishes labor for something over 17,000 employees throughout the year.

The Condition of the Fibre Crop in Foreign Countries: As in the case of the seed crop in America, the flax growers throughout the world, in the fibre belt, have troubles owing

to the fact that the crop does not thrive for any consecutive period on the same land. We found no exception to this condition wherever investigations were properly made. In some particular soil areas the ground is able to stand the crop for a longer period than in others, but eventually there comes a period of failure. It has been previously inferred in this report, that the fibre crop of the world, as an industry, is quite permanently located. It is the general belief of many that certain small areas of Russia, Holland and Belgium produce practically all of the fibre. This permanence of location is really more apparent than fact. For example, the Courtrai country of Belgium holds its reputation not so much because of the large amount of fibre flax which is grown immediately in the vicinity of Courtrai on the river Lys, but through the importation of flax straw to that district, shipped in by rail largely from the more distant parts of Belgium, and especially from North Holland, including the present noted cropping districts of Friesland and Groningen. The chief source once was North and West Flanders and the Islands of Zeeland. The crop is now almost absent from Zeeland and the once noted district of Brabant.

When I asked English, Dutch, and Belgian importers of flax fibre from Russia regarding the proper Russian fibre areas to visit, I was always referred to the so-called Baltic provinces, especially to the governments of Liefland, Westland, Courland and Pskoff. Upon reaching these regions. I was much surprised to find that the crop was no longer to be found in good form in any of the first three of these provinces, and to learn that the present fame of Pskoff rests chiefly in the product drawn from its large areas of newly tilled, scrub, timber, and swamp lands. The great bulk of fibre, exported by Russia and accredited to the Baltic provinces, I find should properly be accredited to the enormous area of Russia lying chiefly north and eastward of the city of Smolensk; in fact, the Baltic provinces, because of their great shipping ports of Petersburg, Reval Riga and Libau, get the reputation in this matter which should fall to the woodland areas of North Russia as a whole. The export of fibre approximates 13,000,000 poods (250,000 tons) which represents the product from some hundreds or thousands, perhaps more closely said several millions of widely separated peasant plots of small acreage. Every peasant farmer prepares a bunch of flax fibre from his small plot of

ground. Often it is almost worthless in quality except only for his own use when it is worked into his coarse clothing. Oher peasant families in each commune and certain of the small land-owners excel in the growth of the crop and the production of the fibre, and they, I believe, owe their success with the crop to their peculiar system of land tenure by re-allotment. In short, Russia seems to owe her continued flax fibre and seed production largely to the same conditions which still allow America to produce a large annual yield of seed, viz., the constant use of new land and to the very small plot system of commune agriculture. The very extended area over which that plot allotment system is in vogue, rather than any peculiarity of culture, intelligent or meritorious cropping methods, I believe, accounts for the large annual peasant fibre product. The crop seemed to be everywhere subjected to essentially the same diseases and soil troubles heretofore noted in the seed crop of America.

,Conditions of Seed Crop In Russia: I found that a very large acreage of flax has been and is now being grown in Russia outside of the fibre areas for the production of seed alone; and, in this, there is no element of culture making the results attained essentially different from the new land methods of America. If one asks to be directed to the best and most noted linseed producing governments, one is always, even by the Russian agricultural authorities, referred to the governments of Tambov, Kharkov, Resan and the Kuban country of the Caucasus. I found there the great oil crushing mills; but one could not drive to flax fields of any extent. Those were always said to be "200" or more versts away. The shipments of seed to the crushing plants also always showed the marks of the estates located in the newer and more distant provinces. When located, the big Russian flaxseed fields were found to be on new breaking upon the rolling prairies in the governments of Ufa, Tchelabinsk and Orenberg. The great new seed producing areas at that time, 1903, being opened up were said to be the Siberian fields tributary to the transcontinental railway eastward from the base of the Ural Mountains, and southeastward towards Turkestan.

In conversation with Mr. Fredrick Ramm, Agricultural Seed merchant of Rostoff-on-Don, and others, I learned that the great flaxseed export from this important exporting city was originally drawn from the immediate plains of that

fertile region. Now, in 1903, I find it 70 versts nearly fifty miles, to the nearest estate interested in the production of linseed. The Kuban River country, one of the most fertile soils in the world under cultivation, was able to produce the crop but a few years. The great estates of Baron Von Steingel and others in this vicinity and about Ekaterinodar once supplied the flaxseed for his extensive oil mills at that place. Now it is shipped in from distant parts, tributary to Steppes of Don and lower Volga. The crop there is grown principally upon virgin lands which may be said to lie northeastward of Stavropol throughout the district touching upon Samara, Ufa, and Orenberg. There are also some extensive crushing mills located at the city of Stavropol. All features of agriculture and of the flax crop indicated that the once famous region of the Caucasus is no longer producing the seed crop with any certainty. I quote from a conversation with Mr. Emile de Sarbo, agent for the grain exporting firm of Lewis Dreyfus & Co., resident of the export city of Novorossisk: "Flax growing in the Caucasus is about over." "The soil is exhausted. It is flax tired." "Dreyfus & Co., exported in 1898 200,000 tons of flax seed from the Caucasus; in 1894, 150,000 tons; in 1902, 15,000 tons; and this year (1903) to date Oct. 18th, we have received at this port but 8,000 tons. The crop does not now pay the farmer."

The writer visited the offices of this export firm in all of the principal governments, including those at the cities Novorossisk, Theodosia, Tambov, Voronesh, Orel, Kharkov, and Odessa. The firm, with its home offices in Paris, is especialy interested in flaxseed, exporting the same to the great oil mills and paint factories of France, located at Versailles and other points. Their agents were thus informed upon all matters of flaxseed production. The story of the different managers was always the same, viz., that it is becoming more and more difficult to get the seed in quantity, except by shipping it from distant districts. The flaxseed crop was once a paying one in all of these regions named above, but is not only becoming reduced in yield, but the seed is becoming scaly and of less value for oil. These features and conditions point to the shortlived nature of this crop as at present handled not only in America but in Russia, and teach that the country which first learns to grow it in a regular rotation as a staple will be repaid by sure profits and an almost certain market. A con-

Plate 11. Fig. *a*, peasant farmers plowing in the fibre region of Pskoff, Russia, showing type of plow in common use, the "*soika.*" It is only a forked stick with a hammered steel point. Fig. *b*, the peasant harrow in common use throughout the Pskoff district. The teeth and frame work are held together by home-made flax fibre rope.

Plate 12. Fig *a*, a rather fine crop of Russian fibre flax, government of Smolensk. Estate grown. Fig. *b*, the common method used by the Russian peasantry in drying the flax straw preparatory to removing the seed.

trast of European and Russian soil and climatic conditions with similar American features also convinces the writer that we have throughout the United States a range of climate and soil which will allow of the development of both the seed and fibre industries under natural conditions to a stage even superior to the best found in all Europe.

Growth Periods of the Flax Crop: The flax plant of cultivation is naturally an annual and is, therefore, limited to climatic and soil conditions which are suited to the growth of such plants. In certain southern regions, including southern France, it is sometimes cultivated as a winter annual. But such varieties are found to mature when sown as spring crops in the usual flax growing regions. The complete growth period varies somewhat according to the types or varieties and quite considerably according to the soil and characteristics of the climate of the region in which it is grown. It may, however, be looked upon as a short season crop. It is quite common for the seed crop to be matured in from two and one-half to three months. This makes it a very important one for northern regions. Indeed, the fibre crop, as has been previously noted, may be produced in very splendid form in regions so far northward that few other crops may be successfully matured. The entire growth period of the plant may, for convenience, be divided into the period immediately following seed germination and preceding the development of the regular foliage leaves, the period from the seed leaf stage to the blossoming stage, the period of flowering and boll formation, and the period of maturing. Very much depends upon the conditions of weather and soil during these periods as to the final types of the products produced; and it depends whether growing the crop for the production of fibre or seed, what sort of weather one should hope for, and what soil conditions he should strive to maintain. Generally speaking, a slow and irregular growth will result in the formation of a woody straw and a poor type of fibre product. There may or may not be a good seed crop produced under these conditions. If one is striving to produce a long, even growth of fine fibre, everything possible should be done to gain an even, rather rapid growth season. To this end one selects the type of soil and climate under which to attempt to produce a good type of fibre, and then makes arrangements to provide that texture and drainage of the soil which will give as constant a water supply as possible. Anything which

checks the growth of the straw during the period preceding boll formation is sure to result in an inferior type of fibre. If a drought sets in, at some time when the straw should be making its greatest strides in length and increase of diameter, there is sure to be a formation of woody straw and a thickening and hardening of the fibre cells, and the straw becomes contracted, stunted, and brittle.

In the case of the crop being grown for seed purposes, an even growth season is almost of like importance for not quite the same reasons. It is extremely important in this case that the atmosphere should be sufficiently dry to cause a sturdy, woody type of stem growth, and a heavy production of foliage for the reason that seed production demands a strong branching plant body with large leaf surfaces. In order that the boll formation may be numerous and perfect, and the seeds may be well filled, large leaf surfaces expanded to the sun and air are a necessity, as these are the manufacturing source of seed contents. Too much moisture throughout the growth season results in weak and imperfect stems, and poor boll and seed formation. If a severe drought should occur at or near the time of flowering or boll and seed formation, it prevents the proper flow of sap and occasions the hardening and ripening of the straw, especially of the narrow and thin necks upon which the bolls are formed, thus cutting off the proper supply of food materials from the seeds. Every effort should, therefor, be made to provide a type of soil which will maintain to the last a sufficient supply of moisture. The oil plant when supplied with a sub-soil moisture will stand very severe conditions of atmospheric heat and drought. In the natural seed producing areas of Southern Russia and the western Dakotas, one of the chief causes for the sudden reduction in yields, which otherwise promise to be heavy, is often largely to be attributed to the rapid drying up of the narrow necks or pedestals supporting the bolls. This is sometimes due to diseases, but often to a lack of sufficient moisture in the plant body to keep the sap flowing through delicate branches while the sun is hot and the air is dry.

A period of extreme importance in the growth of the crop is that which immediately follows seed germination. It is of the utmost importance that the germination should be rapid and that the soil should be in such condition as to allow the seedlings to immediately come above the surface,

This accounts for the great care which should be exercised in the preparation of the soil for the seed bed.

Culture Methods: The necessity of arriving at some systematic methods of flax culture which shall be recognized as of special merit is of first importance, when considering the question of establishing the crop in any particular region. In America, there is a great difference of opinion as to what methods should best be pursued in preparing the seed bed, sowing and harvesting the product. Generally the crop is looked upon as a side issue, and is cared for without much uniformity of effort and method. I was not a little surprised to find that even in the old flax producing regions of Europe, definite knowledge as to the best methods of handling the soil and seed is hardly to be had except from observation. I found a great diversity of belief. I think, however, that I can make a fair statement of the processes generally followed and indicate the methods which may be hoped to give the most satisfactory results. While different men gave widely differing views as to what ought to be done, the conditions, under which a successful crop was always found, were carefully noted, and it is quite evident that these are usually quite uniform.

The Seed: The most successful growers place great stress upon the care with which the seed is handled, and upon the type and character which is used, but it is a peculiar, indeed, strange feature of the entire system of flax culture that, no matter what region is visited, one finds that the producer of the crop believes that he should send to some distant region to procure seed. It is evident that this belief alone would result in a very thorough mixing of all of the kinds, types, or varieties, and at the same time place a very slight premium upon the idea of seed development or seed breeding. In Holland and Belgium I found no person of note who grew fibre seed for seed purposes. In all Russia I found only two estates upon which a specialty was made of this feature, indeed, only two estate owners who believed that a finer crop of flax could be developed on one's farm, should he persist in a method of grading and developing his own flax seed. It was just on these two estates, and upon other estates for which these men had furnished seed, that I observed the purest and finest grade of fibre flax. In southern Russia, in the regions of Kharkov, Tambov, and Poltavia, there are to be found a large number of pure seed farms, some of which give some

attention to the breeding of seed flax for oil purposes. In Holland and Belgium, I find that the growers of fibre rely almost wholly upon seed which has been shipped in from Northern Russia, claiming that such seed is of greater vitality than the home-grown products. Practically all Netherland grown fiber seed is sold for seed purposes in Ireland. American growers of flax for fibre purposes also import from Russian dealers. To quote from the Secretary of the Promotion of the Flax Industry, Mr. G. A. Hasselman: "Dutch farmers think that they get best results by importing seed from the cold Baltic provinces to the warmer regions of Holland." No better reason was offered by any of the growers whom I questioned. Mr. Hasselman gave no definite reason why the Irish farmers preferred the Dutch grown seed, except to say that: "They will not pay the price for the best imported seed." All growers insisted that good results could be hoped from the use of imported Russian seed only, and from the Dutch seed of the first years' growth from the Russian seed. They speak of these two types of seed as Riga and Riga-child meaning the seed exported from Riga, and the Holland grown crop of the following year. The thrifty Dutch export practically all of the Riga-grandchild seed to Ireland.

Mr. A. den Hoed, President of the Society for the Promotion of the Flax Industry, when asked why the Dutch farmers do not grow their own seed or produce it to sell to their neighbors, answered that "The crop from Riga-grandchild," that is seed which had been produced upon the second year crop of flax after importation to Holland, "usually dies early in the field." This Mr. den Hoed believes is due partly because the seed was really weaker and of poorer germinating power and partly because of the presence of "brand" (Flax wilt.) He also indicated that the value of land for the production of the fibre crop was too great to allow its use for the production of seed. This last statement, it seems to me, is possibly the best argument the Dutch farmer could advocate against home grown seed, and that a very poor one. I observed that, wherever the flax was sufficiently thin upon the ground and allowed to mature, the Hollanders raised a good quality of seed. As we have previously noted, the climatic conditions of the best flax regions of Holland are similar to those of the best Baltic regions. After visiting Russia and finding the conditions under which the Hollanders and others must expect

seed from the Russian trade, I am convinced that the raising of properly cared for home-grown seed would be of great advantage to the entire Dutch fibre industry. This statemen is made here in order to impress the American flax producer that, if it is ever hoped to make the crop reach a standard of excellence, he must cease to buy seed of unknown quality, and proceed to grow the crop from seed of known pedigree. Experiments with farm crops have for a number of years shown that crops in their climatic environment do not degenerate by being grown for a long time upon the same type of soil. The cause of weakening depends upon other features which are not properly considered. The Holland grower persists in sowing the seed thick upon the ground in order to give the fine type of fibre straw. He also pulls the straw while yet somewhat immature that he may procure what he considers the best grade of fibre. The result is that each year the seed becomes weaker and weaker. Those who are in the business of growing fibre flax can well afford to set aside a piece of ground, in order to produce a sufficient quantity of thoroughly matured seed of a pure type with which to seed their lands, sowing less seed per acre in order to gain proper seed vitality.

I find the amount of seed used throughout the different regions corresponds quite uniformly. The Russian growers who sow the crop for oil production approximate quite closely one-half bushel of good seed per acre. The Dutch, Belgium, and Russian growers of fibre flax sow quite uniformly an amount approximating from eight to ten pecks of seed per acre, according to the strength of the land and the moisture conditions which the crop can stand. The Russian seed costs Hollanders approximately from $3.00 to $5.00 per acre, because before sowing great care is taken to grade out everything but the very plumpest and best seed. This feature of flax seeding in Holland, I think, in a large part, accounts for the fact that flax wilt does as little damage as it does in that region.

A study of the seed houses in Holland which import seed from Russia, and a study of the firms in Russia which gather up flaxseed for exportation, convinces me that the only recommendation which those firms can give the seed which they handle, is an assurance that it is Russian grown and viable. The Russian seed merchants do not profess to procure seed of particular type or strain. Practically all

of the seed of Russia is grown in small lots; is collected by middle men and sold to large exporting firms in Moscow, Riga, Reval and Petersburg. It thus comes to these firms in a thoroughly mixed state, yet the condition corresponds quite markedly to that of our elevator handled flaxseed in this country. The only way to get a pure strain of flaxseed of a certain productive capacity is to select a good strain of the seed as it is grown in the field, and breed to it and keep to it by proper handling and selection.

Flaxseed is, because of its capability of absorbing water, and because of its oil, of a nature which readily loses its viability. It is particularly susceptible to injury by heating in the bin, by exposure to high dry storage temperatures, or by exposure to slight amounts of moisture under conditions of low temperatures. As the young plants are particularly susceptible to the action of molds and other fungi which attack the seedlings and the mother seeds at the time of germination, it is of particular importance that the seed should be stored dry so that the spores of such fungi cannot gain hold upon the seed. Flaxseed for sowing purposes should, therefore, be harvested dry, and stored in a cool, dry place. In this connection, an interesting custom was observed among the peasants of northern Vologda, Russia. Those who attempt to save flaxseed usually keep it in the unthreshed bolls. They claim that the longer seed flax is thus kept, the surer the crop. I could get no explanation, but was compelled to pay three times as many kopecks per pound for three year old seed so stored as for seed of the season of purchase. Such a method of storing would perhaps tend to prevent injury from dampness and heat, possibly loss thro parasitism in the new crop.

The Land: In America, I find that flax growers make little distinction as to what type of soil they select on which to grow the crop. Speaking generally, farmers of Holland, Belgium, Germany and Russia likewise seem to make little distinction. My observations teach that the kinds of soil, upon which the crop reaches the standard of perfection, are quite uniformly the same in all regions, though fair crops may be raised upon a great diversity of soil types, according to the varieties and methods of seeding, climate, etc.

For the fibre crop, the texture of the upper layers of soil should be such as to give a finely compact surface, well drained, but of sufficiently sandy and loamy nature to allow

the first growths of the root system of the young plant to be rapid and yet not be so loose as to cause rapid drying, or so finely compact as to cause baking and cracking. A feature of greatest importance is that there should be a heavy, rather compact sub-soil capable of persistent retention of moisture. The best types of the fibre crop of Holland and of Russia were found upon soils which seemed to possess these general characteristics with a fine admixture of seasand, giving a type of surface which could stand a large amount of water without baking and cracking in time of partial drought. As elsewhere indicated, the matter of fertility seems to be of minor importance. The flax crop can be grown upon so poor a soil in chemical fertility, that scarcely any other crop may be hoped to successfully develop, if the other more important features are present. In hot, dry regions, where the seed crop is more common, the features of the soil which are of extreme importance are those which insure a shallow but compact seed bed, a rapid first growth, and a steady water supply from a heavy, underlying sub-soil. While good crops of seed flax may be grown upon light lands with a gravel sub-soil, this can only be expected in years when the season of boll formation is given an abundant rainfall, or its equivalent is given by irrigation.

As to the application of manures and fertilizers, the Netherland growers do not recommend barnyard manures upon lands which are to be used for the production of fibre. They claim that it produces too much wood in the straw and thickens the fibre. Many growers, who deal with lands of light quality that need pushing, apply a light top dressing of salt petre near the blossoming period. This is said to lengthen the growth period and soften and lengthen the straw.

The more able producers of fibre in the district of Yaraslav, Russia, a region of very light, sandy soil, make use of commercial kainites in considerable quantities with apparent success. Mr. Leo Piotraschko, agricultural delegate from the Ministry of Agriculture to the Government of Yaraslav, informed the writer that these fertilizers gave much greater economic value than any other. "We recommend from eighteen to twenty-six pood per dessiatin." Equal to approximately 250 to 400 pounds per acre. The cost in Yaraslav was found to be, according to the amount applied, from three to ten dollars per acre. Mr. Piotras-

chko considered that the use of these fertilizers on such lands gave an increase equal to 40 percent of the crop production. He also found that the application of phosphates were of value, but beyond the means of the peasants in this district. As in Holland and Belgium, all Russian growers of note condemned the use of stable manures, saying that too much brash wood was formed with the straw. From these considerations, it is evident that the matter of soil fertility and the use of fertilizers is one which must be worked out for each individual district, indeed, probably for each particular farm. The application of properly composted barnyard manures to the crop which is being grown for seed purposes cannot be condemned, as the strong, woody stem, in this case, is of material benefit in seed production. North Dakotans have found that the application of barnyard manures to this crop in the presence of the flax wilt disease is extremely harmful, the land being quite ruined for flax in some cases by one application. I have, after investigating the matter, come to the conclusion that this, in all cases, may be traced to the fact that diseased flax straw had been used for feeding the cattle, bedding them down, etc. Flax disease fungi were thus able to permeate all of the resulting manure. Thorough compositing of such manures has been found to be a preventative of this trouble.

As flax is now grown, the importance of selecting new or previously unused land seems to be almost imperative. It is probable that this feature of culture can only be escaped by a judicious system of crop rotation, soil resting and seed treatment, not because the soil is exhausted for flax, but because of disease features. The Hollander relies chiefly on the newly reclaimed lands bordering on the sea, the so-called "New Poulder" lands. This, I believe, is not due to the fact that these lands are less liable to attack by flax fungi; but because the water content is better on these lands. It is found that these new lands soon become thoroughly diseased and fail to produce, as in the case of the old lands, wherever flax is grown in anything like a successive crop.

It was also found that the Russian fibre crop in its best form it to be found upon newly cleared scrub lands. Successful crops upon soils of older cultivation were found only on those estates where judicious rotation or rest periods are practiced. Until a wise system of rotation or

Plate 13. Fig. *a*, Russian peasant boy, and rather fine plot of peasant grown fibre flax, Smolensk. Fig. *b*, Russian peasant women removing seed from common seed flax to procure the straw for fibre purposes. These women threshed nearly 700 acres in this manner, their only pay being the straw. Estate near Orenberg.

Plate 14. Fig. *a*, extra fine quality of fibre straw grown in the wooded districts north east of Vologda, Russia. Fig. *b*, photograph showing the manner of spreading straw for dew retting, government of Yaraslav, Russia.

Plate 15. Fig. *a*, showing the common hand break used by the Russian peasantry. Fig. *b*, hand scutching paddles for removing the seed Vologda district, northern Russia.

soil rest can be introduced, a farmer who expects success ought not to undertake the production of the flax crop on other than practically virgin soil. He must also practice careful seed selection, grading, and treatment, if he wishes to continue succesful production for any extended period.

Seed Bed: Great stress is usually placed, by English writers on flax culture, upon the idea of deep working the soil in preparing the seed bed. This may be said to hold good, provided compactness of soil is provided. Thus writers who contend for a loosening and softening of the seed bed seem to be wholly in the wrong. The one thing that the flax crop cannot stand is a friable, loose textured soil. The best flax soils are found to be those with an admixture of very fine sea-sand or silt resting upon a heavy, compact subsoil. Where the better crops of Flanders, Holland, and Northwest Russia are seen growing, the top soil with its fine admixture of sand soon after preparation becomes very compact, save only a slight layer of surface sand, which, working to the top by rain, acts as a mulch or blanket preventing cracking and baking in periods of slight drought. The character of the soil naturally determines the time of working and plowing, but fall plowing is apt to give the best results in all those types of soil which tend to become more compact by working. In all cases in which the soils after deep plowing may become more thoroughly compact by harrowing or top working, much harrowing is desirable. In very rich, loamy, soils which are liable to become loose and friable by persistent working, such for example as the lands of the Red River Valley, the top working should be confined to the office of destroying weeds and should be stopped at the slightest sign that over-work is tending to looseness, liability to blow, etc. The aim is to provide a well worked under soil with a close texture and continuity for the ascent of water, and at the same time provide such surface working as to give a fine, shallow seed bed. Regardless of traditional theories, observations teach that a quite compact soil underlying a shallow seed bed of not to exceed one-inch debt always gives the best results. The deep plowing and working should precede the seed time just as long as possible, as its value consists in a proper aeration of the underlying soil in preparation of food materials for the coming crop, without sacrificing solidity and continuity. The capillary continuity of the soil from below

upward should not be broken by the presence of poorly worked soil or any sort of intervening rubbish.

Seed Time: The seed time for the fibre crop is always essentially the same in all regions. The seed is sown as soon in the spring as the work can be accomplished and not have the young plants injured by frost. The date naturally varies according to the latitude and climatic features. The rather cool, rapid growth months of spring and early summer tend to produce long and fine types of fibre. The fibre plant cannot withstand the hardening influence of the high, dry heat of the late summer months. In the case of the seed crop, the same features will be found to hold true in regions having a long, dry summer season. Northward and northwestward in America, including the Dakotas and Minnesota, the crop may be seeded with hope of success even until the tenth or twentieth of June, as the crop often takes on a very heavy growth in the cool autumn days. In North Dakota, if the late crop is not caught by early frosts, the yield is apt to be even greater than that from the early sown crop which, at times, may be compelled to ripen too rapidly by the action of heat in August. The early crop also seems to be more often injured by rust. However, the date of seeding in this state cannot vary much either way from May 20th to June 20th without loss from frost.

Seeding Methods: The methods of seeding are as various as the people who grow the crop. The larger areas of Holland and Belgium are seeded in ordinary grain drills, and such machinery is also used upon the largest estates in Russia where the crop is grown for oil production. Small areas in all countries are seeded by hand broadcast and harrowed in. Many fibre growers contend that this method gives best results. Russian peasants broadcast by hand almost exclusively. If evenly cast, it is supposed that all straws are shaded alike and hence mature evenly as to fibre. The chief merits of any type of seeding must depend upon three points. The seed should be imbedded at an even depth, not too deeply, and should be evenly distributed. The brush harrow as commnoly made by American farmers gives good results, when properly handled, but no scheme of broadcast seeding can give the regularity of depth that gives best results with this crop. Considering entire crops, the best ones are quite the most apt to follow the drill. Regularity of depth in seeding is of the utmost importance with flax, whether planted for oil or for fibre purposes. If seeds

are buried at different depths, there is very great irregularity of first growth, resulting in an unequal maturing. Trials at this Experiment Station demonstrate that a matter of difference in depth of planting may cause differences of several weeks in ripening the seed crop. If this difference of depth in planting exists among the plants of a single field crop, it is evident that a crop of evenly matured seed cannot be harvested; there will be at harvest time, plants in blossom, and others which are losing seed by shelling, etc. This is a common fault in the large seed fields of North Dakota and can only be overcome by the careful preparation of the seed bed, and careful use of the drill. More crop is lost in the Red River Valley region through too deep driling upon too mellow soil than by any other cause. (See plate No. 21) The young plants often are compelled to waste all of the energy stored in the seeds before they expand any leaf surfaces to the sunlight and thus be able to gain strength. With the fibre crop, evenness of growth and maturing of the straw is of first importance. The North Russian peasant harrow has none of the fine qualities of the brush harrow. It is primarily a good sub-soil packer, and a good illustration of the fact that good crops may often be produced through the use of very indifferent implements. (See plate No. 11.)

Crop Rotation: With the flax grower, "crop rotation" means something more than a good thing to talk about. He must either rotate or cease to grow the crop. This is the verdict of all important growers; and it is mine from observation and experiment. There seems to be but one other alternative, that of breeding and selection. Crop rotation is the natural remedy for many troubles which come from too constant growth of one crop upon a given type of soil. In bulletins Nos. 50 and 55 of the North Dakota Experiment Station it is pointed out that the chief reason flax fails so certainly after a few crops lies in the action of a fungus disease. But this is no argument against crop rotation, nor is it proof that continuous culture to one crop is not a ruinous policy. While flax is not a gross feeder like other plants, and it can be proved it does not feed more heavily upon the available plant foods than wheat, oats or other cereals,* yet it is probable that it has its own particular ways of depleting the soil and that a rest period, regardless of the disease proposition, cannot fail to be beneficial to the crop.

*See Minnesota Experiment Station Bulletin 47, page 5.

An effort to learn the best possible series of rotation for flax resulted in much confusion of ideas. Only one fact was characteristic of all replies obtained, viz., there should be as long a period of years intervening between flax crops as it is possible to maintain. Most Holland and Belgian growers hold that the chief necessity of long seried rotation rests in the destructive action of "Brand," flax wilt, but they also believe in the process as an essential one to general agriculture. With them it is an easy matter, because of the numerous crops available to them and the small field system with which they have long been associated. Of the best producers of fibre flax, few believe in less than seven year series. Many recommend much longer series, by the introduction of grass and pasture periods. One quite commnoly practiced in Holland runs as follows:

1. Manure or Rape.
2. Wheat.
3. Rye.
4. Legumes, usually horse beans.
5. Flax.
6. Potatoes.
7. Potatoes.
8. Fallow, rest, and crop of weeds turned under as green manure late in season.

If the soil is very fertile, potatoes follow the legumes, then flax. Mr. den Hoed, previously quoted in this report, asserted that "flax should never be attempted oftener in this series than twice in three fallow years." On the Islands of Zeeland, a point once famous for flax culture, Prof. Kakebeeke, Government Agricultural teacher at Goes, states that the following series is most to be recommended:

1. Wheat.
2. Peas or beans (horse.)
3. Sugar beets.
4. Spring Barley.
5. Beans (navy.)
6. Onions or other vegetables.
7. Rye.
8. Grass.
9. Grass
10. Flax.

Mr. Kakebeeke claimed that the best results are obtained with this rotation when the flax crop is given a dressing of commercial fertilizer consisting of superphosphates and sod-

ium nitrate so blended that the mixture will place the available nitrogen and phosphates of the soil in approximately the ratio of 7 to 10. To accomplish this result, approximately 240 pounds of the mixture is used per acre.

In Russia the peasants, according to the compulsory customs of the particular commune, practice either three or six year rotations. In the better flax producing villages, the rule is usually for a six season rotation. Wheat, two years; third year, oats; fourth year, rye; fifth year, pasture; sixth year, flax. In many districts the common process is (1) fallow; (2) wheat, rye, oats or barley; (3) pasture for the village cattle; then (4) flax year after year until the soil is practically robbed of strength to support even grass. In the northern regions about Vologda and eastward, a scrub timber country, where the population is sparce, great crops of fibre flax are grown by the "land rest" process. After each flax crop, the peasants allow the land to run wild as a village pasture and to grow up to scrub timber for ten or fifteen years. The scrub is then burned off and the breaking is cropped to flax. From this wasteful process, they grow no doubt the best fibre straw known. The process seems to provide about all of the merits of new land. See plate No. 14. With the peasants in the villages southward, the peculiar methods of allotment often break the regular rotations so that the flax crop of certain peasants may by accident be thrown upon lands which have had long periods of rest from that particular crop. This accounts for the fact that one often yet sees large crops there.

On the estate of Princess Mecheesky at Dugino, government of Smolensk, there is a government flax culture station in the very center of the noted Smolensk fibre district. The owner of this estate was much interested in flax culture both for seed and fibre purposes. The rotation series there practiced was as follows:

1. Fallow—means idle, weeds, grass and pasture.
2. Rye.
3. Clover and grass.
4, 5, and 6. Oats, spring wheat, or barley and timothy.
7 and 8. Hay and pasture.
9. Flax, oats or vetch.

This estate is a very large one and flax cannot be used for an entire crop in the series. Thus, in reality, this rotation series does not demand that flax recur as often as once in nine years. (See fig. 1, plate 12.)

The feature most observed by all is that on light soils a leguminous crop is of much benefit in preparing the soil for flax culture. If however, the soil naturally possesses much available nitrogen, the flax is placed at as distant a date from the leguminous crop as possible and is usually preceded by grass or hay crops. The most common procedure in all countries seems to place flax in the series after several years of grass and pasture. This seems important when considering escape from destructive action by wilt. During my investigations I found no farmer or agriculturalist, however, who believed that any sort of rotation series could serve as a complete specific against the occurrence of flax-sick soil. It is also self-evident that no rotation can be given which will fit all soils and regions. Our experiments at the North Dakota Experiment Station seem to point to the marked value of one or more crops of cultivated corn in the series with the flax crop preceded by hay and pasture sod of several years standing.

Weeds: Very little need be said of weeds. It is not supposed that they should be allowed in any carefully grown crop. Yet there is probably no crop in which their presence is more pernicious. In the case of the fibre crop, they must all be removed from the straw by hand before retting, a very costly process. Their presence in the crop also causes unevenness of growth and maturing with the associated evils. In the seed crop they introduce, by their extra foliage, great difficulty in properly drying and curing the seed bolls for threshing. The greatest difficulty is also experienced in attempting to grade weed seed from seed flax; and, whether the seed is being purchased for oil or for sowing purposes, there must be a loss to the grower from dockage. As the Russian peasant, even though he pulls the crop by hand, always puts into the seeds he sells all of the weed seeds available to him and, as the seed which Russian seed-houses export is made up of many separate small collections of flax seed from many different districts, one is apt to find many types of very bad weeds in any importation. Among the list of destructive weeds sure to be represented in such seed are: Flax dodder, *Cuscuta epilinum,* Cornflower, *Centaurea cyanus* and many types of mustard, including False flax, *Camelina sativa,* and various species of *Roripia.*

Harvesting the Seed: Whether used for sowing purposes or for oil, great care is demanded in the harvesting process to hold the quality of seed. The essential is that the

seed should be allowed to mature, be harvested dry and be kept so. Since there are practically no growers who practice growing fibre flax seed for seed purposes, it is easy to account for the fact that even the best which is to be had is of very uneven grade. In Russia, it is sown so thickly that only two or three of the topmost bolls are able to mature. When the crop is pulled the other bolls furnish weak, half mature, scaly seeds. No Russian peasant grows any great quantity of seed and before it reaches a seedsman in quantity, many different lots and types are mingled.

In Dutch, English and American writings upon fibre flax, much stress is placed upon the necessity of importing seed from Riga. That people who buy may not be deluded in the belief that they are getting anything wonderfully pure to type I quote from a conversation from the head of the most noted seed exporting house in Riga, Mr. A. Selmar: "We do not pretend to raise seed for seed purposes." "We never buy flax seed in the field." "We buy only from middlemen or our agents who collect such seed as they can in a particular district, small lots all dumped together, and ship it to us." "We grade it and test it." "It is impossible to promise to furnish seed year after year from the same province." "Buyers must take our word for what is best for them for any given year." "Sometimes it is all worthless in one province where it has usually been good." "We can promise, if you buy from us, that the seed you get comes from a certain province along a certain line of railway; that it is good, viable seed, but no further." "We have learned that seed for Holland should come from the wetter Baltic regions." "For Belgium, America and Ireland, the seed can be from drier regions. In this respect the different Russian districts vary from year to year." "We select our seed for shipment to the different countries wholly on our experience as to what seed is best for the people there to use." "Our seed house has had this trade for sixty years."

Mr. Selmar impressed the writer as a very earnest, able man, but conditions for obtaining pure fibre seed of any definite type, I am sure, are much against his methods: and just how he decides, at long range, which lot to send to each country is difficult of comprehension. I can only say that, while in Holland and Belgium, I received many flattering assurances that the seed firm of Selmar & Co., furnishes the most reliable seed for use in the Netherland. I found a like difficulty in all Russian seed houses. Immer of Moscow is

the only one who professess to breed pure seeds and farm them out so as to develop them in quantity. This he has not attempted for flax.

The best types of oil flax seed were seen in South Russia in the region immediately northward of Odessa. A valuable seed area is also located immediately northeastward from Orenburg. As this crop is grown upon large estates in quantities of many thousands of bushels per season, if it is wanted for export, it can be had in purer strains than can be hoped for in case of the fibre strains. This, however, is handled in masses at elevators and warerooms much after the American method, and I believe that, if pure strains of flax of even producing quality are wished, our farmers must select and grade up the seeds themselves.

Of those who have had experience with imported fibre seed, much complaint has been made because of its low vitality. I am convinced that this is largely due to the kiln drying process to which the Russian peasant in the rainy districts submit the grain. The heat in the kilns, (rigas) often becomes sufficiently high to scorch the grain. These kilns (rigas) are built in the form of small log barns over shallow basements or holes in the earth in which a heavy wood fire is built. The floor over the fire is made of logs covered by about a foot of sand through which the heat and smoke permeates to the grain above.

Regardless of all these features, Russian flaxseed, when placed on the oil market ready for the mills or for export, far outclasses the American product. It still grades plumper and brighter in either French or English markets. This I attribute to the fact that greater care is taken to insure proper drying at harvest time, and to the fact that methods of grading and caring for the seed in mass are far more carefully and sensibly accomplished in the Russian terminal elevators than in America. Much of the crop value of American farmers is lost by a bad system of mingling grain of all grades, damp and otherwise, in the shipping and elevator processes. Our elevator managers should be expected to exercise some of the good sense demanded by them of the farmers.

Fibre Processes: Though of much interest and importance, it is not possible in this report to discuss in full the fibre processes but, from that which is said, it is hoped it will be seen that the taking up of flax fibre industry in America is not to be looked upon as a matter impossible of

Plate 16. Fig. *a*, types of peasant made fibre and tow, Vologda district, northern Russia. This district is said to produce the finest quality of fibre now produced in the world. Fig *b*, unloading baled flax fibre at a railway shed, government of Pskoff, Russia. The equipment is typical, but of high grade.

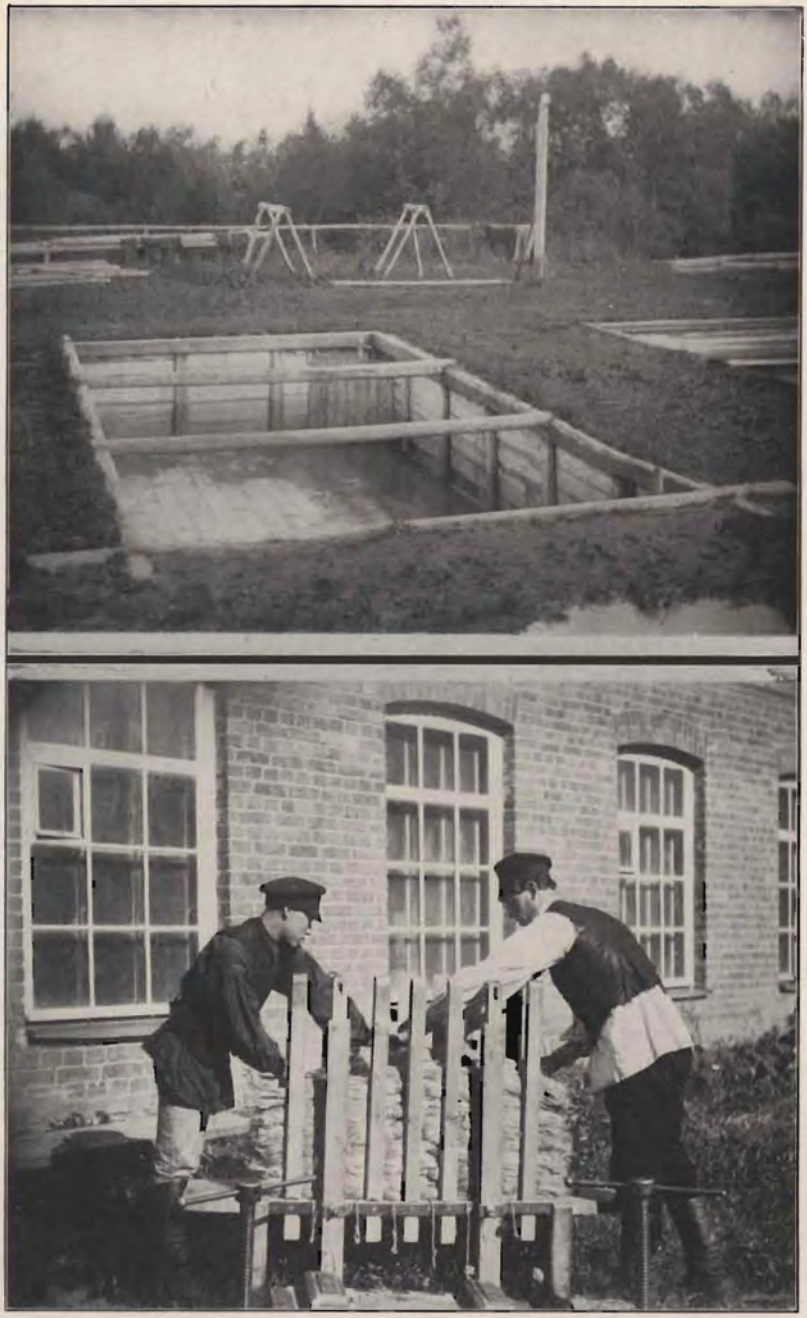

Plate 17. Fig. a, photograph showing artificial retting pools used in the pool retting method, government of Yaraslaw, Russia. Fig *b*, baling the fibre in hand press.

good results. Much has been said by previous writers of the "expert skill" of the workmen engaged in the fibre industries of Holland and Russia; but all is said for the Russian labor when it is named as "cheap labor." In the Courtrai district, long experience in the retting process, as there practiced, has developed much skill in the various processes, but no process involves the possession of superior mental ability on the part of the laborers, or knowledge which cannot be quickly gained by educated labor. As yet hardly any of the processes of flax fibre preparation have passed beyond the stage of hand labor. When machinery is used, it is of the simplest construction and operation, and usually involves much hand work.

The general steps are as follows: Pulling of the straw, removal of the seed, retting, breaking, scutching, combing, inspection and baling.

Pulling: Everywhere the pulling is done by hand. The arguments for so doing are always essentially the same: (1) There is no machine which will do the work well, and (2) it is wise to pull, as all weeds may be discarded and the crop may be sorted and thrown into proper grades of straw. Some writers claim that there is much loss of fibre if one attempts to cut the crop, for the reason that the "best fibre is located in the lower stem and root." There is little or no truth in this. The last two or three inches of stem is exceedingly woody and contains slight fibre. The root contains no fibre of value. Superintendents of some of the large scutching mills of Courtrai contended that the fibre from cut straw is unsatisfactory for spinning purposes for the reason that fibre with cut ends does not bind together in the thread properly, slips, etc. The writer is unable to speak as to the merits of this proposition. There may be some point to the thought, but it would seem to be a matter of much doubt that it can be a feature of any great importance. Clean culture would eliminate the weeds, and the seed bed which is best suited to flax culture is of so even and smooth a nature when properly prepared that proper reaping machines could be set to run so close to the earth as to remove practically every inch of valuable straw. There is no successful pulling machine now in use, though some persons have attempted to contrive such. The crop as now grown in the Red River Valley could be cut and bound in bundles so as to lose less than two inches of valuable straw, and, if special effort were made to prepare the soil, even less loss would

need to be the result of harvest. The cost of hand-pulling by American labor would probably be too great for us to hope to compete with foreign labor in the production of fibre, although it is surprising how rapidly the crop can be pulled even by hand. The fact is not that it is particularly slow work or particularly hard work, but American laborers do not like to work upon types of labor which they think ought to be done by machinery even if there is no machine capable of doing the work. The best Belgium labor for pulling the crop may be had from one to three francs, approximately twenty-five to sixty cents per day. Russian labor costs approximately the same amount per day, but as practically all fibre work is in the hands of the peasant owners, one cannot well estimate the labor there, and it may be looked upon as, in reality, not to be compared with the Belgium labor for cost. Fibre efforts in America should be placed upon as strict a machine basis as possible. (See plate No. 1.)

Threshing or Seed Removal: In European fibre work, the seed is always removed by hand, or such simple machinery is used that hand labor is the main element. The attempt is to save the fibre in the small branches upon which the bolls are located. Much care is placed upon the proper drying of the straw and seed bolls or capsules so that the work of seed removal may be as easily affected as possible. The crop is sometimes left in small bundles or swaths as pulled; then dried and stacked. Sometimes it is kiln dried, or often, in peasant districts, hung in bunches upon fences and other sorts of racks. (See plate 12.)

In Holland and Belgium, the crop is often shipped or hauled by train direct to the retting grounds and threshed there, or stacked and threshed afterwards during the winter period. One may see on the stacked areas about the River Lys near Courtrai ten or fifteen miles of stacked straw waiting for the spring retting season. Among the peasants of Russia, the straw is held in small handfuls and the bolls crushed between simple wooden rollers without running the straw between the rollers; the bolls are stripped off through metallic combs, or more often mashed off through crushing by a sort of flattened mallet, as at Courtrai. (See plates No. 2 and 13.)

The European growers contend that proper saving of the seed crop should give sufficient seed to pay for all of the farming processes, indeed all of the steps in the culture of

the crop up to and including the process of retting. The Russian peasant, forgetting his own labor, thinks the seed should pay for all processes leaving him the fibre for profit.

After the seed is removed, the straw is either set immediately to retting or is stored until the proper time for that work. This proper time depends upon the season of the year for all of the processes.

In the River Lys country the straw is collected and saved for the spring retting at or near the retting grounds. (See plates 3 and 7.) The Russian peasant, because of his urgent needs, sets to work at once after harvest by either the dew or rain retting method or by the pool or pond method. The Russian Government does not allow the use of the rivers or streams for this work. Much is done there to save the streams from pollution in order to protect the quality of the water supply and save the fish.

Retting: This is the process of freeing the fibre from the woody and gummy substances so that it can be easily removed by processes of breaking and scutching. The work may be done either by chemical means or by the slower process of fermentation or rotting; by rotting in water or by a weathering process through exposure to dew, rain and sun. The last process is also one essentially of fermentation. The great mass of flax fibre of the world is produced by the natural fermentation method. To present date, chemical methods have been found too costly and have not received the sanction of fibre men as to the matter of fibre quality. Some very pretty types of fibre have at times been freed by chemical means, but large plants for such work are not as yet successful. The various chemical methods, yet used, result in bleached fibres with which the trade is unaccustomed, preferring the raw fibre color.

Of the natural retting processes, the work in the River Lys near Courtrai, Belgium, is the most perfect and extensive. Approximately 17,000 laborers are employed yearly for this and associated types of work in the immediate vicinity of that city. During the winter, autumn, and spring months, many thousands of tons of flax straw are shipped in by rail from northern Holland, especially from the Gronigen, Brabant, and other districts, indeed, from all parts of the Netherlands. Sometimes the seed is removed before shipping, but quite often the entire crop is purchased by retting firms, and the seed removed at or near the retting grounds. The straw is freed from seed, straightened, pre-

pared in bundles and stacked. It is probable that the Lys is more used than other neighboring streams, not because of any particular quality of the water, but rather because there have become centered in this particular region the greatest fibre and linen mills in the world. The retting work extends over a large area of the land surrounding the river for a distance approximating fifteen or twenty miles. The stream flows slowly through shallow banks, is approximately four rods wide by six to eight feet in depth. The retting work is limited by law to the period between April 15th and October 15th; and is commenced promptly on the opening date and is eagerly pursued to the close. At the beginning of the retting season the straw is straightened and tied in neat bundles, approximately eight to ten inches in diameter with one-half of the butts turned either way, thus forming a compact bundle of equal diameter in all parts, approximating three feet in length. (See plate No. 3.)

When ready for retting, these bundles are placed in large crates having board bottoms and open sides. These crates are about twelve by fourteen feet by four feet deep. A layer of coarse straw, usually rye straw, is placed in the bottom, and the sides of the crate are lined with coarse gunny sacking which acts as a protection against sediment and floating matter. The bundles are packed in tightly, standing upon their ends so that the straw remains vertical and only one tier deep. When filled, the flax straw is covered with about one foot of coarse rye straw, weighted with plank and stone, shoved out into the river and sunk.

The period of immersion depends upon the activity of the fermentation or retting processes. These depend upon various features and conditions of the water and straw including matters of temperature, water constituents, bacterial activity, etc. Straw, which it is intended to work into the finest types of fibre, is often immersed in the river two or even three times with a drying and rest period interposed. This method of slow or discontinued retting is supposed to give even results, and results in a finer preparation of the fibre with least injury to strength and quality. If only one immersion is used, the time is extended over a period ranging from five to fifteen days according to the circumstances involved in the particular crate. Experts make daily examinations of the straw by withdrawing parts of it as the process proceeds. Much depends upon stopping the fermentation at just the right stage. When the conditions are sat-

isfactory, the crates are drawn ashore by heavy teams, the bundles cut open, and the straw arranged in small stooks as shown in plate 6. This stooking of the fibre straw to dry, and the rebunching of it in order to stack it between the retting processes, is exceedingly tedious and exacting work and accounts for much of the cost connected with the retting processes; for the straw must not be crinkled or entangled during the process. Two immersions is the rule at Courtrai. This demands two dryings and two stackings. A month rest is usually given in the stack between the dips. It is probable that the resulting evenness of retting comes from the gradual water action, allowing the action of the water in the second dipping to be more effective in degumming the fibre without too long a period of bacterial action, which is injurious. As the entire process is largely a matter of bacterial distribution and consequent decomposition of the intercellular substances, the reasons back of the various processes become quite easily understandable. While the Russian government does not permit of the genral use of streams and rivers for retting purposes, the writer often saw the peasants along the banks of the Kamma and Volga sinking small bales or bundles of flax straw in fish nets, or encased in gunny sacks or otherwise enclosed, in the margins of the river, showing that they sometimes take advantage of a quick and easy method of retting the straw other than that allowed them in ponds or by dew-retting processes. The Russian Model Experiment Stations for Flax Fibre Culture and Fibre Production, mentioned elsewhere, are striving to teach the peasantry improved methods of handling the straw along the lines commonly followed by the peasants, aiming to improve the work as done in the pool or pond retting and dew retting processes. Director Korenvitch of the Station located at Goroditch has experimented with river retting in a rapidly flowing stream at that place, and has this to say regarding the matter: "Flax retting in the river can be done more quickly than in the pool or pit." This, I think, is interesting as illustrating that a special type of water highly charged with organisms due to much retting is perhaps not necessary. No other retting was known to be done in this stream and yet Mr. Korenvitch says: "The work is nicely finished in the river in eleven days, while it takes thirteen or fourteen days in our pits or pools." "The fibre produced in the river retting was found to be of better color and much stronger." As I observed the content of the water in his

pools or pits, I think it possible that he was trying to do too much retting with a small water supply. Indeed, it is probable that the water was allowed to become too heavily charged with products of the retting process, thus preventing the proper action of the retting organisms and perhaps injuring the quality as to texture and color. As observed elsewhere, I drew the conclusion that perhaps this worker did not sufficiently often change the water in the pits or pools. This might account for his strong endorsement of river retting as against pit or pool retting.

In Kostroma and various other Russian fibre districts, the peasantry used a combination of shallow pool and dew retting. They commence work in the fall as soon as the seed can be removed, wet up the straw once by immersion in some shallow pool for a period of one to three weeks, weighting the straw down by logs or stones. The straw is then removed direct to some grassy meadow and spread in thin swaths for drying and further dew retting. (See plate 14, fig. b.) The dark color of the great bulk of the raw fibre produced by the Russian peasantry is accounted for by the carelessness with which they carry out these processes, often allowing it to remain either too long in the pool or too long on the grass, allowing it to rot rather than to ret. Their numrous religious holidays are a factor in this matter, the peasant often being away from his work several days at a time.

The process practiced at Pskoff Flax Fibre Station was the modified "pool" or "pit" method. This process was, for some strange reason, spoken of by the Russian peasantry as "Amerikansk." They have a tradition that a very bright American introduced the method, although I could not find out definitely at what time or by whom. At the Experiment Station they told me that it was introduced in 1882 by a German, but, as the process was something new and interesting, the natives immediately called it "Amerikansk." At the Experiment Station very fine results were obtained by this method of work. By this method the straw is stacked until May and is immersed in deep pits or pools encased in heavy planking or logs capable of holding many tons of straw in bundles. (See plate 17, fig. a.) The retting processes are continued through the summer months very much in the manner followed in the river work at Courtrai. The pits at this particular station are happily placed upon a hillside in such manner that the water from the spring

above is allowed to pass through a series of pipes from one pit to another and, as there is an automatic arrangement governing the inflow and outflow of the water, the temperature of the fermenting straw and surrounding water can be kept at a very regular point. When the straw is first put in and the water turned on, the temperature rapidly rises, but it is not allowed to go above 35 deg. R., approximately 110 deg. F. The outline of the process as given me by Supt. N. P. Maysnekovitch, showed the following steps: (1) The bundles of straw are introduced in the pit and wet up for a period of twenty-six hours.

(2) Water turned off and the mass of straw allowed to heat for 36 to 48 hours, care being taken that the temperature does rise above 35 deg. R. (approximately 110 deg. F.)

(3) The water turned on again with sufficient refreshening to keep the temperature down, the straw being allowed to remain from one to three weeks according to the progress of retting.

(4) The straw is next spread out in swaths upon the grass to dry and dew-ret for a period ranging from one to three weeks according to conditions observed by the expert.

(5) After proper drying, it is placed in bundles and stacked dry. The breaking is done in the winter time in the usual methods.

The scutching process, as followed here, is essentially the same as that observed at Courtrai, the fibre being tied in small bundles and baled in about the same sized bundles. (See plates 9, 16 and 17.) Such a fibre mill is run upon a sort of co-operative plan, the peasantry being payed for the straw which they bring to the plant approximately one-half cent per pound, if it is properly prepared for retting. The process would be possible on a co-operative plan for American farmers, using machinery chiefly for handling the straw. This pool or pit method resembles in some features the hot water or bacterial process which is now being tested in various places, notably at Olnkerk, Friesland and at Dubrovky in the government of Pskoff, Russia. The so-called bacterial method meets with some success at Olnkerk but the people at the Pskoff Station thought it not a success in that the cost was too great. The process consists essentially in immersion of the straw in large wooden vats or tanks containing water which is kept at a high temperature and grade of fermentation. A pure culture of fermentation bacteria or retting organisms is placed in the tanks. These organisms, which are

essential to the best results, then predominate in the water. The temperature is kept at 32 deg. to 35 deg. Centigrade for about forty-eight hours. It is said that flax can be well retted in this short period of time if the cultures work properly. It is possible that this process could be developed and the straw mostly handled by machinery. As at present in operation, the process can hardly be said to be out of the experiment stage.

Breaking and Scutching: After it is retted, the straw should be bright, thoroughly dry, and have a rather sweet odor. At Courtrai the straw, after being retted, is dried and stacked and remains in the stacks until the close of the retting season when the breaking and scutching operations commence. As the wood, skin or dark parts are harsh and brittle, and the fibre elastic and tough, the straw is broken or crushed in such a manner as to cause the wood to drop away from the fibre masses. This process is called breaking. The straw may either be crushed by pounding with mallets or crimped in some sort of breaking machine.

The hand break in most common use by the peasantry of Russia is shown in plate 15. It is a wooden horse higher on the end next the workman than on the other, and grooved in the back in such fashion that a grooved break-beam or stick hinged at the lower end fits as cogs into the grooves of the horse beam. The break-beam gives a crimping effect with a sliding break and serves well to free the woody bits of the straw from the fibre. The straw is held in small bundles or withs in one hand while the break-beam is operated with the other. Hand scutching consists in beating or shaking the bunches of fibre in such manner as to knock out the broken bits of wood, without entangling the strands leaving the fibre in proper shape for combing and the further processes preliminary to spinning. Although the breaking and scutching may well be done by machinery, yet, at best, much hand labor is needed in order to keep the fibre properly bunched, graded and free from snarls. That which becomes much snarled must be disposed of as tow.

The usual machine break consists of pairs of horizontally placed fluted, corrugated rollers through which the retted straw is passed endwise. There are usually from six to twelve pairs of such rollers so adjusted that each pair crimps somewhat more closely, and fits more tightly together than the preceding pair. (See plate 8.) The scutching is done by means of flattened paddles. If done by hand, a bunch of

Plate 18. Fig. *a*, trained Russian peasant labor twisting rope from flax fibre to be used in baling the product. Model fibre plant, Yaraslav. These men, as well as those shown in Fig. *a*, Plate 10, with the exception of belting, hats and sandals, are clothed wholly in home-made linen. Fig. *b*. a rather typical sample of flax straw of high fibre quality, government of Smolensk, Russia.

Plate, 19. North Dakota grown fibre straw from seed of same parentage as that of Fig. *b*, Plate 18, seeded at the rate of one bushel per acre, one and one-fourth bushels per acre, two, and two and one-half bushels per acre, showing that fineness of fibre quality depends largely upon thickness of seeding. Greatest length attained, 47 inches.

Plate 20. Four types of flax fibre, and a bundle of North Dakota grown Russian fibre flax seeded at the rate of one-half bushel to the acre, showing the coarsest form, 47 inches high. Binder twine type. No. 1, best quality Courtrai made fibre. No. 2, best quality North Russian (Vologda) prepared fibre. No. 5, hand broken and partly scutched at the North Dakota Experiment Station from coarse straw similar to the that shown alongside. No. 3, hand broken and scutched fibre prepared from North Dakota grown dew retted straw.

broken fibre is held tightly in one hand while a glancing stroke is made with a thin, smooth paddle, the process being continued until all of the coarse bits of broken wood are removed. In the regular scutching mills, the work is done by a set of revolving paddles, while the fibre is held in the hand of the operator in such manner that the paddles hit it a glancing blow as it rests over a rounded, smooth-edged board with slanted sides or edges, the ends of the bunch of fibre being reversed from time to time during the process.

In the properly arranged scutching mill, there are a series of stalls for the operators, in each of which scutch wheels revolve upon a power shaft. There are twelve paddles to the wheel, and the wheels revolve at the rate of 150 revolutions per minute. The paddles thus strike regularly upon the fibre at the rate of 1800 times per minute. Because of this regularity of action the operator is able to judge to a nicety the progress and finish of the work. As it is an exceedingly dusty work, ventilation stacks are provided with hoods covering each wheel and an air blast carries off all dust and light matter. See plate 9. At the Courtrai mills, it is a common practice to divide the scutching process into two or three periods, placing the fibre in cold storage during the rest period between each scutching. This method of work is said to give flexibility and "life" to the fibre.

Sorting, Baling and Grading: The scutching process results in cleaning the fibre of all the woody matter, and while this is being accomplished the operator throws the flax in separate piles according to his judgment of quality. It is then tied into small bundles and finally baled, each bale being supposed to contain fibre of equal quality as to market value. It is baled under pressure into small bundles approximating 200 pounds. (See plate 17.) The best qualities of fibre are usually encased in covers of coarse gunny sacking, and each is marked by a particular mark indicating the grade or quality before it is allowed to be placed on the market. This is done in the large warerooms by opening the bales sufficiently to draw samples of the fibre. The writer often saw the process of grading in operation. Mr. A. den Hoad, President of the Dutch Society for the Promotion of the Flax Fibre Industry, kindly gave full explanation of the various processes and purposes, demonstrating the methods while inspecting in the large warehouses in Leuwarden, Holland. The tests applied are those which may be characterized as matters of personal sense, expertness, and cannot

well be gained except through long association with fibre work. It was observed that in all types of the finest fibre grades, the fibre strands were perfectly free of woody or extraneous matter and entanglement. The color of the best types were usually of a pale gray, shading slightly to a light golden greenish cast. If too raw or green in color, it may represent an insufficient retting and degumming. If too white, it is found to have lost pliability, life and perhaps strength. Very dark gray types of fibre, such as that usually sold by the Russian peasantry, represent undue retting and exposure to weather, whereby much strength and pliability is lost before the process of artificial bleaching may bring the fibre back to a useable form.

The Value of the Fibre Crop: Not having investigated the American import market regarding the value or prices paid for imported flax fibre, I am not able to give an estimation of the value of the fibre in this country. It is also quite difficult to give an idea of the value of the crop produced in foreign countries. This is the more difficult because of the variable grades of labor exercised in the different countries concerned with the culture of the crop. The following quotation of figures, as given me by men of much fibre experience, may be looked upon as quite reliable estimates for the districts represented. Mr. Geo. A. Hasselman, Sec'y of the Dutch Society for the Promotion of the Flax Fibre Industry, said: "If all does well, the following is about what may be expected. There are, however, many factors which enter to reduce the profits obtained by ordinary growers of flax fibre; and the crop, as labor now stands, can hardly be said to be a paying one."

Table Showing Cost of Flax Fibre Production in Holland.

Cost of seed	15	florins	per	Hectar,	approx.	$2.40	per	acre.
Sowing and weeding	21	"	"	"	"	3.30	"	"
Pulling	26	"	"	"	"	4.16	"	"
Removing Seed	26	"	"	"	"	4.16	"	"
Cleaning Seed	6	"	"	"	"	.96	"	"
Transporting the straw to retting grounds	15	"	"	"	"	2.40	"	"
Retting	59	"	"	"	"	9.60	"	"
Scutching, etc.	165	"	"	"	"	26.40	"	"
	333	"				$ 53.28	"	"
The product produced equals approximately 300 stone of fibre per Hectar, valued at 1.8 florins per stone, or appproximately						$86.40	per	acre.
Seed removed valued at 115 florins per hectar, approximately						18.40	"	"
Rough tow saved valued at 40 florins, or approximately						6.40	"	"
The net gain per hectar 362 florins, or approximately						60.32	"	"
Total						$111.20	"	"

Mr. Arthur Vannieuwenhuyse, a large fibre producer at Courtrai, reported: "We give the farmer for a very fine standing crop of fibre straw 1000 francs per Hectar. For this amount we get the seed and straw." As this is approximately $80 per acre, including the seed, it will be noted that these two estimates correspond quite closely. For the Russian work, Mr. Leonard Sakowicz of Dubrovka, Pskoff, gave the following figures:

Pulling	4	ruples	per dessiatin,	approximately	$ .90	per	acre.
Sorting the straw and taking the seed	4	"	"	"	.80	"	"
Preparing the straw in bundles for retting	6	"	"	"	1.20	"	"
Retting finished	6	"	"	"	1.20	"	"
Breaking	6	"	"	"	1.20	"	"
Scutching and baling	12	"	"	"	2.40	"	"
			Total		$6.50	"	"

"The product in fibre straw will be approximately one hundred to one hundred eighty poods per dessiatin, about 1300 to 2400 pounds per acre." This is a much higher average yield than was usually estimated for the Russian crop of fibre straw. One thousand to fifteen hundred pounds will represent the average much more nearly, where grown under good conditions, while the peasant on his overworked plots seldom gets anywhere near this amount. It will be observed also that the estimate for the cost of the work of preparing the fibre is very low as compared with the cost as given in Courtrai. This is due to the fact that Russian labor as employed in such work is even of less cost, and the Russian peasant thinks himself well off should he get from four to six cents per pound for the fibre, which approvimates $10 to $40 per acre for his crop.

Flax Diseases: Much effort was made to gain information concerning the chief flax diseases and the relation of each to cropping methods. I had hoped to learn much regarding the flax wilt, and the various damping off diseases which have proved to be so seriously destructive to the American seed crop. Careful observations were made at all European cropping points with a view of ascertaining facts which might aid in combatting these destructive troubles.

Previous to these European studies, the author had learned that a soil trouble is recognized in practically all flax producing countries. It manifests itself in a gradual

dying of the crop from the time the seed begins to germinate until the crop is quite mature, in the later stages giving the appearance which may well be designated as wilt. As the plants rapidly dry up after dying, they assume a blighted appearance as if struck by fire. The flax crop gives a fair yield upon new land, but if allowed to follow itself in reasonably close succession, soon ceases to be profitable, for the crop dies away to such extent that there is not sufficient stand left to pay for the work. The soil is then said to be "flax-sick" or "exhausted" for flax culture. It was also demonstrated at the North Dakota Agricultural College Experment Station* that the trouble is not primarily with the soil, that the soil is not chemically exhausted, but the trouble is rather due to the presence in the soil of micro-organisms. The chief one of these organisms has been named Fusarium lini. The author has since found that there are several species of *Fusarium* which act in the same manner, and that a species of *Colletotrichum* is quite destructve at times, and that various species of *Alternaria* are able to do much damage to the flax crop under certain weather conditions. Several of these fungi may be acting separately or together, and yet give many of the characteristics of the disease which are usually noticed. The studies, previously mentioned, demonstrated the fact that these fungus troubles are usually introduced into a new soil by the seed which is sowed, and bits of old straw, chaff, and other matters which contain the living organisms, are also thus distributed in the soil. It was also proved that in proper treatment of the seed by the formaldehyde method, recommended in those bulletins, there is a possibility of successful prevention of the occurrence of the diseases, provided the land is not already infected. It was also shown that marked benefits may arise from proper crop rotation, and the fact was noted that various individuals, varieties and strains of flax may exhibit a high grade of immunity or resistance to the attacks of these wilt diseases.

These points being well in mind, observations were made in the European fields in accordance: (a) As to what diseases have existed; (b) What, if any, means are used to control or escape the troubles; (c) Selections were made of seed samples with a view to trial in America as to their value in crop production upon soils known to be infected.

*See bulletin No. 50 and 55.

Tersely stated, all types of the trouble in the American crop were found in the various European crops in varying degrees of destructiveness. Generally the producers of the crops were not acquainted with the fact of the presence of an infectious disease and did not recognize the same as a definite soil trouble, but usually spoke of it as being either "flax-sick" or "flax-tired." The impression prevailed everywhere that something had been taken out of the soil, which is necessary to the growth of the flax crop. In Holland, the trouble was given the definite name of "brand." But it was quite generally conceived to be due to soil exhaustion. In Germany the trouble is given the quite descriptive term "bodenmuedigkeit." In Russia, one was quite uniformly told by the Government Agrinomes that no flax troubles existed, but it was found in serious form in almost every flax growing district. The peasants sometimes, spoke of it as due to soil exhaustion, and sometimes, I was told, looked upon it as a form of "visitation."

Flax wilt fungi were not found to be as destructive in Holland as in America or in Russia. There are various reasons which may be assigned, the chief of which rest in the nature of the soil and extreme care with which the Hollanders grade the seed to evenness of strength and quality. When thus doing, they discard all dried particles of straw and shrivelled seeds. We have learned in our early experiments that these matters constitute the chief source of soil infection. The careful pulling of all of the straw and its removal to distant retting grounds, I think, also tend to dispose of one of the great sources of disease accumulation in the soil. In America, great masses of flax stubble are plowed under each year. This decaying mass serves to foster and develop the wilt diseases throughout the entire flax area so that a given field is often so thoroughly filled with fungus the first year, that no flax can, therefor, be grown. The Russian peasantry spread the straw upon the grass of adjacent fields to carry out the process of dew retting, thus quite effectively infecting such soil areas. It was observed that the disease was much more prevalent near the retting grounds surrounding Courtrai than elsewhere in the Low Countries. The disease was found to be no respector of soils, though, usually, most destructive in all cases of droughty lands and those possessed of sub-soils incapable of retaining the moisture. The newly reclaimed lands in Holland, "New Poulder," were quite often badly attacked, but

their high even water content served to save the crop from extreme injury. These soils are also quite evenly compact, and this is also found to materially favor the growth of the crop against the disease. It is found to be quite destructive on soils tending to alkalinity. Soils which were evenly watered from below, and of quite fine, compact texture were affected least. Much of the seashore lands of the Netherlands is quite compact because of the fine admixture of sea sands. I believe that the Hollanders might wholly escape from the ravages of this disease, if they would but practice seed treatment for prevention, for the reason that their fibre soils and climate do not seem naturally suited to the development of the wilt diseases. They also practice such sanitary rotations that the culture of the soil is of the most cleanly character. As to the preventative nature of crop rotation, however, no scheme was found to be wholly effective, and no able Hollandish farmer claimed that soil once "tired" or "sick" could be freed from the trouble in less than eleven or twelve years rest from flax. Tne fact, however, that a seven to eleven year rotation and pasture, as usually practiced, continues to give good paying crops of fibre-straw, indicates that such methods are of much practical merit in controlling the diseases.

The fact of continuous seed importation from Russia is sufficient to account for the continued existence of "brand" in the Netherlands in spite of the high grade of seed cleaning and cleanly farming practiced. As noted above, if the Hollanders, working as carefully as they do at present with regard to their seed and soil, should each have his own seed plot and should practice the formaldehyde method of seed treatment, I believe the disease would be of no important effect in that country. This, too, is the only hope for American flax industry. No hope lies in the importation of seed from other countries, as I have found that the disease is world-wide in distribution and is most notably abundant in Russian seed fields.

As the Russian export seed is of mixed origin, similar in its conditions to what one would expect in an American elevator, one may expect to find many examples of wilt infected seeds in almost any export sample. The wilt diseases, *Fusaria* and *Colletotrichum*, were often found to be exceedingly destructive upon the Russian peasant plots. This is easy to account for from the fact that some of these plots, due to the characteristic chance allotments, come al-

most continuously under flax culture for long periods of time. An extensive fibre crop was visited upon the estate of Leonard Sakowicz of Dubrovka, Pskoff. Mr. Sakowicz grew many acres of fibre flax for the purpose of seed production and had an extensive business in selling seed to the peasantry of different districts. Very little wilt was to be found on his estate, while the crops of the peasantry on neighboring plots were almost destroyed. Mr. Sakowicz practices careful rotation and seed selection. He had grown his own seed upon the same estate for over twenty years; and it was much the best type of fibre flax which the writer was able to find in the Russian regions. A similar condition with reference to disease was noted at Dugino in the government of Smolensk on the large Mecherska estate (See plate 12, fig. a) when comparison was made with the crop of the peasantry of surrounding districts. Peasant areas of the seed variety were often noted to suffer more severely than similar areas sown to the fibre varieties. These observations correspond to similar ones made in North Dakota, where it is observed that the fibre varieties seem to be much more resistant to all types of flax disease than are the seed varieties. I attribute this feature to the fact that fibre flax has been retained in cultivation quite persistently in the same regions and upon the same types of soil, especially by the peasantry of Russia, Germany, and other nations, while the seed crop has been usually a migratory one, being seeded commonly upon virgin soils or soils of comparatively new breaking and thus not subjected to the natural selection occasioned by the action of parasitic fungi.

The Flax-Wilt Disease, Widly Distributed: As suspected in our previous studies, the flax-wilt disease is proved by these European studies to be widely distributed. It was observed in fields in Holland, Belgium, France and Germany, Austria, Hungaria and in many parts of European Russia, including Southwestern Siberia and the Caucasus. I have also had specimens of the disease forwarded to me from Japan and Australia; and have found the spores of the two chief wilt diseases in seed flax from Argentina. Studies made in several great Herbarium collections also prove that the disease has been of long standing and is to be looked upon as cosmopolitan with the cultivation of the flax crop.

Herbarium Studies: Native and cultivated plants collected in the ordinary way and stored in herbaria and museums, though collected to show typical plants, often are

found to bear the diseases which are characteristic of the various species. For this reason, careful studies were made of cultivated and native flax specimens stored in the various college and museum herbaria. There are somewhat over 100 species of the genus *Linum* recorded in the various herbaria. Of these, *Linum usitatissimum* represents the common cultivated flax from which we obtain the various varieties of fibre and seed flax under cultivation. It is probable that the big seeded varieties should be classified as *Linum humille* Mill. Many of the wild varieties of the genus *Linum* are quite distinct in characteristics from ordinary types of cultivated flax. The agricultural varieties may be looked upon as annuals. The native wild flax plants most nearly related to the cultivated varieties are usually perennial in character, as for example, *Linum austraicum, alpinum* and *L. perenne.* The beautiful garden flax, *Linum angustifolium*, is an annual and is quite similar in character to the agricultural varieties. Over five hundred specimen sheets were examined in the University of Munich, and it was observed that the native perennial plants were quite commonly attacked by a flax blight fungus of the genus *Colletotrichum.* Only fourteen specimens of *L. usitatissimum* were found in these covers. One of these was attacked by the characteristic boll disease and was collected in 1902 near Calcutta, India. Two were attacked by the wilt *Fusarium*, and were collected in the neighborhood of Calcutta some time previous to the year 1850. Over nine hundred specimen sheets were examined in the Kew Gardens, London. Over one hundred named species were represented in this collection. The collection is world-wide in its origin and gives fine facilities for determining the question of distrbution of the various flax diseases. It was found that the wilt producing *Fusaria* and the blight fungus, *Colletotrichum*, and the boll attacking *Alternaria* are quite world-wide in their distribution attacking the cultivated flax varieties, either in cultivation or when running wild.*

These diseases were found to be present upon specimens

*This is well illustrated by the following notes accompanying the specimens collected by Mr. J. Gay on the Island of Jersey. I find these and several specimens, by the same collector in France and in the Island of Jersey, were well marked with the wilt fungus, *Fusarium Lni.* His notes with regard to the specimens were as follows: "*Linum*" *angustifolium* Huds. Dans les landes entre St. Aubin et St. Britandes, Isle de Jersey, le 13 daout 1832."

"Il eioit tres commune aubord du chemim dans un lieu tres elongue des des cultures."

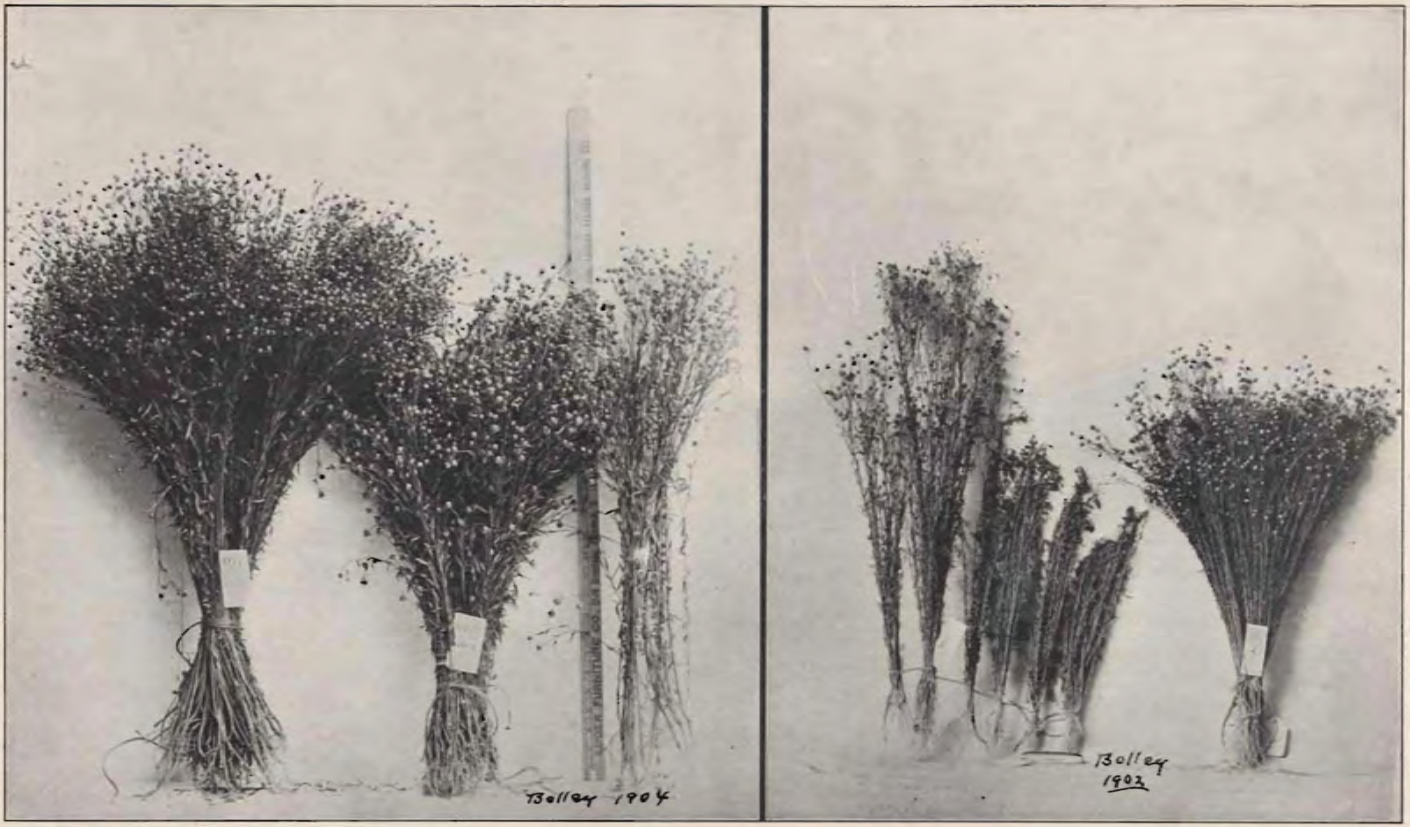

Plate 21. Fig. *a*, types of North Dakota grown Russian seed flax of three evidently distinct varieties. Fig *b*, bundles of flax all grown from the same varieties of seed, seeded on the same day upon the same plot, pulled and photographed to show the evil effects of the irregular planting as to depth: ½ inch, 1 inch, 1-½ inch, 2 inches, 2-½ inches and three inches. Notice the uneven grade of ripening, variation in height, etc. The crop in Fig. 2 was planted evenly at one inch depth.

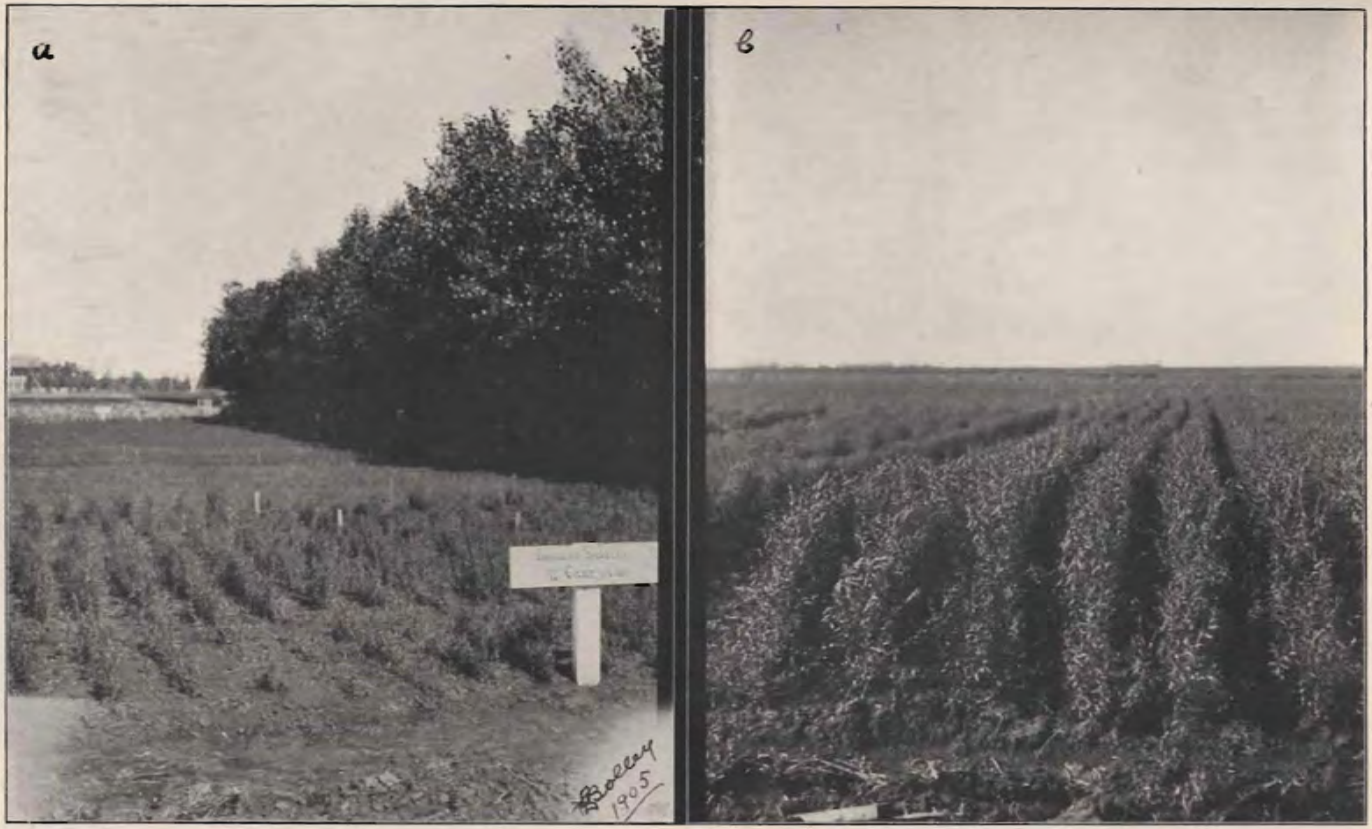

Plate 22. Fig. *a*, flax sick ground showing the method of testing the various samples of Russian flaxseed to determine their resistance to diseases. Second year's trial. Notice the dying away of the crop. Fig. *b*, crop of "immune No. 22" flax grown upon rotation plot No. 30, at the North Dakota Experiment Station. Twelvth consecutive crop of flax. This shows what hopes there may be of procuring disease resistant flax.

collected as follows: John Lang, 1851 and 1852; by J. Gay, Spain, 1856; by J. Gay, Cambridge, England, 1834; by Roucher, Hungaria, 1884; by R. Gay, summit of Jura Mts., 1875; by Boisser, Switzerland, 1867; by J. E. Stocks, Beloochistan, 1851; at Cancapes, Africa, 1880; by J. E. T. Aicheson, Afghanistan, 1879; by G. M. Potanin, Shanghai, China, 1886; by unknown collector, Dehar, India, 1867; and by Dr. Giles, North India, 1885.

The *Fusarium* or wilt fungus is most common upon cultivated flax and, of the above stations, was found on the Isle of Jersey, in Spain, North China, and in North India. The anthracnose, fungus *Colletotrichum*, was quite common upon the perennial types of flax, such as *Linum perenne* and *L. Austraicum*.

These investigations upon herbarium specimens leave us no doubt that the present soil troubles are not new manifestations. They are but extensions of diseases which are characteristic of the native flax plants and are perhaps more strongly developed upon cultivated varieties. It is very probable that in proportion as these cultivated varieties are very delicate and luxuriant in growth, the diseases have become more destructive in their powers. It is also evident that the troubles are wide spread; and as the fungi, which cause the diseases, are of the semi-saprophytic type, having power to live upon decayed matter, as well as powers of parasitism, we think it may be looked upon as present in more or less quantity in all regions where flax is grown at all. For this reason, while seed treatment and careful, cleanly cultivation may tend to prevent rapid soil contamination, it is not probable that it may be possible to wholly escape such troubles by these means. Our studies also convince us that there are numerous species of native flax that are not subject to the action of such parasites; certain species which are but slightly open to attack, and that the cultivated varieties used for seed and fibre show marked variation in ability to resist the attacks of these different fungi. There is, therefor, much to be hoped from the work of intelligent selection of varieties and from the work of careful individual selection, cross breeding, etc. within the varieties.

Varieties of Field Flax, *Linum usitatissimum*: Considerable attention was given to the question of the existence of fixed varieties within the species, known as *Linum usitatissimum*, common field flax. Most practical growers through-

out Europe and especially in Russia contend that there are no truly fixed varieties. It is commonly said that it is a matter of inter-gradation. Mr. L. Sakowicz, the most able grower of fibre flax met with in Russia, contended, for example, that white blossom fibre flax is not stable, that on his farm it passes gradually into blue flower flax within three or four seasons. He also said that seed flax, "*Rogatch*" of South Russian plains, quickly develops into "*Dalgonets,*" long fibre flax, when properly handled in the fine fibre producing climate of Pskoff, and the longest, fine fibre, "*Dalgonets,*" characteristics of the Pskoff region, soon reverts to coarse, short straw, "Rogatch", common seed flax, when sown under adverse conditions southward. He even contended that the big seeded variety of flax "*Siclisky,*" Sicilian flax, soon degenerates into the common seed when grown in Southern Russia. Numerous observations made throughout the different countries, however, allow me to come to the conclusion that there are several well marked varieties of cultivated field flax. Of these there are at least two species, *Linum usitatissimum*, L., including all of the small seeded varieties and the *Linum humille* Mill, including the big seeded varieties. I am inclined to think that at least two more species should be separated, viz., the common white flower and the common white seeded. These, however, are not as yet recognized by Botanists though they seem to me to be of sufficient distinct characteristics. We may, therefor, list:

(1) Common blue flowered fibre flax (Dalgonets);
(2) Common blue flowered seed flax (Rogatch);
(3) Dehescent boll, seed flax (Kudratch);
(4) Common white flowered fibre flax; and
(5) White flowered, white seeded flax.

Of the big seeded, the Sicilian type, *Linum humille*, the following types are noted:

(1) Sicilian, big seeded, blue flowered seed flax, some times grown as a winter variety (Sicilisky.)

(2) Big seeded, white flowered, white seeded flax.

(3) Indian seed flax, Egyptian seed flax, and Argentine seed flax are large seeded varieties of a character almost midway between the Sicilian big seeded flax and the common Russian seed flax. Each has some qualities distinguishing it more or less definitely. There seems to be many intermediate grades or strains between the two species mentioned

and within the various varieties named. Because the crop has always been grown without much care as to purity or variety, there has been much intermingling and mixing, possibly cross breeding, and it is a matter worthy of experiment to determine just how far the so-called "running out" of varieties is due to cross breeding, and how much is due to mixing from careless handling of seed.

Studies conducted upon the varieties of these two species of cultivated flax plants tend to indicate that there is quite close fertilization. Individual flowers, for example, produce seed freely whether in association with other flowers or not. The structure of the flowers, while they might allow of cross fertilization, is such as to indicate that they do not usually do so to any great extent. The writer thinks that practically all cases in which the different varieties are cited as "running out" may be traced to careless seed handling and mixing, whereby the common type of seeds characteristic of a particular region, soon predominates over a poorly-cared for imported strain. It is possible, however, that cross fertilization may in part account for the feature noted, and, if the crossing can take place with comparative ease in nature, it would certainly account for the disappearance of an imported strain when the latter is largely surrounded by a variety common to the entire region. Extended experiments are now being conducted at the North Dakota Experiment Station to settle this point in a definite way. The numerous varieties and strains obtained in these explorations being of much service in determining the point.

Samples of Seed Collected: That the Bureau of Plant Industry of the Department of Agriculture, and the various State Experiment Stations interested, might have a wide range of seed strains of the common varieties of cultivated flax to conduct experiments upon for the purpose of seed breeding and selection, and for the carrying out of various experiments characteristic of the flax industry, samples of seed were collected from each vicinity visited. Special efforts were made to secure all types represented in the present culture of European Russia, for the reason that the different peasant communes for a long time had but slight intercommunication, and the peasants were liable to use the same seed over and over again upon land which was for a long time heavily infected by the various flax diseases. It was thought that in some of these isolated villages there might be found some quite well marked varieties, and some

possibly possessed of a high grade of disease resistance. Two hundred and seventy-two samples were brought back, representing various districts from all points in the route described in this report.* No large quantities of any particular sample were taken, but sufficient amount only to serve the purpose of several propogations and trial tests. After being thoroughly graded at the Department in Washington, these seed samples have since been placed under trial on a number of different Experiment Station Farms, and all of them have been given trial under the same conditions of planting upon the grounds of the North Dakota Agricultural College Experiment Station. In thus giving them close comparative trial under one date of seeding and one type of soil, judgment could be drawn as to purity of variety, variation in type, etc. The experiments at this Station are being recorded year by year along three distinct lines: (a) As to yield under normal culture; (b) As to yield under the conditions of flax-sick soil; (c) As to purity of strain or variety; and finally, individual selections are being made with a view to procuring absolute purity of strain and variety and, if possible, types of standard value for either oil, or fibre production. The matter of disease resistance is of chiefest importance and a wide range of selection is afforded because of the widely separated regional origin of the seed samples, giving a fine chance for success in this work. The first two season's work upon flax-sick soil has demonstrated marked variation in disease resisting powers, and leads to the belief that the idea of procuring disease resistant types or strains is well founded. (See plate No. 22.) The samples all show wide variation as to yield and quality of fibre and seed. (See plate 21, fig. a) The report of the performance of separate samples, however, will more properly figure in separate reports of the different experiments. It is sufficient in this report to note that the most disease resistant strains are found among the fibre types, and the samples which have shown it in the highest degree we obtained from Russian peasant crops grown under the severest climatic and soil conditions, and under the poorest type of agricultural work. This may perhaps serve as a clue to plant breeders, indicating that they should sometimes give their pet breeds and strains cultural trials under hard and trying

*The samples received the United States seed introduction numbers 9897 to 10167 inclusive.

...ons of culture and of disease development, rather condu... ...der the most favored conditions. It may than always ... ...con-
then perhaps be better decided whether the type under consideration is fitted to give a strong performance under the ordinary conditions of agriculture.

The Future of the Flax Industry in America: Although the oil and fibre branches of the flax industry in America depend upon the demonstration that flax can become a permanent crop in any given locality in the same sense that wheat, corn or cotton, are now permanent elements of agriculture, the observations teach that there are regions where, even now, without special knowledge of the existence of the disease, the farmers have succeeded, through careful culture and rotation, in saving the crop, keeping it a permatent element of agriculture. The most noted locality is that immediately surrounding Courtrai in Belgium. Our experiments in North Dakota, and the observations of this exploration trip teach that there is only one bar to the possibility of the crop becoming a permanent one here, viz., the presence of soil infecting and soil persistent diseases. Now, we have learned how to avoid infecting new areas, and of the necessary cautions which are needed to prevent the spreading of the diseases from the infected soils. The most important features of this work consist in each farmer raising, cleaning and grading, his own seed flax, and in seed disinfection.

What To Do: Raise your own seed. Grade it to a plump, bright type, removing all particles of chaff and bits of straw, then treat the seed before sowing.* Our European experiences in the most noted flax areas and our North Dakota experiments upon crop rotation tend to show that this feature of sanitary cropping may aid materially in prolonging the continuation of this crop in a particular soil or locality. Chemical experiments show that flax does not partic-

*The method of seed treatment now followed on many North Dakota farms is essentially as follows: Good, bright, plump, yellow flaxseed is selected and cleaned in a fanning mill until only heavy weight seed remains, blowing out all bits of straw, chaff, dust and scaly seeds. The formaldeh de solution is made to the strength represented by sixteen avoirdupois ounces of standard forty % formaldeh de to forty gallons of water. The cleaned flaxseed is laid upon a canvas or tight floor in quantities of five to ten bushels, and the seed is gradually moistened by use of a fine spray thrown from a small force pump, while it is being rapidly shovelled or raked over. In this manner, the flaxseed rapidly moistens over its external surface, and can be thoroughly dampened without causing it to mat together, the process taking one-half gallon of solution per bushel of dried seed. It is of advantage to cover the pile of seed with a canvas or blanket for a few hours after treatment to keep the exterior of the pile from drying to rapidly. Grain thus treated, when once or twice shovelled over, will readily run through an ordinary drill in a couple of hours after treatment.

ularly exhaust the plant foods in the soil, at least, not more so than many cereal grains. Trials of the fibre crop in Oregon, Michigan, Wisconsin, North Dakota, and other states of the Union, have proved that fine grades of fibre can be grown. Retting and scutching tests, conducted at the North Dakota Experiment Station upon North Dakota grown fibre straw, show that the fibre is of good form, and of splendid strength. (See plates 19 and 20.)

Tow mills in North Dakota and Minnesota give good remuneration so long as flax culture remains in the neighborhood of the mill, sufficiently close to allow the straw to be hauled without loss. That is to say, they would pay well if the ordinary seed crop can be grown rather continuously in a particular neighborhood. Flax fibre binding twine is now being made from North Dakota and Minnesota grown straw with success, and, as we are told, with profit. Undoubtedly there is room for many more such home grown products. Our home experiments teach that fibre straw can be grown in the Red River Valley exceeding one meter in length, without perceptably reducing the yield per acre as seed flax is now grown. Such straw furnished to the binder twine and cordage plants would, I understand from a study of their work, relieve them of the necessity of using other fibre as a leader in the twine making process.

Practice a long period series of crop rotation, in which is included at least two cultivated crops, and two or more years in grass and pasture.

Avoid using poorly composted barn-yard manures which contain flax straw.

After using tools, such as plows and harrows upon wilt infected land do not use the same tools upon other land until they have been properly cleaned.

As to starting the fibre industry in this country, it is thought that success may be brought about along two lines. Our farmers who come from European fibre districts, and are familiar with hand processes of fibre making, dew retting, hand breaking and scutching, etc., might add very materially to their farm economy by persisting in this work along the same lines as conducted in Europe, doing the work in seasons of the year when there is no other farm work and using such improvements upon the appliances as ordinary American intelligence suggest. The pool-retting plant and scutching mill, I believe, could well be run in conjunction with the present type of tow mills now found in the various

flax areas, or could be conducted on a small cooperative plan in almost any community without great cost, upon some such plan as is now represented by the American cooperative creamery industry. I believe small cooperative plants started in localities most suited to fibre growing would speedily solve the present fibre industry question in this country. While most of the work can be done by hand, when such plants were once in operation, simple American machinery would soon take the place of almost all the necessary hand processes. I saw no step in the whole process, as represented at Courtrai, or in the pool retting plants in Russia, which could not be possible on a machine basis. Who and what community will first demonstrate American ingenuity in this matter and prevent in part the present enormous annual losses to American farmers represented in flax straw?

As to the matter of continuing the culture of the crop, proper seed selection, cleaning, grading and treatment, together with proper soil cultivation and crop rotation, will make possible the continuation of flax fibre and linseed industry in America. If these steps are not soon taken by our farmers the crop is doomed.

HENRY L. BOLLEY,
North Dakota Agricultural College
Experiment Station.—March 1906.

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