FLAX: THE FIBER AND SEED. A STUDY IN AGRICULTURAL CONTRASTS [1]

SUMMARY

The old culture and the new, 500. — The two groups of products, 501. — European fiber culture, 504. — Modern flaxseed farming, 504. — Pulling and rippling fiber, 506. — Harvesting flaxseed, 507. — Preparing fiber; retting, scutching, 508. — Attempts to apply machinery to fiber production, 514. — Machinery applied to flaxseed farming, 519. — Migrations of the flaxseed crop, 521. — Attempts to establish fiber production in the United States, 523. — A comparison of productive agencies, 524. — The reasons for separate production of fiber and seed, 525. — The principle of comparative advantage, 526.

FLAX has been cultivated from time immemorial for the strong and enduring fibers of the plant. Out of these, prehistoric man first made his lines and nets, and later fashioned his clothing and household fabrics. Flax fiber, or " line " as it is commonly known, was the first spinning staple; and linens, supplemented by woolens in the colder climates, held the foremost position among the textiles until the industrial revolution of the eighteenth century. The use of flaxseed or linseed in industry is comparatively modern. Tho the medicinal and food values of the seed were known, the peculiar drying or filming property of the oil contained

[1] The writer has gathered much of his matter from observation and investigation prompted by the use of one of the flax products in manufacturing The case of flax was clearly set forth twenty-eight years ago by Professor F W Taussig in " Some Aspects of the Tariff Question," vol III of this Journal. I am indebted to him for helpful criticism of this paper. Reference is made to the following books and papers J G. Wilkinson, Manners and Customs of Ancient Egyptians, F. Kellar, Lake Dwellings of Switzerland and Europe; A J. Warden, The Linen Trade; A S. Moore, Linen; E A Whitman, Flax Culture, U S Department of Agriculture, Fiber Investigation Reports, H L Bolley, Flax Bulletins, North Dakota Agricultural College; Flax Culture, Bulletin 274 U. S Department of Agriculture

in it was not generally recognized until the fourteenth century. This important discovery made possible the rise of the art of oil painting in the Renaissance, and created an entirely new set of material demands. A new group of commodities then appeared gradually, and in time an essentially different branch of flax production. In surveying flax culture from its very beginning we find three periods. At first the plant was cultivated for fiber only. Then from the fourteenth century to the close of the eighteenth century it was still cultivated for fiber primarily, tho there was a secondary production of seed for oil from the same plants. Finally, after the industrial revolution, flax came to be grown for seed only, particularly in connection with the opening of new lands in this country. The older countries still continued to grow flax for fiber.

Thus we now have two separate and distinct cultures, which appear to be confined closely to seats of production possessing certain natural or social advantages. The older countries of Europe have retained the ancient flax fiber production. The newer countries have developed the modern flaxseed farming. Between the new culture of flaxseed as a grain crop and the old culture of flax fiber as a garden and handicraft product, there are many contrasts interesting to the student of economics. This article will sketch some of the more striking features and examine the causes which seem to determine the source of supply of the varied commodities produced from the flax plant.

Of these there are two groups—the flax fiber products or linen textiles; and the paint and covering products of which linseed oil is the base. The first group comprises the time-honored and beautiful linens, damasks, lawns and cambrics, in addition to crash, bagging, nets, lines, thread and twine. The second —

the more modern and less familiar group — includes paints, varnishes, printing ink, oiled fabrics, oil cloth, linoleum, imitation and patent leather, waterproof clothing, oilskins and soap. The linseed products now form a larger item in the world's annual income than the linen textiles. At the close of the eighteenth century the situation was quite different. Then linseed oil was in little use, while linens were the universal textiles for personal and household use. The causes which brought about this revolution must be examined at some length.

There are several varieties of flax, but the blue-flowered flax plant, linum usitatissimum, yields all the fiber of commerce and nearly all the seed. It is an annual and can be grown in almost any climate. It is found in Alaska and Argentina, in the alluvial soil of Mesopotamia and the sandy steppes of Russia. Most of the seed of India is produced by another variety of flax — the yellow-flowered plant, linum trigynum. This has the same general characteristics of linum usitatissimum, from which the great bulk of flax products is derived. The plant has a pithy wooden stem covered with a fibrous bark. The bast fibers [1] are extracted by decomposing the plant, and when prepared become the "line" of commerce, so highly prized for spinning and weaving into linen textiles. Tow or codilla is a by-product of the processes by which the dressed flax or line is obtained. It is used for making the coarser yarns, twines and fabrics. These two fiber products, line and tow, form the base or raw material of the linen textile industries.

The base of the linseed industries is found in the oil contained in the cotyledons of the embryo plant in the

[1] The word fiber is used to describe the long hair-like compound of the bast cells of the plant

seed of flax. This seed is about one-tenth of an inch in length, somewhat pear-shaped, and glossy, greenish-brown. It is easily and quickly handled in great bulk. In modern practice the oil is expressed by hydraulic presses in a highly-organized milling process, called in the trade "linseed crushing." The residue from the presses, linseed cake, is a valuable by-product used as a stock food.

Here are two raw materials of first importance, which seemingly should be joint products of the same plants. Yet in fact we find separate production: millions of bushels of flaxseed and millions of pounds of flax fiber or line, accompanied in each case with the rejection of a potential joint product. What is the explanation?

The production of good long line requires first the growing of good flax stems or canes. This is gardening — horticulture rather than agriculture. The greatest care is used, from the thoro preparation of the ground to the hand-pulling of the stalks at harvest time. The soil must be brought to the best garden tilth, and then settled or rolled to make a compact smooth seed bed. The seed is sown broadcast, preferably by hand. Eighty pounds to one hundred and sixty pounds, the larger quantity in the case of the finest line, are sown to the acre, so the plants will grow thickly and without branching. The field is then either hand-raked, dragged or brushed to cover the seeds, after which follows another rolling or treading. Treading with boards attached to the feet, and hand-spading, may still be seen in parts of Europe where the best flax fiber is produced. The careful preparation of the seed bed, thick sowing, and even covering of the seeds, bring up the largest possible number of shoots which develop into long sinewy stems with the branches at or near the top. Besides this, an equable climate causes the con-

tinuous and even growth of slender bast cells ensuring a fine tenuous fiber. The flax plant is peculiarly susceptible to injury from weeds, and the fiber grower wants the soil to bear only the flax stalks or canes, and these in perfection.

It is the European custom to begin weeding by hand — the only method possible in such thick growth — when the plants are but a few inches high. As numbers and length, not bulk, are desired, the thinning so often practised in other culture (e. g., *beet culture*) is omitted. Women and children creep slowly and carefully through the fields, examine every inch of ground and pull up every weed. They kneel face to the wind, and work toward it, so that plants which are bent over are straightened by the lifting action of the sun and wind. Two or three such searching weedings leave the ground wholly to the tall, slender flax stems.

There is no such culture in America, North or South, save in experimental plots. The nearest approach to it for any sort of agriculture is the truck farming in the vicinity of our larger cities. Thus the amount of flax fiber grown here and in Canada is of no consequence in the market. Where it is occasionally grown the rough and ready methods are far removed from gardening, and yield generally a kind of line suitable for the coarser yarns and tow products. Prime long line can be produced only by the most thoro and painstaking cultivation. The intention of the European grower of fiber, carefully carried out from the start, is to produce plants with tall, slender stems or canes yielding the greatest possible length and fineness of line.

In sharp contrast is the planting of flax for seed only. The desired end is the greatest number of flowering heads which will bear seeds. Hence a bushy form with many branches must be developed. To secure the

greatest yield of seed, the land ought indeed to be better tilled than for the ordinary grain crops, because the flax plant cannot take up raw manures immediately and is quickly weakened by weeds. Virgin soil is best, due to the abundance of natural plant food and the absence of weeds and fungi. Thus in this country, Canada, and Argentina, flaxseed growing has become large-scale frontier farming. All the modern farm machines are employed in preparing the soil and in planting the seed. From fifteen to twenty-five pounds to the acre are sown by a mechanical drill in rows about eight inches apart. The seed is effectually covered and the seed bed made firm and smooth by a plank drag, often drawn tandem with the drill. The result is a thin growth in rows, each plant having room to grow out rather than up — to branch and bear flowering heads. This secures the maximum yield of seed. Many farmers do not weed at all, tho the plants are so spaced by the drill that weeding or cultivating may be done with a disk harrow or other machine cultivator. The ideal is the most efficient seed-bearing structure; no further use of the stems or branches of the plants is contemplated. The great bulk of flaxseed is grown in the newer countries as grain, by extensive agriculture, employing horse or tractor-drawn farm machinery. There is a small secondary yield of seed in northern Europe, notably Russia, as a by-product of flax fiber production. Russia is the only country producing both flax fiber and flaxseed in large quantities. Tho some of this flaxseed is produced as a grain crop on extensive land holdings, with the modern large-scale farming methods and implements, introduced from the United States, Russia remains the chief fiber-producing country of the world.

Contrast now the two cultures at the next stage, the harvesting of the crops. The flax raised for fiber is

pulled by hand. The time is determined by the condition of the stalk, which should be green for about one-third its length. In this state the cane possesses its natural oil and gums and is in prime condition for making soft, pliant line. The seed is then in the milk, tho it may be saved by stacking the flax for a time in order that the seed may mature and cure. Many years ago this was a common practice, but the large-scale separate culture of flaxseed has forced the older methods into the distant background. Pulling flax is hard work. The laborer must kneel or stoop, and must grasp a handful of stalks near the roots and draw them from the earth. He then shakes them to remove the dirt, and if he has not taken care to pull stems of about equal lengths, he must sort them before laying them down. This pulling is frequently done by women and children in Europe. In Canada the limited amount of flax grown for fiber is usually pulled by Indians. It is the usual procedure to " ripple " the flax in the field as it is pulled. Rippling is getting rid of the seeds by drawing the stalks through a ripple or coarse comb provided with iron teeth so fashioned and set that the openings between them are wedge-shaped. The workers sit on a bench upon which the ripple is mounted with teeth upstanding. They grasp the stalks by the root end and draw the heads through the ripple. A cover on the ground catches the seeds as they are stripped off. They may be saved in this state and cured for crushing into linseed oil by spreading and drying them under cover. This requires time, space, frequent turning, and much patience; as a consequence they are usually fed to cattle at once. The stalks are then ready for the next process, that of " retting," by which the fiber is made ready for extraction. In certain parts of Europe, a small portion of the world's supply of flaxseed is saved

by tying the flax into bundles or sheaves after pulling, and stacking it away until the seed is ripe. The flax is then rippled or top threshed in the fall or winter, the stalks are again bundled, carried over into the next spring, and then retted. But the usual method, bringing quicker returns, is to ripple the flax in the field as it is pulled; the stalks are then bound into sheaves and are taken at once to be retted.

It will be best to leave the flax fiber crop at this stage and turn from the harvesting of fiber stalks to the harvesting of the flaxseed crop. In striking contrast to the long drawn-out production of flax for fiber is the production of the seed of the plant for the crushers making linseed oil. In this case harvesting follows about twelve weeks of the usual passive waiting of the grain grower. During this time the plants have put forth many branches which have borne all the late summer a profusion of ephemeral but beautiful blue flowers. The five-petalled blossoms have matured into bolls containing ten seeds each. In fruiting, the plant elements necessary to reproduction, including the oil, have passed into the seeds; the stems have become lifeless straw. While the bolls are still somewhat green and before they fully ripen and cast their seeds, the well-known harvesting machinery is drawn through the field by horses or tractors, and quickly cuts down the standing grain. The flax is then put through the power threshing machine, the grain is separated or beaten out and is ready for the market.

It is plain that good flax fiber for spinning cannot be made from straw which has passed through the rollers and beaters of the threshing machine. Even if it were not in a tangled and broken state, its fiber is short, coarse, and lifeless — lacking the very essence of good line. It is usually burned in the field where it falls.

Many inventors and experimenters, aroused by this apparent waste of flax straw, have spent fortunes in attempts to find some way of making from the straw the line or even the tow used by spinners. In this country alone many different processes have been thoroly tried and numbers of patents taken out. But so far all have failed to produce anything better than coarse fiber or tow, similar to that which is the residue from the operations for preparing line. Ventures requiring large investment in machinery and equipment have produced for a time limited amounts of the coarser fabrics, toweling and crash. Most of these undertakings have been abandoned, and in some cases the factories have turned to other products. Some tow obtained from seed straw is used for making twines. Upholsterers' tow, refrigerator insulation, straw mats and rugs, fiber board and paper have been made from it with varying success. New and elaborate processes are still being tried; yet the unquestionable fact is that all attempts to produce the better grades of long line from flaxseed straw have failed.

The flaxseed crop, harvested easily and rapidly, may now be sold. But in the other culture the flax fiber stalks or canes have only been gathered, and prepared for the next step in fiber production, that of retting. From the stalks the bast fibers must be got out whole and in spinnable condition. The fibers still possess their natural oil and gum and are bound together, and to the woody stem, by the plant substance known as pectose. This must be broken down by decomposition in order to extract the fibers. From the earliest times, the common method has been to subject the stalks to the action of water either in pools or streams — the surer and quicker way — or by exposure in the fields to the dews and rains, a somewhat longer and less certain means.

This process is called " retting "; in plain language, rotting. The first method is commonly called " water retting "; the second, " dew retting." This latter means is used in Russia, in certain other parts of Europe, and to a very limited extent in Canada, in places where there are heavy dews and plentiful rains. But water retting is still the process by which the best line is produced.

After the seeds have been removed the flax is bound up in sheaves and placed in pools or " lint-holes," made by damming small streams or by digging basins close to the banks of streams and connected with them. The usual lint-hole is about four feet in depth, eight or ten feet in width and of variable length. The sheaves are carefully laid in by hand, not on top of each other and haphazard, but placed in a slanting position, roots down, each sheave overlapping the one beneath, until the area of the pool is well covered. A wicker or straw mat is then placed on the layer, and a few flat stones put on top to make sure the immersion of all the sheaves. Flax is often retted in a running stream. In the famous river Lys in Belgium the flax is sunk in crates just below the surface of the river.

The reasons for pulling the flax instead of cutting it are now clear. In addition to the shortening of the fiber which would occur if the flax were cut, the lower ends would draw the water by capillary attraction and ret first. The retting must progress evenly and uniformly throughout the stalks. The roots naturally close the ends against soil and discoloration as well as against premature retting. The flax is handled with the greatest care to avoid breaking or bruising the stems and to ensure the production of an evenly retted fiber or line of good color, length and strength. To safeguard all these qualities the bundles are examined diligently as decom-

position advances. The best of cultivation will produce stems which vary somewhat in bulk and condition. To check the fermentation at just the right time so that the line retains its strength and just enough gum and oil to make it suitable for spinning, requires careful and unusual attention. This operation takes about two weeks.

Much of the finest Belgian flax is double retted in the river Lys. The sheaves are placed in crates which are sunk in the river for a short retting of about a week. The flax is then removed, dried and stored for a time, after which another retting of a few days in the crates finishes this more elaborate method. The double retting with the intermediate curing is said to bring out a finer and brighter line. The river Lys flows through the renowned Courtrai flax district. There is a strong belief amounting to conviction among flax and linen folk that it has retting properties far superior to any other water. This is probably a myth; the true explanation is to be found in the inherited and acquired skill of the flax workers and the better methods of the organized retting concerns in this ancient seat of the linen industry.

In the more common method of retting at one steeping the time varies from ten to fifteen days, depending upon the condition of the flax, the chemical properties of the water, and the atmospheric conditions. During the last few days the flax is frequently uncovered and tested thoroly to avoid over-retting. The retter, by manipulating a stem, can tell at once whether the fibers will come away from the shove or woody portion without injury. If over-retted, the flax is discolored and lacking in strength. If under-retted, the fibers cannot be separated without injury and extracted whole in the " scutching " process which follows. They will be torn and rendered into cheap tow instead of the valuable long line.

The test proving satisfactory, the flax is then lifted by hand from the pool, preferably by men standing in the liquor, so that the bundles may be washed off and handed out free from contact with the sides of the pool or any soil. This would be difficult with forks or any implements, and moreover, the fiber would be bruised and impaired. The liquor in the pool, a solution of decomposed vegetable matter, is a valuable fertilizer and is usually returned to the fields. Stringent laws prohibit the pollution of the streams by turning it into them. An extremely offensive odor and some very unwholesome fumes arise from the masses of putrefaction during the retting and subsequent grassing of the flax. After having drained awhile, the bundles are taken, generally by women and children, to grass lands and spread out for airing and bleaching. This grassing takes about a week during which the flax is frequently turned. The fibers are bleached and cured by the grassing so that they are ready for separation. When the woody part has become brittle, the flax is gathered, bundled and stacked for a few days, either in the fields or under cover, until it is thoroly dry and ready for the next process of " scutching."

Where the climate gives plentiful rains and dews, the extremely unpleasant features of water retting may be partially avoided by dew retting. This method is long and tedious. As it depends on the weather, it requires much labor and attention and double the time necessary for water steeping. The decomposed plants have to be actually taken in the hands in much the same way and for the same reasons as in water retting, but the decaying vegetable matter is spread out in the open and the offensive odors are dissipated. The dew retting having reached the right stage, the flax is usually taken under cover, to properly dry and cure the fiber for scutching.

The line obtained in this way is unevenly retted and dark colored. It is inclined to heat if not properly stored, because of the large amount of oil left in the fiber. For this reason it is pliant and well adapted to spinning after proper preparation.

The next step, completing the extraction of the fiber, is the process of " scutching," which separates the fibers from the woody part of the stalk, and from each other. The plant substances have been decomposed, the stalk with its bast fibers is dried, and the inner wood is very brittle. The simplest way to break up the wood and free the fibers is to grasp a handful of the flax, twist it, and strike the stems gently with the open hand. This is precisely what was done at first. Then a wooden paddle, called a " scutching sword " was used, and much scutching is still done with this simple instrument. Scutching wheels provided with paddles or blades, and run by foot or other power, are now in use. Even with the wheels much hand labor and skill are required, and scutching is far from a machine operation. Still, this is the only process in the production of true long line in which there is any application of machinery, however slight. Before the flax is taken to the scutching wheel it is passed through the fluted rolls of a rolling and breaking machine which presses open the stems and breaks up the wood or shove.

In the usual form the wheel has a number of projecting blades set like those in a revolving fan. The axis is horizontal and the blades revolve in a vertical plane, when propelled by a crank and treadle or a pulley and belt. A slotted board or rest for the flax called the " stock " stands close to the wheel. The scutcher grasps a bunch of the broken flax stalks at the middle and thrusts one end through the stock so that the flax will be stroked by the revolving blades, just hard enough

and long enough to remove the wood and short fibers, and thus make the line free and fine. He then changes ends and completes the scutching of the tress. If the flax has been retted properly, and if the scutcher has the required skill of hand and eye, the result is a yield of good line amounting to about two-thirds of the original fiber. The residue, the short and broken fiber which has been struck off with the wood, is tow. This is gathered and saved for making coarse yarns and twines. If the flax has been over-retted and weakened, or if under-retted so that the fibers do not readily separate, scutching will make tow of nearly all of it. A lack of skill and judgment in handing the best of flax to the scutching wheel will reduce it to mere tow. It will be seen that even with the wheel, scutching remains essentially a hand process. Moreover, it is, of necessity, a dirty, dusty, disagreeable operation. In addition to the particles of wood and fiber, there is decomposed vegetable matter and other soil in the air. Where many wheels are gathered together in scutching mills, such as are found in flax districts, the laws require ventilating systems. These are ineffectual, because if there were draft enough to take off all the dirt, much line and tow would be taken away too.

All the operations for growing flax fiber and getting out the dressed flax or line have now been described, and the grower can at last exchange his product in the market. The farmer who raises flax fiber, unlike the producer of flaxseed, grain or other crops, cannot market his product until he has put it through processes requiring much additional labor and time, extending far beyond the ordinary season of harvesting. Contrast the long, tedious, messy methods employed in growing and extracting the fiber of flax, with the simple and ready production of its great rival, cotton. This staple

is the pappus of the cotton seed and matures with it. The plants are grown by machine farming methods and the staple is developed by nature to the spinning stage. After cotton is picked it has only to be ginned, a very simple machine process since Whitney's invention; thus it is quickly and easily separated from the seed and made ready for the spinner. The cotton seed, once considered worthless, is now a very valuable joint product.

Some of the attempts to apply machinery and other economies to flax fiber production have attracted the attention of considerable groups of producers, tho none have displaced the older methods. The familiar farm machines have been tried experimentally here and in Canada for preparing the seed bed. The seed for fiber must be thickly sown and is scattered broadcast from the hand in the old countries, tho the hand-driven fan sower is sometimes used. In Canada horse-drawn broadcast seeders are occasionally used. Some growers use an ordinary drill adapted to broadcast seeding by feeding from the hopper through the spouts onto a wide slanting board hung just under them. The seeds deposited at intervals along this spreading board are jarred off by the motion of the machine as it is drawn over the field. The mechanical seeder is a great time saver and will sow ten acres while one acre is sown by hand. But the result of mechanical sowing for fiber is at best a spotted uneven stand of flax, far from the crop obtained by the gardening method, with its thoro and even hand sowing. No machine could be made for weeding or cultivating the thick grass-like stand of fiber flax.

To do away with the slow, back-breaking task of pulling flax many minds have schemed and worked, but so far without producing a successful pulling machine.

Most of the devices are attached to a reaper in place of the usual mowing or reaping mechanism. In one form there is a succession of finger-like projections, close to the ground, similar to those on the cutter bar of an ordinary reaper. As the machine is drawn against the flax, the fingers guide the stalks into the grip of rubber belts, running in opposed pairs on pulleys mounted vertically on an inclined platform. These belts grip and lift the stalks from the soil and pass them over an apron to the ground for curing. Much power is required to propel the weight of this machine with its collection of gears, pulleys, idlers, and belts, taxed with wresting the strong roots of the plants from the soil. The weeds are pulled with the flax and must be separated from it; the dirt must be shaken from the roots, and the stems must be sorted for length. All these tasks are still left for the hands. The ground should be rolled smooth in any case to ensure the production of long even line; but when a pulling machine is to be used, the field must be made as smooth as a putting green. So far, this quest is much like that for a machine cotton picker.

The retting process has probably attracted as many and as brilliant minds as any of the textile processes. Much might be written of the attempts to bridge the slough of retting. A century ago the Lee process promised a revolution in the methods of fiber preparation. The English Government gave special and unusual protection to the Lee patents, which covered elaborate machinery designed to do away with the long and objectionable methods of rippling and scutching as well as retting. The stalks were put through a threshing machine, then through fluted rollers to break apart the wood and the fiber. The fibers were afterwards cleaned and bleached by means partly

chemical, partly mechanical. Tho the Irish Linen Board and large producers in Scotland gave much time and money to complete and thoro trials of the scheme it failed to produce strong spinnable line.

Among the earlier modifications of the old time retting methods the invention of Schenck, an American, appears to be the only one used today. He patented in England in 1846 the first indoor or factory retting system. Vats containing heated water maintained at a temperature of about eighty degrees caused the retting to progress faster and without the interruptions incident to natural means. Schenck's process effected a great saving in time but never came into general use because of increased cost. The salient feature of his method, a temperature favorable to the rapid growth of the bacteria of retting, is found in certain present day processes. A later scheme to ret flax in steam was abandoned after many years of experimenting. High temperatures greatly hasten the extraction of fiber but make it brittle and unspinnable. Various chemicals and common substances like milk and oil have been used to quicken or improve the natural method but without success. Recently a French process has attracted the attention of prominent spinners. Briefly, it embodies the essential principles of Schenck's method, with frequent movement of the flax and changing of the water, simulating the retting in the river Lys and other running water. So far, it has not furnished any considerable addition to the supply of the best line.

A fiber factory was built several years ago in Ontario designed to produce line on a large scale by machine processes. A similar plant was established in the heart of the Montana flaxseed district. Electric cranes and machines as well as many novel devices were assembled with great outlay. The flax is de-seeded, not threshed;

the stalks are baled instead of being made into sheaves. Large concrete vats holding many tons of flax are filled with heated water under pressure, and charged with retting bacteria. After two days the flax is said to be thoroly retted. With heat and an exhaust fan the bales are dried in a few hours, and the fibers are then ready for extraction. They are got out by breaking and tumbling the flax in an automatic machine. The product is tow suitable for twines and the coarser fabrics. It has long been held that these short cuts through retting left too much pectose for a complete separation of the fibers, and that quick drying with heat made them harsh, brittle and unsuitable for line. The engineers of this factory retting system claim to have an entirely new type of scutching machine under construction which will produce true long line.

In scutching, as in the other flax operations, great efforts have been made to develop automatic machinery. The type of wheel described before in connection with the scutching process, appears to be the only successful implement for the purpose at the present time. This is not a machine, but simply a power-driven tool, and requires the skilled hand. All straight machine scutching has so far failed, because the cleaning, separating and fining of line is not a simple extractive process. The scutcher must actually see and handle the flax, in order to submit it to the scutching action just enough to remove the boon or shove and to separate the tenuous fibers of the line. A lack of judgment or deftness, carrying the scutching action too far, will reduce the best fiber to mere tow.

Reduction processes in general are not complex, and machinery can be applied without great difficulty to the extraction of an element. The chemical and mechanical means to reduce flax to the elementary cells of the

plant constitute a comparatively simple machine process. But the result is a conglomerate of fibrous matter, worthless for spinning and suitable for upholstery or mattress filling only.[1] The extraction of the hair-like fiber of flax, composed of the bast cells of the plant, overlapped and joined together, is a totally different and more delicate operation. To adjust and arrest the processes of retting and scutching appropriately, to separate the fibers, and at the same time to preserve the union of the cells of which they are formed — these are tasks calling for individual attention and for control modified to suit varying conditions. It is the precise measure of the action in both processes which determines the character and proportions of the complementary products — line and tow. While this handicraft requires no high degree of intelligence, it is one whose better craftsmen seem to possess some special aptitude. In fact all the way from planting to weaving the production of fine linen approaches a specialized art. In producing line the successive processes are usually carried through by the peasant farmer who raises the flax. Tho there are a number of retting concerns in the Courtrai district, and scutch mills are frequently found in flax districts, the production of dressed flax remains largely the handiwork of the European peasantry.

There is thus a striking contrast between the production of linen fiber and linseed. The old world product, flax fiber, is gained through intensive cultivation followed by the prolonged application of hand labor under conditions far from attractive. The new world product, flaxseed, is extensively cultivated and quickly harvested with highly developed machinery. In the old countries

[1] "Cottonized" flax was introduced before the close of the eighteenth century, when the first power spinning frames turned off cotton successfully but failed to produce yarns from the longer and less elastic flax fiber. The scheme was revived about the middle of the last century and received much encouragement in England and New England during the shortage of cotton caused by the Civil War.

we find the slow toiling handicraft bringing forth the fine, flax fiber for dainty linens; in the new, the rapid-fire machine production of grain in bulk for the linseed oil industries.

In the production of flaxseed every modern farming implement and machine is used. Tandem plows, harrows, and rollers, often drawn by tractors, prepare the soil. Seeding is done with a mechanical drill followed by a plank drag or a roller. Some growers draw this whole train of machines with a tractor, and thus plow, harrow and pack the soil, drill and cover the seed in one operation. In harvesting, the combined reaper and binder is most used. The binder is sometimes thrown off and the flax allowed to pass over the apron and fall to the ground. This is poor practice, because of the increased cost of raking and stacking the flax and the danger of mold if it is allowed to dry on the ground. Frequently a bunching attachment is put in place of the binder. A wagon then follows, the bunches are taken up and stacked for threshing. The header is common, and when used with a buncher attachment drops the flax as fast as cut into a wagon drawn alongside. When loaded, this wagon takes the flax to the stack and another wagon swings into place. Forty acres a day may be harvested by these means. A combined header and thresher, propelled by a traction engine, has been used in some sections where the bolls can be dried on the straw without loss of seed. Green or damp flax is hard to thresh. The usual method is to stack the flax for curing. It is then put through the power threshing machine, and the flaxseed, separated from the straw, is ready for the market.

The flaxseed crop is the most conspicuous example today of extensive cultivation. Many growers here and in Argentina plant three or four hundred acres. Tho

twenty-five bushels to the acre is the possible yield, the average is not far from ten bushels. With intensive cultivation more could be produced. But the crop is an alluring one to the frontier farmer; flaxseed is the only grain which can be grown to full yield the first season on land ploughed and planted in the spring. Many farming lands have been paid for with the flaxseed crop obtained from the first breaking of the soil. Some corn might be grown the first season, tho with a much smaller return. For a good wheat crop the pioneer farmer must wait until the second season, but flaxseed brings an immediate and profitable yield. It has often been planted several years in succession, but such cropping results in failure. A rotation with other crops, varied to suit the soil and climate, is needed to ensure good returns. It has been demonstrated that flax exhausts the soil no more than wheat or the other grain crops. In fact some growers claim that wheat will yield more after flax than flax after wheat. Rotation with other crops is in any case necessary, otherwise the land becomes "flax sick," in the farmers' language. The plants wilt and die if flax is planted too often. Professor H. L. Bolley of the North Dakota Agricultural College says it is not the land that becomes diseased, but the seed. He has shown the presence in the soil of micro-organisms from diseased flax which attack the seed and cause "flax wilt." The prime cause (fusarium lini Bolley), has been named after its discoverer. These fungi are found in soil possessing all the chemical elements of plant life. They are transmitted in the seeds, straw and chaff of diseased flax. The preventive measures are clean culture; then plump healthy seeds only should be selected and sprayed with formaldehyde. The careful cultivation and selection of seeds, together with pulling up and decomposing the plants at some

distance from the tillage, have prevented the spread of plant disease in the European fiber districts. Flax wilt has been the chief cause of the striking migrations of flaxseed — its wanderings from one new region to another.

The bulk of the flaxseed crop has been produced by the frontier farmer. He had the advantage of a better yield on newly broken land, and could produce the crop successfully for a considerable period, tho in time the land would become "flax sick." As the crop has been handled, after a few failures the standard grain crops tend to displace flaxseed and drive it on to another frontier. Now that science has found the cause of its wanderings, flaxseed may settle down so that a thoroly scientific culture may be developed. There is nothing in the economic conditions which would prevent continuing production in the same regions, as in the case of wheat, corn, and the standard crops. Like them it will always be produced most effectively on a large scale on the great outlying tracts.

A brief sketch of its wanderings in the United States will prove interesting, as it is this phase of extensive flaxseed culture which accentuates the contrast with the staid and intensive culture of flax fiber.[1] In colonial times flax fiber was an important product on the Atlantic Coast, and the seed for oil was a by-product. In the early days of the last century the expansion of the country and of building, with newly-discovered uses for linseed oil, had brought about a great increase in the demand for flaxseed. On the other hand, the rise of cotton and the decline of linen had caused such a diminution in supply that it became necessary to seek new sources. It is impossible to fix the exact date, but

[1] The movement of the flaxseed crop across our country, with the pioneer farmer, is clearly shown in Table No I in the appendix.

early in the nineteenth century a new culture was tried on the new lands of western Pennsylvania and New York. Flax was planted for the seed alone and proved a successful crop for a time. From the records of old linseed crushing mills, and the data of our Department of Agriculture, the course of the flaxseed crop can be traced through the West as the land was opened to the settlers. From Pennsylvania the crop spread into Ohio, then into Indiana and Illinois. Cincinnati was the center and the market for flaxseed in 1850, the first year giving any accurate records. The crop then declined in the older states, Pennsylvania and New York, and advanced into Missouri; a little later, into Iowa and Wisconsin. In 1870 Chicago was the center. In the next ten years flaxseed spread into Kansas, Nebraska, and Minnesota, and Minneapolis became the market. In 1890 it was well advanced in the Dakotas, and that year saw the retirement of almost all the states producing flaxseed east of the Mississippi. The immense tracts of the Dakotas and Minnesota sufficed for a period, but about 1900 the crop moved into Montana, where it is now held up in its march by the mountains. The great bulk of flaxseed has long been produced in the northwestern states, tho there has been a smaller but similar movement to the Southwest, and some seed is produced in the far west. Duluth, at the head of the Great Lakes, is now the chief market. The lands of the prairie provinces of Canada are producing much flaxseed and Winnipeg is also an important market. Practically all the new land has now been cropped and flaxseed production seems to be on the decline in the states. Unless scientific methods are adopted our flaxseed production will gradually diminish. In the meantime, a newer country, Argentina, has entered her fields and has outstripped us. So far as can be judged from incomplete

crop reports, there is in that country a tendency similar to the movement in our own. As long as there are new lands in the world, flaxseed may keep on wandering, tho the scientific development of the culture promises a great change and the possible standardization of the crop.

No fiber culture of any consequence has ever been developed in this country, in spite of colonial and state bounties in the early days, many private promotions since, and continued aid from the federal government. The Department of Agriculture has maintained for years a bureau for plant fiber investigation. A chief object has been the encouragement of flax fiber culture, and much time, energy (and flaxseed also, in the form of printing ink), have been expended in vain attempts to foster even an infant linen industry. Tho many immigrants have come from the flax districts of Europe, they cannot be induced to continue in flax fiber production after settling here and finding more attractive and profitable employment open to them. Projects to develop the industry are still on foot. Probably the most recent is the attempt of the state of Oregon to introduce fiber production in the Willamette Valley. The Dominion of Canada has given government aid to the establishment of fiber culture. The early settlers in the Lower Provinces of Canada, like those in the New England colonies, produced flax for home consumption. The industry declined there as here. Later attempts to restore it, undertaken in Ontario with substantial backing and continued with energy down to the present time, have resulted in the sporadic production of small quantities of inferior line.

It is apparent that the countries having new lands, and a supply of labor accustomed to handle farming machinery, have an advantage in flaxseed farming. It

would not be impossible to produce flax fiber in these countries, but their labor would be applied less effectively to the fiber than to the grain. Small farming or gardening, on the other hand, is still the preferred pursuit of a large part of the population of Europe. On the Continent and in Ireland are an immense number of peasant proprietors or small tenants. Here is a great group of producers having inclination, aptitude and the social conditions for such undertakings as the growing of flax fiber. The fiber is usually grown, retted and scutched on the farmer's premises and by his family, with a ready supply of supplementary labor in the neighborhood. Money wages in France and Belgium for such work are 2 fr. 50 or 3 fr. per day. In Russia and Ireland money wages are less. An old Irishman once said when discussing the extremely disagreeable and unhealthy features of retting: " there are people all over my country who are willing to do anything for a livelihood." A livelihood, the means of existence, the " subsistence " of the older economists — this sort of life has played no part in the agriculture of the United States.

No doubt the European producer of fiber has some advantage in climate. The cool, equable temperature, and the moist, cloudy atmosphere of Ireland and the lowlands of northern Europe, are favorable to the growing of fiber. The sudden changes of our climate, from wet to dry and from hot to cold, check the growth of the plant stems and thicken the bast cells. Even where there are no droughts, the sunny atmosphere, the extreme heat of our summers, and the high winds, are unfavorable to the growing of prime flax fiber. True, there are localities in our country which come nearer the required conditions, such as Michigan and Wisconsin on the lakes, and the coast districts of Ore-

gon and Washington. In Canada two regions also are more suitable than other parts of the Dominion — the lowlands of western Ontario and the shore of British Columbia. Even Alaska has grown experimentally some very good fiber. But what matter the relative natural advantages? Apart from these advantages, the older countries because of labor standards, agricultural surroundings and acquired skill, will be able to apply their labor more effectively to fiber production. The newer countries with large tracts of land, efficient farm machines and skilled operators, will enjoy a substantial advantage in the production of flaxseed. If a scientific culture disposes of the wilt and develops the flaxseed crop, it will possibly settle down for long periods; in any case, it will always be conducted on the outlying lands on a large scale with machinery.

The two products, flax fiber and flaxseed, cannot be produced in the better grades from a single cultivation by any methods now known, because of the differences in the development of the plants which produce fine long line, and those yielding the rich, full seed. And even if these differences be modified or overcome, a vital element is still lacking. The oil — fundamental to both products — cannot be possessed in the required measure by both the seed and the fiber of the same plant at the same time. If the flax is allowed to grow until the seeds are fully formed and ripened, the stems are lifeless and brittle; the fiber has lost the oil and gum required for making prime long line. If the flax is pulled at the proper stage for making line, the seeds can be cured only by protracted handling and will not contain enough oil to return the expenses of production save in those countries having a supply of very cheap labor. One end defeats the other. To paraphrase an old adage — you cannot spin your flax and crush it too.

Until machinery can be effectively applied to the several operations in growing and extracting flax fiber — an improbable contingency — the characteristic direction of labor in the two branches of flax culture, and the sources of supply for fiber and seed, will remain unchanged. The differences between the two serve as an example of the way in which the principle of comparative advantage acts in production. Flax fiber or flaxseed *can* be produced in almost every country; but each *will* be produced, if let alone by governments, in those countries able to apply their labor most effectively to each. The production of either will be determined by comparative advantage; by the relative measure of the return when labor is applied to it. Flaxseed is produced most effectively under one set of conditions, and flax fiber under another. A climate suitable for either culture is found in many parts, and soil which will bear the flax plant is found all over the world. But soil and climate on the one hand, social conditions and skill of the required degree on the other, concur for fiber culture in certain regions only. These have a comparative advantage in fiber production. Labor applied to fiber is in them more effective than when applied to seed. Flaxseed can be produced in all of the fiber countries and is produced in some. Nevertheless, the countries with new and extensive lands have a clear advantage in flaxseed production; in addition, efficient farm machines and the mechanical skill to operate them combine to make their labor far more productive in flaxseed farming than in fiber culture.

Flax fiber can indeed be produced in the United States and the other machine farming countries, if labor be forced into this slow, plodding employment. But workers with mechanical inclination, the spirit of

enterprise, and plenty of land, will not take up this handicraft — such it is and is likely to remain — while they can find congenial and profitable employment in flaxseed farming under agricultural methods fitted to American standards. America has abundant land, and is trained and equipped for branches of production in which machinery can be used with greatest effect. Tho much may be accomplished in the future through invention and scientific development in the two fields of flax, the production of fiber and seed, if left free, will be regulated and determined by the proportional effectiveness of labor in the new countries and the old.

APPENDIX

TABLE I

PRODUCTION OF FLAXSEED BY STATES, CENSUS YEARS 1850–1910 AND 1915

Bushels (000 omitted) [1]

STATES	1850	1860	1870	1880	1890	1900	1910	1915
Penn.....	42	24	16	5	4			
N. Y. ...	58	57	93	72	21	1		
Ohio.....	189	242	632	593	146	30	5	
Ind. .	37	119	402	1419	18	1		
Ill. .	11	9	280	1812	35	4	1	
Wis.....	1	4	112	547	68	141	119	94
Iowa.....	2	6	89	1511	2282	1413	141	162
Neb.....				78	1401	55	21	77
Minn...			19	99	2722	5895	3277	3150
S. Dak. ..				27	1801	2452	4760	1650
N. Dak...					164	7767	10246	6534
Mont. ..						1	447	1890

[1] Compiled by the writer from figures furnished by the Department of Agriculture. The step line indicates the decline of flaxseed from the peak of production in the several states, and the movement of the crop across the country with the frontier farmer As evidence of the positive character of this movement, about 90 per cent of the total production in these states up to the census of 1910 will be found below the line The crop of the southwestern states, not here shown, is small, and shows a similar tendency

TABLE II

FLAXSEED ACREAGE AND PRODUCTION IN UNITED STATES, 1849–1915 [1]

(000 omitted)

Year	Acres	Bushels
1849		562
1859		567
1869		1,730
1879		7,170
1889	1,319	10,250
1899	2,111	19,979
1902	3,740	29,285
1903	3,233	27,301
1904	2,264	23,401
1905	2,535	28,478
1906	2,506	25,576
1907	2,864	25,851
1908	2,679	25,805
1909	2,742	25,856
1910	2,467	12,718
1911	2,757	19,370
1912	2,851	28,073
1913	2,291	17,853
1914	1,645	13,749
1915	1,387	14,030
1916	1,605	15,459

[1] Statistics of the Department of Agriculture

TABLE III

World's Production of Fiber and Seed, 1911–13[1]

Some producing countries omitted because not reported
(000 omitted)

Country	Fiber (lbs.)			Seed (bu.)		
	1911	1912	1913	1911	1912	1913
United States				19,370	28,073	17,853
Mexico				150	150	150
Canada				10,075	26,130	17,539
Argentina, S. A.				23,424	22,534	43,305
Uruguay, S. A.				660	879	1,302
Austria-Hungary	68,026	80,729	71,976	890	874	801
Belgium	52,000	64,000	39,437	515	514	387
Bulgaria	878	308		12	6	8
France	45,003	46,074	48,437	496	576	740
Italy	6,078	5,511	5,732	341	343	405
Netherlands	20,929	21,217	16,606	579	428	326
Roumania	4,530	8,953	4,759	607	772	569
Russia (European)	785,136	1,172,059	1,703,209	20,544	22,177	24,456
Russia (Asiatic)				1,099	1,230	1,927
Serbia	2,091	2,095			.	.
Sweden	1,500		418	17	...	...
Ireland	25,179	29,021	28,341			...
British India				22,544	25,592	21,544
Algeria				16	13	15
Total	1,011,350	1,429,967	1,918,915	101,339	130,291	131,327

TABLE IV

World's Production of Fiber and Seed, 1896–1913[1]

Year	Fiber (lbs.)	Seed (bu.)
1896	1,714,205	82,684
1901	1,050,260	72,314
1906	1,871,723	88,165
1911	1,011,350	101,339
1913	1,918,915	131,327

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[1] Statistics of the Department of Agriculture. These are the latest complete figures, because all the important fiber-producing countries are involved in the war. The fighting on the western front has laid waste the best linen district in the world.