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AGRICULTURAL SCHOLARSHIPS

**From Seed to Shirt:
Flax to Linen in Canada for
the Local and Global Market**

Josh Oulton

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SCHOLAR PROFILE



Josh Oulton was born in Newfoundland in 1973 and moved off the rock to Nova Scotia in 1976. His family moved into a home next to a dairy farm and it took no time at all for him to start idolizing the dairy farmer, Bob Wilson.

Under the influence of Bob and his two farming grandfathers, at a young age Josh had his sights set on becoming a farmer. Once Josh completed high school, there was never a doubt that the Nova Scotia Agricultural College was the next destination. One year into Nova Scotia Agricultural College, Josh got the travel bug to explore agriculture in other parts of the world. The first stop was still in Canada, but a long way from Nova Scotia, at a great little college in Olds, Alberta. This was the start of Josh understanding that travelling away from where you live can teach you other ways to farm.

When he returned to Nova Scotia to finish his Farming Technology Diploma, a friend introduced him to Patricia Bishop. Now the two of them have 3 children: Izaak was born in 2002, Lily in 2005 and Frank in 2007. The five of them currently live and play on TapRoot Farms, 300 acres of mixed farming with a line-up that includes tree fruit, vegetables, and pastured livestock, 30% of which is marketed through a Community Supported Agriculture program and the remainder in partnership with their sister farm, Noggins (three retail locations). Moving forward from 2020, TapRoot Farms will be 100% organic. Josh's role on the farm is owner/production manager.

The move to add fibre to TapRoot Farm's offerings was first discussed in 2011 at the Fibre, Fabric, and Natural Dye Symposium that was hosted at TapRoot Farms. Flax has been grown and stockpiled since 2013.

Josh is active in the farming community. He is a past president of the Atlantic Canadian Regional Organic Network and of Horticultural Nova Scotia. At the present time, Josh represents Horticulture Nova Scotia on the Council of Leaders for the Federation of Agriculture in Nova Scotia, and he sits on the Nova Scotia Ministry of Agriculture Development Board to Horticulture.

TapRoot Farms can boast that they are one of the largest organic farms in the Atlantic Region and were early adopters of the Haygrove High Tunnels in this region. It gives Josh great pleasure to be part of this farm and family that he and Patricia have built together.

ACKNOWLEDGMENTS

The first person I need to acknowledge is my life/business partner, Patricia Bishop. She has encouraged me forward at all steps of the way. She is a constant source of inspiration, and I am so lucky to have her in my corner.

Our children Izaak, Lily and Frank pitched in to help their mom cope with the farm and daily routine in my absence. I would also like to thank my Mom, Valarie Cunningham, who is a huge part of the success of our family and farm.

The decision to embark on the Nuffield adventure started at a meeting with a very passionate scholar on his Nuffield Global Focus Program (GFP) at a neighbours' house one summer night in 2010. The Nuffield passion was infectious and that meeting offered the encouragement that Josh needed. On Josh's own GFP he visited with that same scholar at his new farming adventure in Kenya. Thanks for the inspiration, Stuart!!!!

On my Nuffield learning and travel people have given their time to help me learn in various countries:

Belgium: Jan SIJNAVE, Micheal Oosterlynck

Poland: Malgorzata Zimniewska, Barbara Romanowska, Jakub Karon

Egypt: Motaz Elkholy, Khaled Kilany

India: The team at Golden Fibres LLP, and Abi Joseph Andrews

I would like to thank the selection committee of Nuffield Canada for having faith in me and my topic, and my travel mates for my Global Focus Program Africa: Andrew, Jimmy, Turi, Solis, Colm, Jenna, Alison, and of course, our captain Shannon.

Thank you to Christa Bedwin & Robert Harris for support in structure and proofreading.

Thanks to the Nuffield Canada Reports Committee for helping me find my voice and organize my report.

And lastly, I appreciate the wonderful crew at TapRoot Farms that has continued the great work of feeding Nova Scotians, during those times when I needed to be absent.



My Family

SPONSORSHIP

My Nuffield Scholarship was sponsored by Nuffield Canada Alumni and supported by TapRoot Farms.



EXECUTIVE SUMMARY

Canada has a history of growing flax and processing it specifically for fibre. It has been over 80 years since we, in Canada, grew flax for fibre. In 2011, on our farm in Port Williams, Nova Scotia, we started to grow flax for fibre, with a vision to offer textiles to our customers along with fruit, vegetables and meat.

In 2019, I had the privilege of completing travel for a Nuffield Scholarship (6 countries in 4 weeks) to learn about flax for spinning yarn and making fabric around the world. My study focused on how other people are growing and processing their flax, challenges they face, the history of the industry, the markets they sell to, and the potential for Canadian and Nova Scotian flax to fit into the world market. Flax is a relatively lightweight but high-value commodity; it has great export potential for the world market.

I travelled from mid-January to late February and visited Belgium, Poland, Egypt, India, Singapore, and Guam. I found the most relevant information for our purposes in Belgium and Poland, which I feel have the most similar growing and marketing conditions and most applicable lessons to the Nova Scotia case. Egypt and India offered interesting market contrasts.

I came back to our own farm in Canada re-invigorated about our idea that we can produce quality long line flax for fine fabrics, of the quality that they achieve in Normandy, and which is highly valued for flax spinners and weavers. In addition to gaining knowledge about growing and selling flax in similar climatic conditions, I gathered information about what to do with the other products that result from flax processing, such as the tow (short flax fibres) and shives (flax straw) so that I might understand how to optimize both our production and sales ecosystems.

Specific climatic regions of Canada are well positioned to begin growing flax for long line linen production. I propose three main recommendations based on my study:

1. We need to start educating farmers in those regions of Canada about growing and retting flax;
2. Include instruction in flax fibre production, perhaps under the Flax Council of Canada;
3. Investment should be made in scutching mills to make fibre available for export.

DISCLAIMER

This report has been prepared in good faith but is not intended to be a scientific study or an academic paper. It is a collection of my current thoughts and findings on discussions, research and visits undertaken during my Nuffield Farming Scholarship.

It illustrates my thought process and my quest for improvements to my knowledge base. It is not a manual with step-by-step instructions to implement procedures.

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In submitting this report, the Scholar has agreed to Nuffield Canada publishing this material in its edited form.

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1. Introduction

1.1 Context of Study

Consumers around the world are seeking products that are less harmful on the environment. This consumer demand is impacting the natural fibre value chain and spinning mills are searching for sources of flax fibre. We can grow flax fibre crops in specific regions of Canada and we have an opportunity in Canada to be a supplier for this expanding market. I would like to see more farmers in Nova Scotia and Canada-wide get on board with flax production. My Nuffield world travels and studies, on top of the work and research we have already done on our farm, have only further strengthened my resolve and enthusiasm that flax fibre is an excellent addition to Canada's agricultural future.

Flax and linen production flourished in various places around the world for centuries until the industrial revolution came along. Cotton rose during the industrial revolution upon the invention of the cotton jenny. Then, in the last century, modern technologies enabled the production of clothing from synthetic fibres. This largely petroleum-based clothing came to control the market because it was comparable quality to natural fibre clothing, could be made with bright synthetic colors, and a much lower production cost.

However, growing awareness of the effect of the carbon economy on climate change and other factors has caused today's consumers to begin demanding products that are locally made, more durable, and more sustainable.¹ Linen (which is made from flax) is an ideal sustainable fabric because, when grown in the right climatic conditions, it needs less irrigation, fertilizer, and pesticides than other crops.²

For high quality flax fibre, it is necessary to have the proper amount of natural moisture for retting. Retting is the process of breaking down the cellulose bonds allowing the fibre to be free from the stalk (shive). Historically, multiple regions across Canadian have proven to sustain flax industries with preferable growing and retting conditions including Nova Scotia, New Brunswick, PEI, Ontario, and Quebec. British Columbia's West Coast shows good potential as well.

At present, agriculture is essentially a global marketplace. It was not always like this, and the jury is out if that is the way it will stay. In our little part of the world, 'local' (within 100 km's, within our province, within Atlantic Canada, the definition depends on what is available within those regions) has been a big part of the success of many small farms, including ours. Patricia (my wife and business partner) and I asked ourselves, "If our food can be local, why not our clothes?" This was something I had not thought about before, the connection of the farmer to clothes; nor have most Canadians.

In collaboration with others who are passionate about flax, we started to talk to other flax growers and linen makers around the world. This Nuffield scholarship has given me a chance to travel extensively, with a targeted vision, to see vastly different economies, markets, growing and retting conditions, and facilities for flax scutching, spinning, and weaving (often not in the same place!).

1.2 Objectives of Study

The burning question: Can we create a textile industry here in Canada, completely from seed to shirt? Canada has proven itself as a food producer, so it seemed feasible to grow commodities, which can produce clothes as well. The Nuffield travels and connections opened my eyes to market forces, ways of selling, collaborating, and networking, that could help us to make our Canadian seed to shirt value chain a reality.

1.3 Approach to Study

There are various steps to go from seed to shirt. Although I had planned to fully explore all three steps, most of my studies focused on steps 1 and 2. Without quality fibre there is no step two or three.

- 1) Producing the flax fibres includes growing, retting and scutching (mechanical process to go from retted flax straw to long fibres ready for spinning preparation). As we can produce high-quality long line fibres in some places in Canada's climate, this is one juncture at which we will be able to export or use within our communities as a primary product for yarn. There is also a strong market for the shorter tow fibres for yarn, composites and paper. The shives produced in this step can be a value-added product as well, creating bedding for animals, the materials for particleboard, and more.
- 2) Prepare and spin the fibre into yarn and finish the yarn for the marketplace for either knitting or weaving. This is a value-add proposition for producers, as we can sell spun yarn.
- 3) Finally, weaving, finishing and sewing. We have this infrastructure within Canada currently. Steps 1 and 2 are our biggest barriers to seed to shirt value chain in Canada.

All three steps take skill, patience and investment in equipment. I will touch on all three steps in this report so we can better understand what is needed to get the "Made in Canada" label on more and more clothes. Linen clothes last longer, minimize water and petroleum needed to get from seed to shirts, and are better for the future of our environment.³

1.4 Industry Overview

According to the Confederation of Flax and Hemp (CELC) report included in the Bast and other Fibres text, in 2000 the world was using 413,706 hectares to grow flax totalling 217,849 tonnes of flax fibre produced.⁴ This production is taking place in a handful of countries including Belarus, France, Belgium, Netherlands, Egypt, and Russia. Global flax industry represents 1% of all textile fibres used around the world.⁵ According to the Flax Council of Canada; we grow 1.6 million hectares of flaxseed per year. Canada is the third largest producer of flaxseed in the world.⁶ According to Farmlead, the three largest export countries that Canada ships our flax to are China at 330 metric tonne, then Belgium at 100 metric tonne and US at 80 metric tonne.⁷ In terms of value adding the flax straw in Canada, Alvin Ulrich at BioLin Research, Saskatoon mission is to utilize 100% of the flax straw for commercial end uses so that the straw, traditionally burned or chopped in the fields by farmers, becomes a viable and profitable product, completing the natural recycle circle. Also, there is a French paper company, Schweiter-Mauduit in Winkler, Manitoba. This company is working with the flax straw from the oilseed field of Canada to make Tobacco paper. The area they are using is around 50000 acres, which gives them 35000 ton of Straw and 9000 tons of after processing. They can process around 5 ton per hour. Unfortunately, the demand is low because wood base paper is less expensive.⁸

2. Why Flax

The three bast plant fibres (vascular tissue of a plant as seen in Figure 1) that could be grown on farms in some regions of Canada would be nettle, flax and/or hemp. On our farm, as we researched the idea it became clear that flax was the best option, as it was the most commercialized and mainstream. Finding examples of growing and processing from seed to textiles of either nettle or hemp is almost impossible. I could not ignore the ever-present question about hemp, as I moved through the world; often, when telling people about my topic of flax for fibre, they would then say something like “have you thought of hemp”. People are interested in the world of hemp but in my opinion, there is a need for value chain creation.

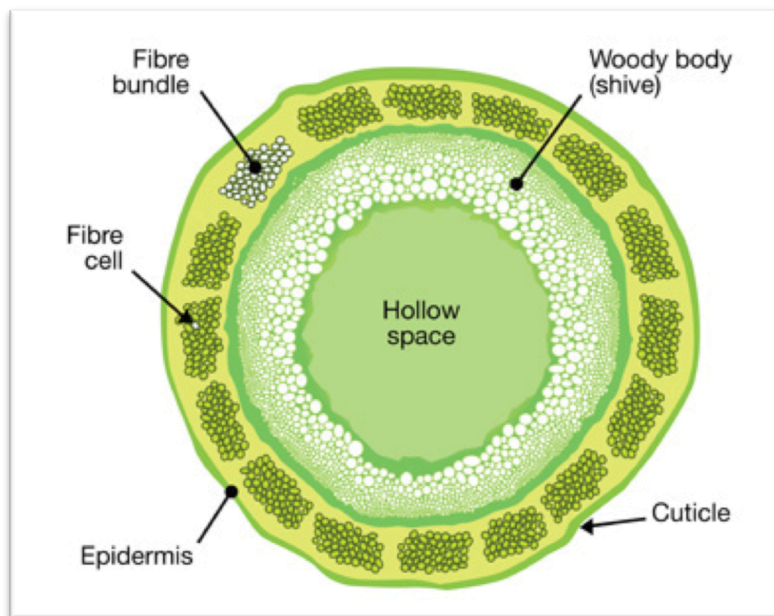


Figure 1: Cross of the flax stem, National Research Council

2.1 Social Practicalities

Flax, though a smaller player than the mighty cotton, is still being farmed and traded in large quantities around the world. According to Michel Oosterlynck, the manager of Groupe Brille a scutching mill in Belgium, flax represents 2% of Global textiles.⁹ Significant research and development is occurring by the flax fibre industries for example the CELC is active in research and marketing of flax and hemp products. The Institute of Natural Fibre and Medical plants in Poland are researching various applications for natural fibres. To achieve the goal of zero greenhouse gas emissions by 2050, as a target by the Intergovernmental Panel on Climate Change (IPCC), the fashion industry needs to move away from synthetic (mainly polyester) production. In 2018, the

fashion industry was producing 8% human CO₂ emissions.¹⁰ Flax fibre is even more relevant now than ever as we confront a climate in crisis. Both nettle and hemp have great potential and should not be forgotten.

Hemp has regulations in terms of cultivation so sourcing seeds and completing the regulatory paperwork for growing hemp fibre can be a barrier. Hemp has many good characteristics, however, growing it for textiles is different from growing for other end uses and is one of the main reasons I became interested in flax.

2.2 Modern Social Values & Environmental Sustainability

As with many products in the world, it would appear that the flax and linen trade was once a community-scale way of generating income and a way of life, but it has now amalgamated to a few “last man standing” industry-entities. The market demands have forced farmers, scutchers, spinners, weavers and garment manufacturers to find more efficient, cost effective ways of producing their products. When I close my eyes and dream of the future of agriculture for Canada it looks very different than it looks right now. The world is now working so hard to optimize for less costly products that we are optimizing ourselves out of work, out of community, and even out of our own abilities to feed and clothe ourselves.¹¹ I would like to see Canada invest in regional infrastructure supporting the creation of regional food and clothing industries that can help resurrect sustainable local economies.

One of the reasons we began this journey of growing clothes was to try and find new innovative products that we could create from the farm. Both federal and provincial departments of agriculture are often investing in innovation in agriculture. Because we were working with a community of people who were getting their food from us, it seemed like an interesting idea to see what other products people use in their daily lives that the farm could offer. From an environmental and societal concerns perspective, the more we learned about the textile industry, the more we felt we needed to find a way to participate in changing the narrative.

Gary Markle, a professor in the Nova Scotia College of Art and Design (or NSCAD), explained to us one day how he is teaching courses on sustainable fashion, but there are no local sources of fabric that the students can work with that aligns with what they are learning. A great disconnect exists between where we are in education (imagining what we can do differently as designers of products) and in production (where things are being made and how). Our continued research in flax production and building of relationships within the industry kept us moving forward, all the while realizing there is a very large gap. So large in fact, that even though we have been working at this since 2013, we are still challenged to make the gap smaller between seed to shirt.

Here we have a situation in the world where fast fashion (fast design changes and low quality made clothes purchased and discarded without regard of impact) is the dominant model. It is driven by people wanting to purchase, for example, a \$15 shirt, wear it once, and let it go. It is also driven by the interests of the companies that benefit most from this. We all must take responsibility for our choices and how they impact people and planet, including our textile choices. Where do our clothes come from and what is the environmental and humanitarian impact? If we encourage flax to be grown regionally, then people will begin to have an awareness and connection.

3. History of Flax & Linen Production

Flax has been grown and cultivated by people in various places around the globe for thousands of years. Archaeologists have found remains of flax that are dated from the Stone Age – as far back as 8000 BC. The Flax and Linen museum in Kortrijk, Belgium has linen artefacts displayed that show that bast fibres in flax were cultivated and processed to provide fine linen yarns. Evidence and story telling of flax starts in Egypt and the Mediterranean region, then is seen in Europe, and across to North America in the early 1600s first by the French and then by the English.¹²

Fibre flax arrived in America when Europeans arrived in 1640 in Connecticut. In 1670, the new French governor of Acadie observed the settlement close to Port Royal and wrote: “On these dykes they raise with so little labour large crops of hay, grain and flax, and feed such large herds of fine cattle that an easy means of subsistence is afforded, causing them altogether to neglect the rich upland.”¹³

In Ontario in 1866, according to *The Canada Farmer*, “the manufacture of flax is rapidly rising in importance in Canada; although the trade is still in its infancy its importance is every day becoming better appreciated.”¹⁴

In her book *Flax Culture from Flower to Fabric*, Mavis Atton outlines the extensive history of flax fibre production in Ontario. According to Atton’s research and findings, in 1829 there was a flax-scutching mill situated in Kitchener that could clean 800 pounds of fibre each day. By 1866 there were 100 scutching mills in Ontario and 3 linen factories. Just 40 years later, it became less expensive to import flax than to grow and process it in Canada, and all flax was imported to Ontario rather than grown there. Atton notes in her book that Atlantic Canada had a research relationship with Ireland, growing flax fibre seeds for them.¹⁵

We know from Canadian Department of Agriculture research that was completed in 1935 by the Division of Economic Fibre Production, that flax fibre varieties were being

tested for yield and fibre quality across the nation. In 1932, there were small experimental flax and hemp plots in Fredericton, NB and Nappan, NS. In Kentville, NS there was a small flax fibre mill that was used as a demonstration for the surrounding flax growing regions.¹⁶

Back in 1932 flax growers in western Canada were experiencing struggles in retting the hemp and flax because of dry conditions.¹⁷

The focus by researchers, farmers and industry for growing and processing of flax for the fibre seems to have ended in 1950. In 1998, investment in value adding flax straw from the oilseed fields occurred. Initiatives, including research and innovation to add value by using flax straw, a by-product of seed production in western Canada and in the Quebec region have been ongoing.¹⁸

In the end, we did not get a flax fibre industry well enough established to withstand the rise and fall of the prices and markets and so, like many other countries, we divested of our fibre industry and focused our flax growing efforts on seed production. Over the past 80 years we have nearly lost not only the equipment infrastructure but also the knowledge of growing crops (hemp and flax fibre) and processing for fibre.¹⁹

4. The Journey From Seed to Shirt

I am going to explain all of the steps I have learned that are required to accomplish seed to shirt production. As I go I will provide an analysis of each step in terms of what I think is possible for Canada. I am hoping that I can explain that Canada can firstly grow and scutch quality flax fibre that can compete in the world marketplace. At TapRoot Farms, we already have many of the steps in this process in place and working. Step by step, we are building detailed business plans to arrive at a viable linen industry.

The growing season of flax for fibre is achieved in 100 days in any flax growing region.²⁰ The current high quality standard of retted flax straw is in the Normandy region of France. It has been said that a good linen shirt is like a fine wine. It all stems (pardon the pun) from good growing and retting weather in the flax fields. The knowledge of harvest time, and the precision of the dew retting, which is the process required in the fields that allows the scutcher to expose the fibres, is as important as the quality of grapes and chemistry of the process for the exquisite characteristics of a fine wine. Once the farmers have finished the retting process it moves on to the scutchers. This is where the straw is processed into its different components, long and short Fibres, shives and seeds.

The dollars and cents of primary production, of course, is forefront on the minds of every farmer when the discussion of growing a different crop begins. Fibre flax is a crop

that requires specialized equipment and knowledge that differs from many crops that Canadian farmers grow. However, from Jason Finnis' report (Figure 2) which shows the value of a flax crop's various components, demonstrates that growing flax fibre for the spinning mills can definitely be a winning proposition.²¹ Like other crops that leave farmer's fields to get processed, the farmer will get paid on how well the raw material breaks down into the different components that have value in the supply chain. Flax is no different; as we move forwards in Canada on flax fibre production, it will be important to pay attention to these percentages. The highest value component is the long line, which is the longest Fibre left after scutching. These long Fibres are what the spinning mills of the world are willing to pay top dollar for.²²

Average Yield		Yield in Kg's	Selling Price / KG	Income
Straw Yield kg/Ha	6,200			
Long Fibre	21.80%	1352	€ 2.75	€ 3,717
Short Fibre	10%	620	€ 1.00	€ 620
Seeds	5%	310	€ 0.32	€ 99
Shives	48.40%	3001	€ 0.05	€ 135
			Total Income	€ 4,571

Figure 2: Jason Finnis, Canadian Flax Fibre Market Feasibility, "Net Revenue to Farmer on 1 Ha of Fibre Flax in Euros", August 9, 2019

The spinning mills of the world negotiate with the scutchers to receive the best quality Fibre they can afford or need. From the spinning mills comes the yarn, which comes in many different qualities depending on application; a high percentage of this yarn heads to weavers. The weaving is the start of what the cloth will look and feel like. The designers take this fabric to create stylish and eco-friendly clothes for a multitude of people to enjoy on their bodies. The idea of growing a product that makes the many steps to one day be designed and worn at an upscale event will be very satisfying for me, both as a farmer and consumer.

4.1 Site Selection: Where to grow flax

Flax grows all around the world, but it grows differently according to the local climatic conditions. On my travels I saw flax growing as far north as the Baltic Sea area of Poland and as far south as Upper Egypt in the Minya area. The best conditions were found in the south west of Europe, in particular France's Normandy region. In Poland the challenge was short dry summers and cool late summer/falls, resulting in short flax straw. As I moved south to Egypt, the growing conditions were almost ideal. This is because most flax is grown on the rich soils of the delta or the river; the Nile flood plains

are also rich in nutrients. With the heat of the ever-present sun and the irrigation waters of the Nile, the flax grows very tall which gives long Fibres as well. Looking at the growing conditions in Western Europe, they have mild winters and long summers, historically; throughout all of their seasons they get a perfect mix of sun and rain making it an ideal place to grow flax as well.

Flax doesn't need a lot of rainfall to grow nice and tall. It only requires at least 600 mm of rain for the growing season.²³ Since flax also needs to be field retted, it is best to grow fibre flax in regions that have heavy dew and timely warm rains in the retting season. Retting season in the northern Hemisphere runs from mid July to mid October depending on the growing conditions and rains for retting.

Atlantic Canada, and especially Nova Scotia has a very similar climate to the regions in Europe that are known for growing great fibre flax, which also fall on the 45th parallel. Other regions in Canada with this appropriate climate include: southern regions near the water in Quebec and Ontario and along the southern coast of British Columbia. Regions of the country where it is dry and hot for long periods of time are not ideal for growing flax for the intent of producing long Fibres for textiles.

The map in Figure 3 shows ideal regions for flax growing; however, microclimatic zones outside these idealized regions may also work very well, for instance, areas of Quebec.

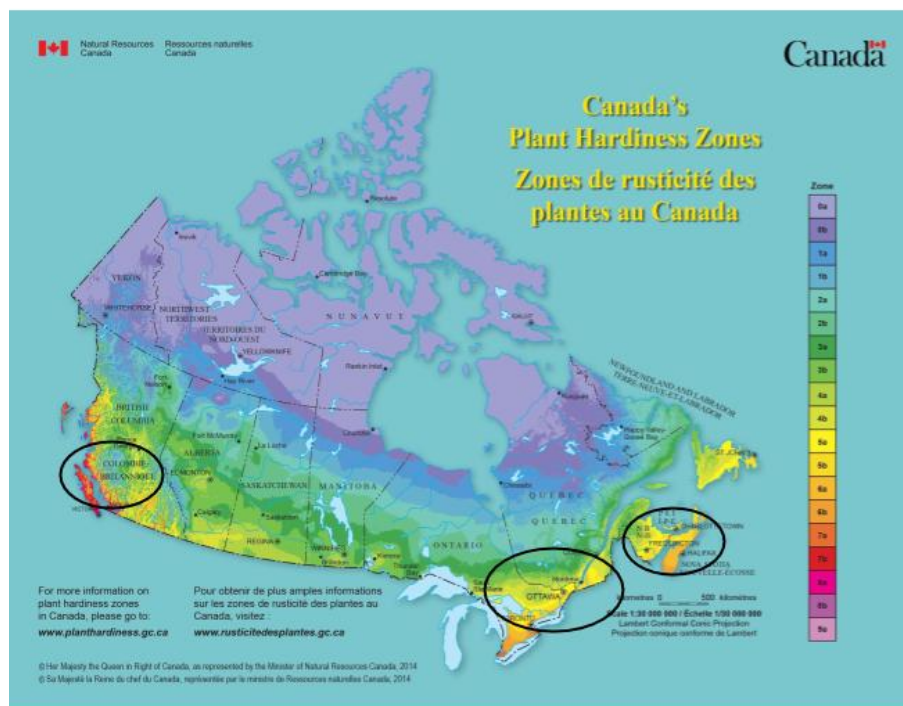


Figure 3: Natural Resources Canada, Canada's Plant Hardiness Zones, highlighting possible flax growing regions

4.2 Seed varieties

Selecting seed for the region is important. We do not currently know which flax fibre seed varieties are best suited to the regions in Canada. The AAFC Plant Gene Resources seed bank in Saskatoon, Saskatchewan has more than 20 varieties of fibre flax that are no longer grown in Canada.

TapRoot Farms did work on a small research project with Acadia University to grow varieties indoors and to produce enough seed to do a field trial. The field trials will happen at some point in the future. In the meantime, the industry has a list of approximately 20 varieties they use in the fibre flax growing regions of the world. Of those 20 there are four that are most popular. They are: Agatha, Hermes, Marilyn and Diane.²⁴

All flax plants have bast fibre in the stalk, as do hemp and nettles. To grow flax for fibre rather than flax seeds, we need to choose varieties that have been selected by breeding programs to give high yields of Fibre rather than seeds. The priority of the Fibre flax breeder at present is the disease package. Most of the work being done in flax fibre science is happening in Western Europe. One example is the work at Terre de Lin, a cooperative in upper Normandy. Figure 4 shows the seed varieties used at Terre de Lin.

Multiplication area by variety (GNIS 2014 DATA)

VARIETIES		BREEDER	MULTIPLICATION AREA IN FRANCE
ARAMIS	The new yield champion	TERRE DE LIN	19%
ARETHA	Potential and regularity of yield	LIMAGRAIN	18%
ALIZEE	The reference of fiber flax	TERRE DE LIN	14%
EDEN	Richness and lodging resistance	TERRE DE LIN	7%
DAMARA	The high productivity	LIMAGRAIN	7%
DRAKKAR	The income asset	TERRE DE LIN	5%
MELINA	Rusticity and versatility	LIMAGRAIN	5%
VESTA	Good value	LIMAGRAIN	5%

Figure 4: Terre de lin, Spring Flax Varieties that grow well in France

I would like to see Canada begin field variety trials in the locations best suited for growing flax fibre. At this point there is no known field trials being done in Canada to evaluate flax fibre varieties.

4.3 Seeding and growing

Seeding can be done with a seed drill, which most established crop farmers will have access to already, or by broadcasting. Seeds should be planted 2 cm deep with a row spacing of 12.5 cm, this is known to result in the best even stem diameter and height. The seeding rate is in the range of 1800 – 2200 seeds per m², which is roughly 120 pounds per acre.²⁵ Ideally, seeding would be as even and uniform as possible and it

would be done as early as possible in the year. In France and Belgium, seeding is completed between March and April. In Nova Scotia, we have usually been able to get our flax planted by the end of April. The flax is able to survive the spring cold snaps and wet spells. The fertilizer required of flax is 90 kg/hectare of nitrogen, 40kg/ hectare of phosphorus and 140kg/ hectare of potassium. There is also evidence that a zinc application will aid in yields in your flax fields for both oil seed and fibre flax.²⁶

Throughout the growing season, if weeding by hand, you need to get in early so you do not pull out the flax when weeding. If weeding with herbicides, the availability of products is low with only pre-emerge or early growth stage applications available, leaving a small window of opportunity for control. There is work being done in mechanical weeding, with tine weeding on top of the efficiency list. The flax growers in Western Europe feel that soon the herbicide option will be gone, as the major herbicide companies do not see flax worthwhile to invest their resources on.²⁷ On this same thought Victor, a fellow Nuffield scholar and flax farmer in France, also sees this becoming a reality and has participated in a tine weeding trial in this past 2019 growing season. This will give flax textiles an enhanced “environmentally friendly” image than they currently have. As consumers look for clothes options with less chemical residue, linen is emerging as their best option in this category.

A Czech flax consultant, Zdenek Sprynar, visited with us at TapRoot in 2015 and told us that “machinery and processing is nothing if you don’t have good growing practices.” You must grow great flax to have high quality fibre.²⁸

Flax is sensitive to soil-borne diseases like fusarium, so the rotation is long. The recommendation is 6 years between flax plantings.²⁹

4.4 Harvesting/Pulling

Flax harvesting for flax fibre involves pulling the plant out of the ground to ensure you get the longest fibres possible as the Fibres run into the root of the plant. In the major growing areas of western Europe this happens with self propelled pulling machines that can do up to 20 Ha a day. As the machines pull they are laying the flax down in a straight uniform line with the root and seedpod always lined up. This orientation is key in this method as the rest of the processing all the way through the value chain depends on the important orientation. Industrial-scale equipment to do the pulling (called a “puller”) is available for purchase from Europe and costs up to \$350,000 CDN, though smaller used equipment might be sourced for as little as \$5,000 CDN. Most pullers, as I have mentioned, can do up to 20 Ha a day, which would be a long dusty day of pulling. When in Egypt I learned that the flax there is still pulled by hand and some of the larger players are trying to get this harvest more mechanized to allow for the farmers to be

more profitable and to encourage more production as demand is increasing. Even when pulling by hand the orientation is still important for the next step in processing. Once pulled, a deseeding machine can come along and harvest the seed so it can be cleaned and either sold or kept for replanting. In Egypt, the process of deseeding is as follows: putting the flax on a large sheet of plastic and driving over it with a tractor to knock off the seed pods that will be collected from the plastic to be cleaned for food and replanting.

4.5 Retting

In the areas that can dew rett, the flax that has been pulled lies on the ground for 2–3 weeks. The weather impacts how long it stays out. Dew is essential for this stage, as retting requires moisture. I did ask the question in Poland if you could use irrigation to rett and they said it does not work, as the water is too cold and the bacteria that is active during the retting process prefers the water to be warm. In some areas of the world flax is tank retted. According to our connections in Europe, including Safilin's buyer, the highest quality flax is all dew-retted lying in the field. The advantage of dew retting is it allows the bacteria found in soil, the rain/dew and the sun to break down the pectins in the stem to free up the fibres.³⁰ One of the lessons I learned in the labs of the Institute of Natural Fibres in Poland was there are many fine fibres in the flax plant; if retted to perfection the best spinning mills can use these fibres to make the finest yarns. When tank retting, not only do you create toxic waste water, but you don't have the symbiotic relationships that break these pectins down, thus limiting the fineness of the yarn you can spin.

In the dew retting process the flax is turned over after 2 to 3 weeks. This, too, is done either by hand or by a machine called a turner. Once turned, it stays out for another 2 to 3 weeks. Once the fibre is ready (meaning that the fibre separates from the shive easily), it is baled up and put into storage for processing. Here is the biggest challenge for new entrants to flax fibre production. Knowing when it is ready is very hard and comes only with time and experience. The ability to walk the field and pick up samples of retted flax with your hands and test to see if the flax is ready to bale or not is a specialized skill. This skill comes with seeing the crop go through the first process called scutching, the learning process will require farmers to, with their hands feel and understand the difference between under-retted, over-retted and the sweet spot of perfectly retted.

The retting process would be the same for adding value to the waste stalks left after linseeds are harvested. In Canada we currently have lots of flax straw out in fields, but farmers need to gain retting skills and also invest in turning, monitoring and baling the flax straw when it is ready. Unfortunately, the varieties used in oilseed production are bred to produce seed not fibre; therefore, the yields of straw are low. This lack of straw

yield creates a feasibility challenge to justify the extra work of harvesting the oilseed straw.

4.6 Baling

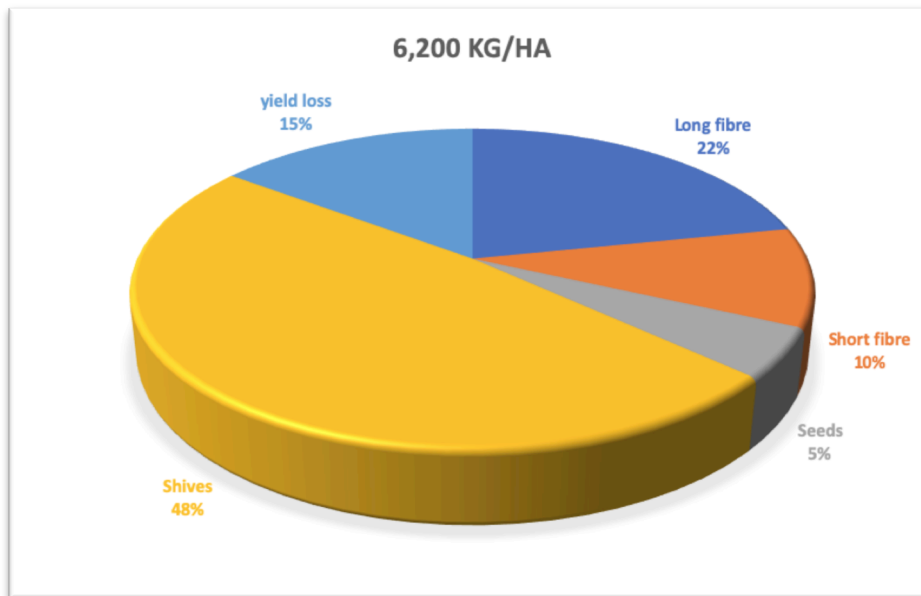
At this point the farmer bales the retted flax straw once it has dried. If growing long line fibre flax you must at all times maintain the orientation, keeping the fibres parallel and uniform which requires an adjustment to the baler to put strands of yarn between each layer in the bale so that the flax will unroll in one flat layer and not become jumbled up with other layers. There is also a specialized baler you can also buy that is designed to do just that. For short fibre production this is not needed, because the uniformity is not a concern for short fibre.

The yarn or twine used to separate the layers in the bale needs to be natural fibre and are typically made from hemp & flax. While in Poland, I visited a processing facility called LENKON, which was part of The Institute of Natural Fibres. Here they are scutching and spinning flax and hemp grown in Poland. Due to the poor growing conditions and short flax they were spinning it into twine for the balers of Normandy. I spoke with Victor Leforestier from Sainte Colombe, France; he was saying this year, 2019, that he harvested/baled 9 tonnes/ha of flax straw from one field, with the average being 6.5 tonnes/ha in Western Europe.³¹ I would say 2019 has been a good year for yields in the flax fields of France, which I hope will not depress the prices. In Egypt, they do not bale in the field. They carefully pile the flax onto trailers, again, keeping the flax all facing the same way. All the flax is loaded and unloaded by hand.

4.7 Scutching

Most often the bales get loaded onto a flatbed truck and trucked to the scutching mill directly from the farmer's field. The scutching mills do take on the task of storage of the baled flax straw until the time comes to scutch it. The storage in Egypt was simpler as the lack of rain made piling up outside the norm. There are five outputs from the mill, as shown in Figure 5 from Jason Finnis' 2019 report.

- 1) Clean long fibre
- 2) Clean or not clean short fibre (depending on the mill infrastructure)
- 3) Clean or not clean shive (depending on the mill infrastructure)
- 4) Seeds
- 5) The 15% yield loss relates to dust, dirt, weeds, bad quality fibre, and other contaminants that enter the skutching line. Dirt and weed contamination is pretty common given that the fibre lies in the field during the retting process. When it is baled, clumps of mud and other foreign matter are baled up with the flax.



**Figure 5: Jason Finnis, Canadian Flax Fibre Market Feasibility,
“Proportions of products from a flax crop”, August 9, 2019**

The scutching process consists of a number of steps. These steps can be done by hand or by machine, and over time the scale of the equipment for this process has increased in size and cost to meet the market demand for increased throughput per hour. Currently, all but a few small farmers use machines to scutch the flax straw.

The bales are brought out of the storage and all the traceability information is recorded, then placed on the unrolling tables to unroll the uniformly oriented flax straw. With all the root side on the same side of the machines every time. From here it moves on to a machine that removes what is left of the seedpods; this is called rippling. If you do not have a deseeding machine, then the seeds will go through the retting process and the seed quality may be less desirable as they can be underdeveloped and/or the seeds are of poor quality because they have collected moisture after drying on the ground for 2-3 weeks. In order to expose the fibres, the outside of the stem needs to be broken (this process is cleverly called breaking). This is the machine where most of the shives are collected, which is the outside hard bit of the stem of the flax. From the breaking rollers the flax moves into the scutching turbines. This is a very aggressive spinning blade that knocks off the rest of the shives. At this point a farmer can win or lose. If they under rett the flax straw, the long fibres will come out of the turbine with too much stem still left on the long fibres, and this causes the quality to be significantly reduced, making the payout much less.

If overretted, the scutching turbines will pull apart the long fibre, increasing the short fibre percentage, again reducing the payout to the farmer. As the broken straw passes through the scutching turbines, what falls off is then transferred to the short fibre or towline to be cleaned. This process separates the shives from the tow by passing it over a 6 to 8 roller/shaker table. Once the tow is clean, it is compressed into a square bale to be shipped to spinning mills. The final step for the long fibres, or long line, once out of the turbines, is sorting (a human stands there and pulls/picks out unacceptable long line flax). From there it is rolled in a small round bale of 100 KG, again keeping it oriented as the spinning mills want to know which end is the root end and which end is the head. These bales of scutched flax are then labelled, stacked by their lot and sold.

At Albert Brille, a scutching mill outside of Kortrijk in Belgium, Michael, the mill manager, showed me their scutching line (Figure 6). They have 1000 ha of flax feeding into that mill and each 8 hour shift they get eighty 100 kg bales of long fibre.

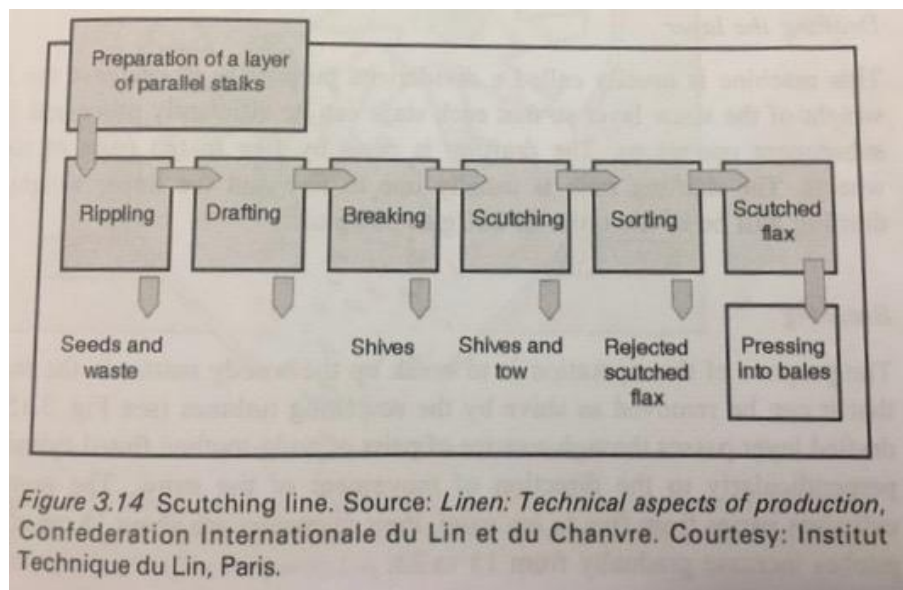


Figure 6: Robert R. Franck, Editor, “Bast and other plant fibres”, Scutching line

This mill, and I would say most scutching mills, have great traceability as the farmers are paid on the yield of all four different components which are long and short fibre, seeds and shives. The long fibre is the most desirable.

4.8 Buying

Often the buyers will come to the scutching mill to see the fibre before purchasing it for their spinning mills. Companies such as Safilin, known to produce some of the finest linen in the world, are extremely particular about the quality of scutched fibre that they buy. Through the growing season, they keep their attention on the weather in each of

their source growing regions, and have an idea about where they think the best long line scutched fibre will be produced.

The bales of long scutched fibre are then shipped to the spinning mill. The mills are located mainly in countries with lower costs. Most of them are now in Poland, India, and China. On my Nuffield travels, I had the opportunity to visit mills in Poland and India. These mills had differing opinions on the supply of quality scutched long line flax. The mill I visited in India seemed confident that flax was in good supply because they always had supply at the mill and more on the water coming from Europe. When asked if they were concerned over supply, they quickly answered “no”. The Poland mill really had a different story. They try to have a year’s supply in storage, and at the moment of my visit, they only had 6 months, which made them nervous. Speaking to Micheal from Albert Brille after my mill visits, he spoke of a bottleneck at the scutching mills in the supply chain. Michael's feeling is the farmers can keep up but the scutching capacity is the problem. This seems like an opportunity for Canada to enter into the fibre business through scutching mill investment.

India spins linen primarily for domestic use. They buy all of their long line fibre from France and buy other flax fibre of lower quality (shorter fibres) to blend with the western European flax. They are experiencing a boom in popularity in linen but it is still a small player in the textile industry because the cost to produce synthetic is relatively inexpensive at the present moment in time.

4.9 Wet Spinning into Fibre

When the bales arrive at the spinning mills they are unrolled onto a hackling machine, again saving the tow from both the head and root/feet ends of the fibre. The long line flax is always rolled into the bales in Europe to ensure spinners know which end is root end. In Egypt, they can tell by the colour as the root end is whiter. This tow is called hackled tow, and it has more value in the spinning marketplace. This hackled tow has more value because of its fineness, which allows the spinning mills to develop higher quality yarns. In comparison, the tow from the scutching turbine tends to be coarser resulting in a less valuable yarn. When it leaves the hackling machine, the flax is now in a sliver (pronounced slei-ver) form and put through a series of doubling/drawing machines. This process requires up to 10 different machines that take a sliver from the hackle machine at 20g/meter down to 4g/meter. What happens in these machines again goes back to the efforts of the farmers and the dew retting in their fields. The flax sliver is run through wooden rollers (at Safilin mill it was a special Maple) that crush the softened pectins from the retting; this releases a greater amount of finer fibres, allowing the sliver to be pulled/drawn out longer, therefore reducing the overall weight per meter. This step requires very spinnable flax and skill, which results in extremely high-

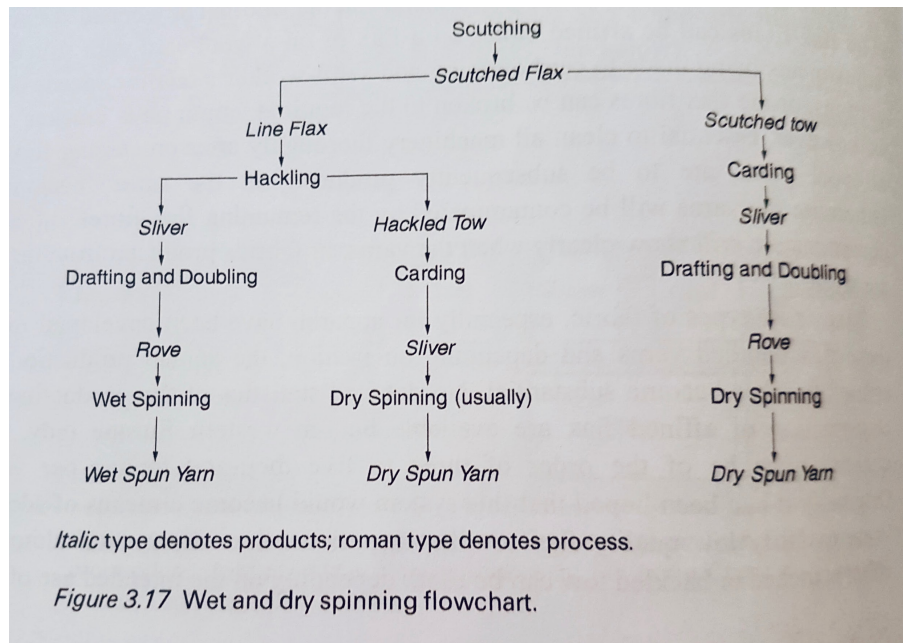
end yarns. The mill in Poland, Safilin, prided itself in this ability to produce the finest yarns in the world by paying close attention to the detail from seed to yarn. The area of doubling/drawing is called the preparation hall, where temperature and humidity must be accurately controlled (See Figure 7).



**Figure 7: A humidity and temperature monitoring device,
picture taken at the Safilin Mill in Poland**

The ideal temperature for top spinning mills is 20C and with a humidity of 82%. This allows the pectins, that hold the fibre bundles together, to be soft enough to be crushed by the wooden wheels in the drawing process. This crushing action allows the sliver to be drawn out lighter to make it possible to spin fine yarns.

From the preparation hall the fibre is spun onto a spool and is now called roving. This spool is designed for the washing/bleaching; the design allows for the movement of the liquid through the spool to ensure that the roving is evenly washed or bleached. This process can take up to eight hours. Once it comes out of the vats it is ready for the wet spinning process. The roving is still wet from the washing/bleaching; plus, it is run through a small water trough just before the twist is applied to the roving. This wetness allows the Fibre strands to be twisted together smoothly; once the twisting is complete, it is put on a specialized cone that allows for drying. The last step in the spinning mill is winding on to the cone that will be sold to the weavers. See Figure 8 for an outline of the process from The Textile Institute.



**Figure 8: Robert R. Franck, Editor, "Bast and other plant fibres",
Flowchart of wet and dry flax spinning processes**

Dry spinning is used in coarser applications in which scutched tow is spun to create twine or rope; this has no moisture in the process, hence the name dry spinning. As you can see in the flowchart Figure 8, when using hackled tow you can use what is called semi-wet spinning. The hackled tow is smoother and can be spun into yarns that can be used in textiles as an added value in the spinning mills. In Poland, Safilin had two mills, one that was wet spinning and another that they called dry spinning, but was actually semi-dry, as the spinning area has high humidity and the sliver passed through a water trough just before it was spun. The dry spinning I saw in Egypt was very dusty and the mills were extremely dry. There was no moisture in sight, but they were spinning mainly twine.

China has really taken ownership of linen spinning, not only building spinning mills but buying the technology from Ireland. They have moved the manufacturing of the James Kay "wet spinning" and hackling machines to China, and this is where you buy new machines if wet spinning is your business ambition.

I travelled to India to Golden Fibres. At their mill (family-owned) they run 9,000 spindles of the 80,000 spindles that exist in India. It takes 7 to 9 days for the flax fibre to go from scutched long line fibres coming into the mill, to fine linen yarn, 3 shifts per day. Forty percent of the workers are women and the machines are cleaned between each shift. They have two weeks of fibre in storage and are eager to access high quality fibres for their inventory. The owner of this mill, Anuj, is excited for Canada to start producing flax

fibre to give him another option for his flax needs. This mill currently uses 1800 tonnes of scutched fibre per year. All of this 1800 tonnes is shipped in containers from Western Europe and hopes that someday he will have an option to buy from Canada as he hopes to double his production. He does like the idea of having more growing regions of the world growing flax to spread out the risk. There has been years where France has had a poor growing year and the price is increases making the business less profitable. They are planning to increase their production. They spin the fibre between 10 and 13.4 twists per inch and the spindle turns 7,000 turns per minute yielding a 15 – 36nm yarn. Nm stands for number metric, which is the measure of fineness, specifically, the number of meters in 1 gram of yarn. The average mill spins yarn at 24nm, and the finest yarn spun by Safilin is 50nm, which is 50 meters in 1 gram of yarn.

4.10 On to the weavers and knitters

Finished yarn goes to either yarn shops or weaving mills. Like spinning mills, many of the weaving mills have left Europe. The cost of production is very high, making it hard to compete with other countries with lower costs of production. As a rule, developing countries fall into this category, having lower labour costs and less regulatory burden.

One larger-scale family owned weaving mill is still in full operation near Kortrijk, Belgium, called Libeco. Libeco weaves for clients all around the world while also value adding and providing a line of household textiles. The looms are large, loud, and highly technical. In the weaving mill there are five steps:

- 1) Warping the beam, sometimes outsourced to companies that only prepare the warp.
- 2) Setting up the loom.
- 3) Weaving.
- 4) Menders inspect the woven textile for any errors or inconsistencies that need fixing.
- 5) Then the fabric is sent to the finishing department which is either in-house or is a separate company.

Libeco has great confidence in the linen industry globally and one of their slogans declares, “Believe in Linen”.

4.11 Finishing

At Libeco they complete all of the steps in-house. Finishing the fabric means washing and treating and drying so the fabric is ‘sized’ or as often called, “pre-shrunk”. This can be a very chemical-intensive part of the process; if done properly this enhances the quality and appearance of the material. Speaking to Dr. Malgorzata Zimniewska, at the Institute of Natural Fibres in Poland, I learned she has been involved in experimenting

with a new finishing technique called Corona. The process involves a discharge being created between two electrodes with high voltage and a frequency of 20 – 40 kHz affecting the surface of a fabric running continuously at ambient pressure and temperature.³² Dr. Zimniewska doesn't like the idea of chemically finishing as it takes away all the beneficial properties of linen. The Corona treatment has positive effects on the linen's response to dying, printing and bleaching. I am not sure how this would affect the market place if widely adopted; my opinion is this would increase efficiencies of dying, printing and bleaching, making linen more competitive in the marketplace. Another non-chemical treatment she recommends is mechanical softening with the use of silica.

4.12 On to the garment manufacturers

From here a large bolt of fabric will be sold and shipped off to a garment construction mill. Patricia Bishop, my business/life partner recently toured such a mill just outside of Boston, where they are manufacturing men's suits. Again, it is a large assembly system of parts being put together. First the mechanical machines cut the pieces from the fabric. Those pieces are all stacked and move along an assembly line of sewing workers. The sewers get paid by the piece. The space is mechanized, loud, hot, fascinating and surprising all at the same time.

4.13 Climate Control

With all aspects of seed to shirt production, climate control is a serious consideration. The fibre responds to humidity in the air and therefore having a controlled environment for consistency and success in processing is critical at each step in the wet spinning value chain. In the steps leading up to the wet spinning, dust is a real concern from pulling all the way to scutching. So when people are working in any of these steps there needs to be safe guards in place to ensure the safety of the workers. This is a cost that is a reality and must be considered. In our great country we have regulations in place to ensure a safe workplace, so in a scutching mill in Canada you will need an air cleaning system within that mill. Some less fortunate workers I saw were working in an abundance of dust; for me, an interesting observation is that I was having trouble breathing but they were working 8 AM to 5 PM without masks or clean air. As I coughed and wheezed for hours afterwards, I wondered what their bodies do to allow them to work in this environment.

5. Current Flax & Linen Production

Throughout my travels I learned of various linen production initiatives (hobbyists, businesses, non profits). These are just a few of the examples of work that is occurring in the flax fibre space that we are aware of. It seems that many of these initiatives have been created because of one of four things:

- 1) Artisans want to work with fibres that have a story of their origins; however, in the globalized fibre world traceability is not open to the customer;
- 2) The people who are working on these initiatives believe in regionalizing and providing meaningful employment to people within the region – to grow, harvest, process, spin, weave, sew, etc.;
- 3) Given their knowledge of the textile industry, they are working to make a change for a local and healthier value chain; and
- 4) There is a goal of creating valuable products from natural fibres.

Currently in North America there are nine initiatives, besides ourselves, that we are aware of: Earthhand Gleaners in British Columbia, Frank Wheeler at the Composite Innovation Centre Manitoba Inc., Denis Rho in Quebec, SWM in Saskatchewan, Upper Canada Fibreshed in Toronto and surrounding area, Fibreshed in California, Fibrevolution in Oregon, Chico Flax in Northern California, New England Flax and Linen Study Group in Massachusetts. In Northern Ireland, the Linen Biennale. (See more details on these initiatives in Appendix C.)

There are major challenges, that I understand to be true for Canada to develop a flax linen value chain: a) facing the creation of a Canadian linen industry is the fact that this is an unknown crop to people in agriculture in Canada; b) everyone involved in the Canadian flax industry from government to farmers, cannot see beyond the oilseed production box; c) the focus when it comes to flax fibre in Canada is how to value add the oilseed straw. Such circumstances have contributed to lessening initiative. Oilseed flax straw, I believe, will never be part of the linen value chain.

The European Confederation of Flax Hemp (CELC) is the organization that represents all stages of production transforming flax into linen. They also represent hemp. They have created marketing campaigns and most recently the “I Love Linen” campaign. Adopting a similar campaign would help develop opportunities for Canadian linen. This could help raise awareness of the possibility that Canada can produce our own clothes.

All around the world when you begin searching you will find collectives of people for either industry, survival or hobby, working with fibres. Similar to food production, fibre production is everywhere and it is happening at various scales.

6. Personal Nuffield Travel Observations and Reflections

Before leaving on my Nuffield journey, the only experience I had with flax production was that of the experimental growing and processing at our farm in Nova Scotia. The excitement of learning about the global flax industry felt surreal at times. Western Europe is the epicentre of flax cultivation, and this is where I started my travels. Here they have survived the perils of the ever-changing textile industry.

6.1 In Northern Ireland.....

In October 2018, I had the opportunity to travel to the Linen Biennale conference in Belfast, bringing together designers, local businesses, researchers, weavers, artisans, scientists, industry, and anyone interested in linen and bringing Irish linen back to prominence. Their theme was Recall, Rethink and Reform. The idea is to stimulate new thinking about Northern Ireland's oldest textile products: flax and linen. The Biennale was well attended by people from around the world. It was my first experience seeing the excitement of flax on an international stage. Here is where we made contact with Dr. Malgorzata Zimniewska, which made it possible to go to Poland to The Institute of Natural Fibres and Medicinal Plants. I also got to meet and spend time with Shannon and Angela at Fibrevolution in Oregon, who are facing similar infrastructure challenges.

6.2 In Belgium.....

Belgian flax producers are seeing that the demand for their scutched flax fibre is growing. At Albert Brille (a 3rd generation flax growing and scutching firm in Belgium and France), they have never seen their storage so low. If for some reason the 2019 crop was even a little bit lower than 2018's, this meant they would be in a position of a supply shortage. Micheal Oosterlynck, the plant manager at Albert Brille in Belgium, is encouraged by the future of flax fibre. He does believe that the straw from the oilseed in Canada can be of use in technical applications, insulation, composites, etc. Michael also shared that he believes Western Europe can fulfill the market demand for flax but it is the scutching that is the bottleneck in the value chain at the moment.

Jan SIJNAVE, Directeur at the Belgian Flax Association, has interesting points about the flax industry in his country. He feels they should start bringing back the spinning mill to Belgium as they have almost lost the knowledge and once it is gone it is so hard to get back. I feel that there are similarities to this loss of knowledge in Canada, and we are experiencing it in all aspects of the flax journey. A better grading system in the scutching mills for the fibre coming off the scutching machine would be advantageous for increasing the value for the better growers. This, he feels, would be a nice option for those wishing to increase the end product quality, knowing that they are getting the

best through the value chain. The flax industry does not have a lot of newcomers; “None actually,” says Jan SIJNAVE. “As I have observed,” he says, “all involved are long time family operations.” Jan is sceptical of flax in the composite space, some of his concerns are: a) flax is unpredictable as an ingredient, b) being plant based causes slight differences in each batch, and c) this adds degrees of difficulties in the composite making process compared to petroleum based product. Also, the automotive industry is so cost driven that he feels this relationship will not be feasible for the scutching mills. In Kortrijk, I got to visit and explore Texture, Museum of Flax and River Lys. (<https://www.texturekortrijk.be/en/>). Here they explained the long history of the growing of flax for Fibre in Belgium and the world. The reference to the River Lys is that up until the mid 1900’s this river was famous for the flax straw that was retted in this slow flowing river. They also called it the Golden River for it created income in the communities along the riverbanks of the Lys.

Reflecting on my Belgium visit, it was inspiring to see what I envision to be true. They have, what I feel, can happen in Canada, an industry with a goal of “Seed to Shirt”. Through the well-documented history, I see this industry has adapted to changes stemming from public pressures of production practises and the consumer demand for their product both increasing and decreasing over time. What exists today is an industry that has long time players and an exciting future. The exciting future is their product is in high demand, because of the sheer fact that the world population is growing, meaning more cloths are required and flax/linen has a “green” image. Flax is often cited as the most sustainable/eco-friendly for its low pesticide use, low requirement for irrigation, its durability and how easily it can biodegrade after its long life of clothing people is over. Engaging youth into flax business is proving to be difficult, which is a common narrative throughout the global agricultural sector. I see an opportunity for Canada to use this new, exciting, and green industry to engage with youth to enter and help build a linen industry here in Canada. The fact that both Jan and Micheal are seeing a strong demand for scutched long line, causes me to believe that this is a good point in history to bring flax fibre to Canada.

6.3 In Poland.....

The mood in Poland was not so upbeat as it was in Belgium. At the Institute of Natural Fibre & Medicinal Plants they were encouraged by hemp but seem to have lost faith in the cultivation of flax in Poland. Being at the Institute was insightful. I spent a week learning about the parameters and measurements that define the quality of flax for linen in the industry and understanding what makes one fibre better than another fibre. Even in the laboratory setting it was clear that retting is so important. Flax straw that is well retted will have good fibre count and strength, which is very important in the

spinners ability to make a fine yarn. The week in the lab was difficult as working in a laboratory environment for 8 hours has not been something that I have done before. Even though it was tough it really helped me understand how all the steps contribute to the overall end feel and look of a linen product. Figure 9 shows the process of determination of fibre length. I also assessed the fibre count for various yarns.

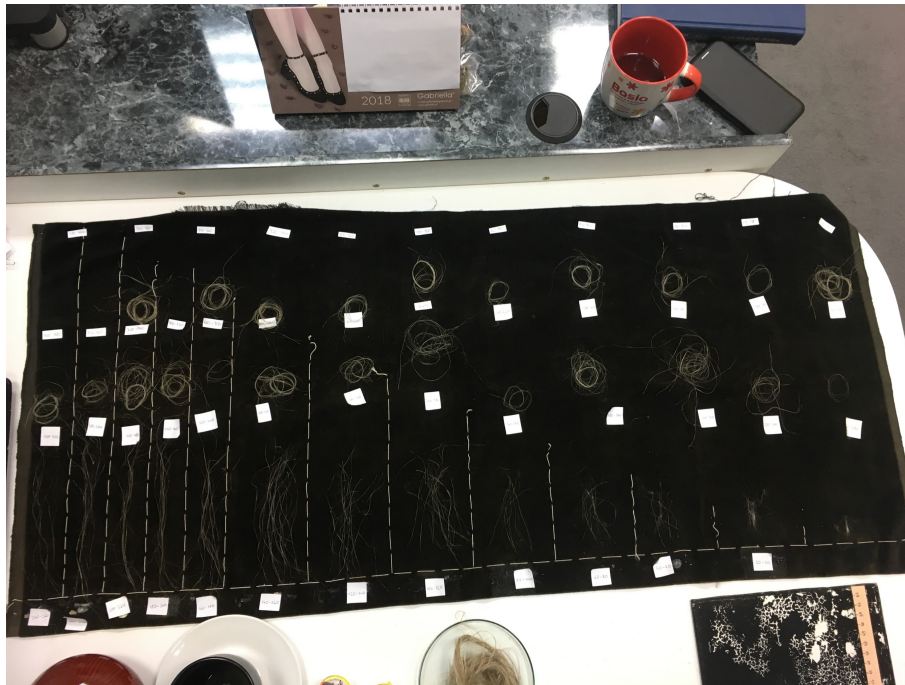


Figure 9: Determination of flax fibre lengths in the lab at the Institute of Natural Fibre and Medical Plants (<https://iwnirz.pl/>)

An interesting area of research that the Director Dr. Malgorzata Zimniewska has been working on is the healing properties of linen. They have discovered that bandages made from linen increase the speed of which the body heals. Also, test results confirmed that linen clothing enriched with medicinal plant extracts enclosed in microcapsules have an effect on the reduction of itching intensity; this process has a patent.²⁶

Following her extensive research on flax, Dr. Zimniewska's conclusion includes the following quote:

"The demand for European flax fibres on the EU and world market will grow due to increased responsibility for the environment and increase of needs of production and recyclable goods according to European regulations." – Dr. Malgorzata Zimniewska

Poland's flax regions are typically too dry, getting less than 600 mm annually, producing short plants and making it difficult for retting. However, they do still etch out a role in the global flax industry by using shorter coarser flax fibre to blend with hemp to make

the string that they use in the balers in Normandy. This provides jobs for 25 people at Lenkon and provides a market for the flax grown by the few remaining flax farmers in and around Lublin, Poland. Lenkon is the experimental processing facility for the Institute of Natural Fibres and Medical Plants (Figure 10). Here they have a small Scutching Turbine, a breaking for hemp and the rest of the equipment to make it possible for them to dry spin the flax and hemp into twine. As a side note Lenkon means flax hemp in Polish. <http://www.lenkon.prv.pl/>



Figure 10: The Lenkon processing facility in Poland (scutching, carding, and spinning)

In a conversation with the LenKon manager, Andrzej Kubacki, he became aware of my interest in the spinning of linen so he got in touch with another local spinning mill he thought I needed to visit. This allowed me to visit and compare two spinning mills, one was for long line processing and the other was for tow spinning. My host of the day was the plant manager at Safilin's long line spinning mill in Szczytno, Jakub Karon. This company is a French company that moved into Poland where costs are lower than Western Europe. At both Safilin spinning mills I heard the same song as Belgium. Demand is high and therefore supply of the raw material is cause for concern. They also were very encouraging to start cultivating flax if the conditions were favourable in our region. The two plant managers were not in control of buying the raw scutched flax fibre and they did have at least a year's worth of fibre in storage so they did feel they were in a good position as that gave them a cushion if supply really became an issue. The Safilin Company has deep roots in France and my assumption is that they also have deep ties to flax farmers giving them an advantage over the recently established spinning companies in Asia.

The plant manager at Safilin's tow spinning mill, Andrzej Grabowski, was very keen on flax production for fibre. He spoke to me about how aggressively China is pursuing the linen market. According to him they are starting to grow and scutch flax in Belarus to

the tune of 40,000 ha, in cooperation with the Belarus Government. Also they have decided to move some of their new builds of wet spinning mills to Ethiopia. The company called "Kingdom" is sitting up a spinning mill with 40,000 spindles in it, which will need a lot of fibre. He is seeing a world shortage of flax fibre and says this will continue as demand for quality long line increases as more wet spinning mills are being built. He looked right at me and said, "If I was young I would build a scutching mill and grow 300 ha of flax for long line in Nova Scotia". I questioned him why and he answered quickly with "I love flax and have great confidence in the industry". The 300ha is what he considers a minimum production unit for flax production. He is in favour of the production of long line flax and feels we should waste no time to get started.

Reflecting on my time in Poland, it was so great to get the unexpected view from the Saflin Mills. Even though Poland has marginal growing conditions because of low rainfall and a cooler growing season, I still came away optimistic. When the market for flax fibre tanked after the Korean war in the mid 1950's, Poland did not evolve like their Western European counterparts, I believe, due to Poland's inability to produce high quality flax straw that was coming from Western Europe. Even though there is knowledge of growing/retting the crop, and, at present, increased interest and demand, Poland cannot scale up production, as there has not been the investment in infrastructure.

6.4 In Egypt.....

Egypt is definitely in a world of its own, and they work with what they can produce. All the growing/retting is done by hand as they have not mechanized as of yet. They see that flax fibre has increased in value, pushing the domestic prices higher than normal. This, of course, is sparking the interest of farmers to plant more in the following cropping season. The movement of scutched fibre in and out of the country is minimal, as they have the knowledge and infrastructure to deal with all they produce. They have found a place in the market that works for their quality and companies dealing in flax seem stable.

Motaz Elholy, Managing Director, Egyptian Industrial Center, has a huge passion for flax passed down from his mother who also travels to study the production of flax. Egypt had a very booming era of flax production, but the drop in price and the unrest in that region of the world was too much for the industry to bear. At present they are still growing and selling 30,000 acres of flax and still they need to import higher quality from Western Europe. Motaz would love for Canada to start producing flax as he has a hard time finding flax to buy if his local supply runs low. This is an important contact as Motaz has markets for flax fibre that cannot enter into the linen value chain because of quality issues. Motaz has market share for coarse scutched fibre. The increase in the price of flax has had a positive effect on the supply of local flax in Egypt. Motaz's company,

Egyptian Industrial Center, buys roughly 2,000 tonnes of flax fibre a year all in the form of scutched long line fibres. He then hackles and uses all the tow in their ropes and twine spinning, and the long line goes into plumbing flax. In many countries the building codes are written to use flax rather than teflon (See Figure 11), sliver/roving, and some spun yarns up to 10 NM which is fairly coarse.



Figure 11. Flax fibre used in plumbing at Motaz Elkholy warehouse in Egypt

Motaz says that the value in flax production is using the whole plant and processing for long line. If you are going to grow a flax fibre crop you should do it for long line.

Reflecting on my time in Egypt, I was blown away by how much economic activity can be created by farming with hands alone. They are growing the flax and using every bit of the plant, which is a lesson from which Canada can learn. Motaz was, like Micheal in Belgium, curious regarding why we only use the seed and nothing else of the flax plant. In Egypt, the quality of the flax fibre is “different” from that of Western Europe; no longer am I saying poorer. The industry is not based on a fine soft flax fibre for textile, but rather, on agricultural products that also have a growing market, actually. The eco-friendliness of flax makes it attractive for many applications such as butcher, vegetable supports (tomatoes trellis), and baler twine for example. It was really great to see how this flax is used in many ways in the different countries I have been to.

6.5 In India.....

In India, they focus on spinning for their own domestic use with a small portion exported. They love to wear linen for its breathable quality, durability and the natural look of the fabric; for these reasons the demand is growing along with the population

growth. They do not grow flax for fibre in that country on a commercial scale so all of the flax is imported from Europe, primarily. Anju Biyani, owner of Golden Fibre, a newly constructed spinning mill in Nagpur India is seeking sources of high quality scutched long line flax fibre. Their growth plan for the mill is to get from 8,000 spindles to 20,000 spindles. He is eager to visit Nova Scotia and see our flax production. Hopefully one day, we will grow flax to the quality Anju requires and his dream would be one day we can export to his mills. This mill was very calculated to produce quantities of 24nm yarns, which is an average yarn. They were in the business of producing the quantities their large population required.

Reflecting on India, the investment in flax/linen by Anju's family is an example of the value that linen has in the global textiles. It was beneficial to meet with the owner/family of such a large company in a value chain that was so satisfied with the role they play in this value chain. They always have flax fibre en route and they only service India. Their output is consistent, and the simplicity of the system made for an efficient mill.

7. Market Opportunities

The market for scutched flax is growing and there is a bottleneck at the scutching mills. Spinning mills are searching for high quality flax fibre to spin. There are new spinning mills setting up in India, China and Ethiopia. On my travels I toured four spinning mills and in all locations they are eager to learn of our progress in growing flax in Canada. Since my travels we have made contact with a new spinning mill setting up in China and they too are interested in our flax production.

There is an opportunity for Nova Scotia and other regions in Canada to establish a mid-sized industrial scutching mill that would have the capacity to process 300 acres per year of flax. The returns per acre range from \$400 – \$2,000 per acre for the retted flax straw, and if there were collaboration, one puller and turner could do the work for all 300 acres. The very fact that the world is expanding in the number of spinning mills requiring flax fibre provides evidence that demand will continue to increase. This would get Canadian long line flax into the spinning mills around the world. In Nova Scotia, we have already started to demonstrate that we have the conditions to grow and rett flax to produce the kind of high-quality fibre that is so prized emanating from Northern France. Long line flax production will also provide us with two by-products: short tow fibres and shive for further processing and product development. It would provide a conservative start into the industry. As the demand for high quality textiles increases in regions like China, and the environmental realities of using plastics for textiles impacts consumer choices, the market for natural fibres will increase.

According to Jason Finnis, there is a market for tow. He suggests in his report that the demand for linen fibre is growing by 12.2% per year. The market is seeking alternative fibre sources and people are looking for more responsible options. He also states that bast fibres have a significant opportunity in dozens of value-added consumer markets.³³

8. Conclusions

The flax industry is entrenched in the present day value chain with the dogmatic idea that how it has always been done is how it will continue to be done. There is now room in this industry to have new entrants, and I believe spinning mills are eager to see a new supply region come on board. This comes from two places: a) competition could reduce the price of their raw material, and b) the managers are genuinely concerned the flow of flax fibre could stop. The idea of supply shortage for these large companies could be disastrous, so the idea of another supplier seemed to lighten the mood.

There is also a building movement to bring flax fibre back into communities around the world where it once was. Unfortunately, these places have lost the ability to follow the steps needed to create the clothes at a reasonable price point, as it requires much labour due to lack of mechanization in all steps of “seed to shirt” process. The rate of growth that has occurred has been absorbed by the present day value chain, but many feel this current status quo will now have a hard time to grow with the demand. This will now open the door for the aspiring flax fibre initiatives making it possible to move their dreams to reality.

Demand for flax clothing is increasing. The demand for high quality long flax fibre is also increasing. The marketplace is asking for alternatives to petrochemicals. This greening of the textile and composite industries is increasing opportunities for farmers. The less valuable parts, including the tow, are in demand as industrial materials. I have met with people who share the passion of flax, I have seen the technology required to fulfill our dream of clothes from our Canadian farms and believe it is worth the investment.

Consumers are demanding more climate-beneficial clothing options. Canadian farmers and processors, within the ideal growing regions for long line flax, have an opportunity to grow and process flax fibre in Canada.

Our government can help ease the burden of risk by supporting and encouraging entry into long line fibre production. Our Nova Scotia provincial government currently has people working in sector development, research and innovation; their mandate is to “reduce risk”. Through the development of a flax fibre industry, Canada can increase its agricultural offering to the world and reduce reliance on importing clothing. Of course, there will be challenges when the knowledge is gained by trial and error rather than being passed down from the older generation. Research and demonstrations of how to

grow, rett and process flax will be required. There are already a handful of experts in Canada who have been working on this for many years.

Nuffield has provided me with great confidence in the future of natural fibres. I have a newly formed network because of Nuffield. Even though I focused my travels and research on "seed to shirt" within the flax industry, there is also a lot of excitement and opportunity in the many other uses the flax plant can offer.

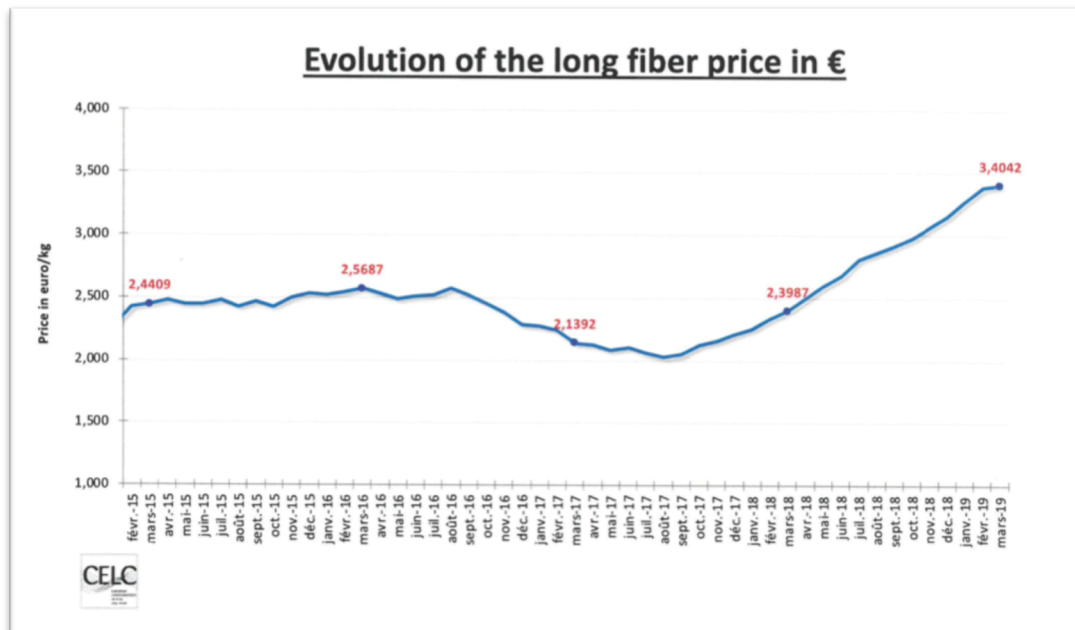
We have demonstrated on our farm in Nova Scotia that growing valuable long line fibre is possible. It can be done in the other regions of Canada that have a similar climate to that of Western Europe. We can produce high quality, highly priced, long line flax because we have these growing and retting conditions. There is a high value on long line flax and there are world market conditions that make pursuing flax a worthwhile investment.

What we have in Canada is a lack of knowledge and confidence to grow flax for fibre instead of just for the seed. This bale you see in Fig. 11 can be Product of Canada.



Figure 12: A 100kg bale of long line flax showing the traceability (origins) and exact weight in Belgium at Albert Brille's scutching mill

Andrejz continues to encourage me to use my Nuffield travel knowledge to take advantage of the local and worldwide flax market and expand Canadian knowledge of this lost industry. This image from the CELC (European Confederation of Flax and Hemp) confirms that flax is a good-and-getting-even-better industry to invest in at this time.



**Figure 13: Jason Finnis, Canadian Flax Fibre Market Feasibility,
The rise in long fibre price in Europe, August 9, 2019**

As I have studied this topic "Flax Production- Seed to Shirt," it is clear the major players are France, Belgium and Asia (China/India). Canada can have a role to play in this sector.

Though there are some deep historic ties in this global value chain that will be barriers, but the world is changing and consumers are becoming more aware of the clothes they wear. I think now is the time that we need to break down these barriers and reclaim our destiny of our clothes. Today in 2019, we import a very high percentage of the clothes we wear and most come from deep in the earth in the form of petroleum-based fabrics or water-intensive cotton.

As governments talk of import displacement and greening of the products we use, flax fibre growing and processing fits like a personally tailored suit.

9. Recommendations

My Nuffield research travel included visits to western and Eastern Europe, Egypt and India to study flax production "seed to shirt". Before my travels, my partner Patricia and I have been involved in local flax fibre/linen initiative on our farm in our community. Also, Patricia and I have researched, designed and built small scale scutching equipment. From these experiences I will give these recommendations.

Nova Scotia and Canadian farmers can and should pursue growing fibre flax as part of their agricultural blend of products to send to market. To achieve this, we need to start

educating farmers in Nova Scotia and the other likely regions of Canada about growing and retting flax. For agricultural know-how, there are three main sources of historical knowledge that I suggest we draw on for education in Canada. There are not many living people who remember the big flax-growing periods, though Lunenburg, NS, still has some people who have living memory of the industry, as studied by Jennifer Green, Professor, Nova Scotia College of Art and Design. Knowledge is available from the long history and current practice of flax growing and retting in Europe, and I believe we should focus our studies on what is known in Normandy. Recent knowledge can also be gleaned from the handful of farmers who are reinvigorating flax fibre agriculture here in Canada. (ie. TapRoot Farms)

The Flax Council of Canada: At the moment, the Flax Council of Canada focuses only on flax seed production. Bast fibre production needs to be included in the conversation for farmers. Flax fibre can be profitable, and Canada can join the leaders growing bast fibres for a better future. The Flax Council can encourage fibre production, help with education about how to grow and rett flax to achieve the best quality, help farmers understand their seed varietal choices, participate in experimental trials, and possibly even help to coordinate investment in scutching mills. There is a very active Flax association in Belgium, and they would be willing to mentor our flax council to encourage flax fibre production by sharing information.

Canadians should invest in scutching mills in areas where dew retting is possible.

There are two models that Canadians could consider for ownership of scutching mills: the French model and the Belgian model, both of which have been proven to work over decades and even centuries, and in today's market as well.³⁴

- In the French model, flax growers cooperatively fund scutching mills for their neighbourhoods.
- In the Belgian model, separate business people buy flax from producers, scutch it, and sell it.

As much as I would love to see the entire, "Seed to Shirt" happening in Canada, I also see a challenge regarding Canada's competitiveness in spinning and sewing. These steps are done in low cost countries and enabled by our present low cost of transportation. Therefore, I recommend Canada focus on the growing, retting and scutching. At the same time this will allow there to be local fibre for the small community based fibre initiatives. I would hope this could bring more knowledge of textiles to Canada that would increase capacity to one day have "seed to shirt".

GLOSSARY

Breaking: break up the woody part on the outside of the stem releasing the fibre

Dew retting (a.k.a. ground retting): an in-field method where the pulled flax is left to rett on the ground with natural dew and rainfall as the only moisture source and the contact with the soil helps break down the stem. Nova Scotia, Quebec, Ontario, and British Columbia have regions that are ideal for dew retting.

Fast Fashion: Inexpensive clothing produced rapidly by mass-market retailers in response to the latest trends.

Hackled Tow: short flax fibres that are produced by hackling; finer than that obtained by scutching.

Hackling: The process of combing the flax to remove short fibres and remaining shives and make the other fibres parallel and smooth, like freshly brushed hair.

Retting: Flax is made supple by exposure to water after it is harvested. This activates enzymes in naturally occurring fungi or bacteria in the flax, which decompose the pectins that bind the fibres to the stems and leaves.

River retting: Egyptians traditionally retted their linen by putting the stalks directly in the Nile. This process is usually no longer allowed. (This is also made famous in Belgium.)

Rippling: Removing the seedpods from harvested flax stalks.

Scutched Tow: short flax fibres that are produced as a by-product of the scutching process.

Scutching: The process of getting the fibres out of the flax straw. By-products include pebbles, weeds, insects, and shiv. Scutched flax fibre can be baled and sold around the world to processors.

Shiv or Shive: the woody matter of flax stalks that is removed during scutching. They can be used as animal bedding, mulch, particle board or biofuel.

Sliver (rhymes with diver): scutched, hackled, carded and doubled flax with parallel fibres, which is ready for spinning. When a twist is added, sliver becomes roving.

Tank retting: Retting the linen by placing it in tanks of water.

Tow: Short flax fibres left after hackling and scutching.

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Appendix A: Case Studies

Case Study 1: Poland

Safilin: Producing the finest quality flax yarn in the world by strict monitoring of climate conditions in the flax growing regions and buying only the best each season.



Figure 1: Jakub, Josh and Andrzej

Safilin was established in 1778 in France, aspiring to meet the rigorous demands of the French fashion industry. They bought mills 21 years ago and located them in Poland, because that was where the competitive cost for labour was.

Between the two mills, Safilin now processes just over 5,000 tons of scutched flax fibre each year, with roughly 500 people working in the mills. They are working with 20,000 spindles; in comparison, the large Chinese company "Kingdom" runs 200,000 spindles.

On an interesting note, Safilin were just approved to spin Organic Flax as of January 24, 2019. Safilin follows the growing conditions of the flax-growing areas of France and only buys flax from areas that have ideal

conditions to ensure they have the best chance to produce the best quality yarns possible. This company buys 6% of the world production of long line flax fibre.

As a risk mitigation strategy, Safilin stores a year's worth of scutched fibre to give themselves a buffer against a sharp increase in price or a crop failure in France. For example, in 2007 they did not buy any flax from France, as it was a bad year. They used stockpiled flax from previous years. They have been quite shocked as they watched the price of good quality scutched fibre from France double in price in the last 2 years as the demand has risen due to Chinese and Indian spinners buying more.

Safilin differentiates themselves by making very fine yarns from this top-quality scutched flax from France. They have extremely clean, precise, and high-quality mills. The attention to detail in the preparation halls shows. For example, they clean the hackle machines every 4 hours and their temperature and moisture are bang on 75% humidity and 22°C all the time without fail. If these values change, they will stop production and sort it out. These parameters are so very important to ensure all the fibres are releasing as the sliver moves along the draw frame.

Another interesting fact is that the wooden wheels in the draw frame that squeeze the fibre as it is being pulled through the many draw frames have to be a special kind of maple. Jakub Karon, Plant Manager, usually makes 24nm fibre because that's what most people want, but he can make 50nm (very fine) fibre as well (most other spinners have no hope of achieving such a fine yarn).

Safilin's two mills are roughly a 2-hour drive apart. The second mill we visited spins the tow, (a short fibre by product of the scutching and hackling process) in a dry spinning application. At this secondary mill, Andrzej Grabowski dry-spins 24nm yarn. I was surprised at the quality of this yarn made from tow. I didn't realize before seeing this that short tow fibres could be used to make such fine yarn.

Lessons for TapRoot Fibre Labs from Safilin:

We aspire to produce the quality of flax that we could sell to Safilin.

While in Poland I learned from Jakub, that during hackling it is important to know the feet from the head, which means the top of the plant vs the bottom. When you put the flax into the hackling machine you must ensure you process the root end, or feet first.

I also learned how important the drawing out process is for spinning high quality yarn. Wooden rollers are important. Quality of flax and temperature and humidity control are critical factors for yarn production.

We look to Safilin for the quality of their spinning mills and aspire to produce that quality of spun yarn.



Figure 2: Draw Frame



Figure 3: Andrzej walking past the winding room



Figure 4: The finest Safilin yarn 50 Tex 245 T/m

Case Study 2: Egypt

Low production costs, tank retting and diverse products



Figure 5: Motaz assessing flax

There are over 5,000 years of history in Egypt of growing flax. Originally, flax was retted in the Nile, but due to river pollution, it must now be done in tanks, as their climate does not offer the dew that Canada and France have. Once dew retting started in Western Europe as the preferred method of retting (due to river pollution), Egypt could not keep up with the quality in the world market. At present Egypt produces 5–8% of total world production of flax. The industry has taken a nosedive recently, going from 100,000 acres to less than 30,000 acres. The production is still done with plentiful inexpensive labour by hand pulling and tank retting, which gives the flax a smell like horse manure and a golden colour.

I spent the day with Motaz Elkholy from the Egyptian Industrial Center touring his flax contacts. We started at his storage shed for his scutched flax. There, he stores the different quality batches of the fibre. The 2018 harvest was not as good because the farmers did not rett it properly. This was due to the high price of scutched fibre. The producers did not take care to rett properly; they just wanted to move it fast to collect the high price.



Figure 7: Scutched Flax

There are roughly 25 scutching turbines in Egypt and some farmers do have their own retting tanks but once retted, they take it to the scutching turbines. Most of the production of fibre in Egypt seems to be dry spinning of coarser yarns for applications like garden twine. They also use their long line flax for plumbing thread tape, which is standard in many countries of the world. They also sell some of their best fibre to be blended with French fibres in big spinning mills in Asia. The one wet spinning mill I saw in Egypt was using French fibre. The challenge is, it is still very labour intensive and mechanization is on the tip of Motaz's tongue. He is actually working with an equipment dealer to build a one-row puller.

Lessons for TapRoot Fibre Labs from Motaz in Egypt:

Motaz showed me the many different uses of scutched fibre and the various low-tech innovative methods of processing the flax. His encouragement has been helpful and inspiring as we consider our next steps on our own farm.



Figure 6: Breaking Machine



Figure 8: Balls of Flax Twine

Case Study 3: Canada

TapRoot Fibre Lab: Growing Flax in Nova Scotia, Canada. Seed to Shirt.

2019 marks our seventh growing season of growing, retting and scutching flax. The learning curve has been steep and we really had no idea how much knowledge we would gain over these seven years.



Figure 9: Flowering Flax

The first year, 2013, we planted our flax at an oil seed seeding density. When the plant looked dry we harvested it, bunched it, stooked it and brought it inside to dry, thinking that we needed to have it dry before we could rett it. That first year we experimented with various methods of retting. Through this experimental process we discovered that: firstly, the seeding rate was too light for fibre production, which produced a stem that was too thick. Also, we

waited too long to harvest; therefore, the fibre bundles were mature and coarse, making first crop unusable for quality linen. It was educational.

The next year, 2014, we planted with an older grass seeder and because of the oil content of the seed they were slippery. This created a situation where we had a high seeding rate due to the seeder metering mechanism not working properly. We learned more about harvest

maturity dates and experimented with dew retting. Because of high seeding rate and the drought we experienced, the straw was short. We also discovered that buying small-scale scutching/hackling equipment was not an option. We had purchased some new traditional breaking and scutching and hackling equipment from our local historic farm, Ross Farm Museum. This equipment was very effective but of course slow. It was great



Figure 10: Hand Pulling Flax

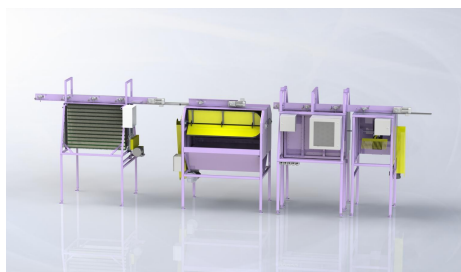


Figure 11: TapRoot Fibre Small Scale Scutching Mill

to see the fibre appear from the retted straw from our farm. We formed an agreement with a college friend to help design and build the machines required. Through this equipment project we had the pleasure of welcoming Zdenek Sprynar from Czech Republic, who was the first flax fibre expert to look at our fibre and give us a nod of approval.

proper retting, which gave us our first quantity of usable scutched fibre. We also had small scale scutching mill prototypes to test, this sped up the scutching process. For spinning we tested a local PEI company who sells mini mills, called Belfast Mini Mills. They have a system designed for cleaning and processing animal fibres into yarn. We successfully spun the tow (short fibres) into yarn and had hackled long fibres available for sale.



As the years have gone by, we have been experimenting with varieties, weed control and fertility methods. With the passing years we are getting more confident in our ability to rett the fibres so we can get a better fibre yield. The varieties we have been working with are Melina,



Calista and Vesta. Melina seems to be the best variety for our farm so far. Flax does not require a lot of fertility: about 150 units of nitrogen on our farm is enough, we have applied too much and found it will cause the flax to lodge, which is a disaster for flax as it curls when it falls to the ground.



Moving along to 2018, this was the best growing year so far. The flax field was a small area and we were successful in pulling it all quickly, properly retting it and getting it under cover in a timely manner. We

are now getting the small scale scutching equipment we designed, built for our own use instead of using the prototype. This will speed up the scutching and we will be able to process three years worth of retted flax. The challenge for 2019 is setting up the wet spinning, which again requires specialized equipment. So far, we can only spin the tow, as previously mentioned.

TapRoot FARMs  **2018 Community Shared Linen**



Learn more at
taprootfarms.ca
sign up is open Sept.16-Oct.1

#locallinen #taprootCSL #localclothes

Figure 15: CSL Offer Post Card

In 2017–2018, we launched a community supported linen project, and the investors received felted shoes and 7 woven or knit linen items, including garments. The project cost us much more than we were expecting, but investors did receive the garments as shown below. We learned a huge amount in this undertaking about the realities of spinning, weaving, knitting and garment creation with our flax. Our enthusiasm for the project has not diminished! We still firmly believe that returning Nova Scotia to our linen-loving past is a good path forward for a sustainable future.



Figure 15: Celebrating 2018 Community Shared Linen

Appendix B: Further Resources and Reference Lists

More References from TapRoot Fibre Lab from Flax Studies by Taproot Fibre Labs and Jennifer Green

General flax information

Flax Cultivation: <http://www.angelfire.com/me/absent/plants/linumusitatissimum.html>
Accessed July 22, 2019.

Richters: <https://www.richters.com/show.cgi?page=InfoSheets/d2701.html>

Saneco: <http://www.saneco.com/spip.php?rubrique1&lang=en>

Maison Du Lin: <http://www.lin.asso.fr/>

European Linen and Hemp: <http://www.mastersoflinen.com/>

Fedustria: <http://www.febeltex.be/Content/Default.asp?>

Belgian Linen: <http://www.belgianlinen.com/>

Fibre & Textiles in Eastern Europe: <http://www.fibtex.lodz.pl/>

How to History: <http://www.howtohistory.com/2010/11/how-to-process-flax-into-lin>

Flax for Sale: http://flaxforsale.com/html/flax_process.html

Discover Natural Fibres: <http://www.naturalfibres2009.org/en/index.html>

Antidote: <https://antidotecounteragent.wordpress.com/2011/10/08/the-fourth-step-to-self-reliance/>

Small-scale flax processing

Aberthau+Flax+Fibre+Food: <http://aberthauflaxfibrefood.blogspot.ca/>

Fibreshed: <http://www.fibreshed.com/economic-development/>

The Urban Weaver Project: <http://urbanweaverstudio.blogspot.ca/2012/11/exciting-news-for-vancouver-flax.html>

Irish Linen: www.irishlinenmills.com/flax/early.html

Flax Machine: <http://www.ftlcomm.com/ensign/industry/flax/flaxmachine.html>

Sharon Kallis: <http://sharonkallis.com/2014/09/24/flax-to-linen-advances-next-fibre-report/>

Flaxland: <http://www.shopping-for-linen.co.uk/working%20flax.html>

The Woolgatherers: <http://www.woolgatherers.com/FlaxTools.html>

The Spinning Project: <http://spinning-wheel.org/2013/11/flax-dressing-in-pennsylvania/>

Irish Linen: <http://www.irishlinen.co.uk/>

Linen fabrics, home textiles, and clothing suppliers

VAVA! VEVE!: <http://www.vavaveve.com/>

South Street Linen: <http://www.southstreetlinen.com/about.html>

Linen Way: <http://linenway.com/>

FLAX Design clothing: <http://www.flaxdesigns.com/index.php>

Procotex: <http://en.procotex.com/index.php>

Wild Fibres: <http://www.wildfibres.co.uk/index.html>

Brahms Mount: <http://www.brahmsmount.com/>

LIBECO: <http://www.libeco.com/en/about-linen/ecological-aspects.aspx>

Biolin: <http://www.biolin.sk.ca/potential%201.htm#.VOdbdPnF9Ee>

Linens for Life: <http://www.linensforlife.com/index.htm>

Whitney Linen: <http://whitneylinen.com/blog/>

Cut Loose: <http://www.cutloose.com/>

Rawganigue: <http://www.rawganigue.com/>

Urbanity: <http://www.urbanity.ca/clothing/>

Frog Linen Work: <http://www.foglinenwork.com/en/>

UCHIT: <http://www.uchit.biz/#socialenterprise>

Epic Linen: <http://www.epiclinen.com/en/>

The White Company: <http://www.thewhitecompany.com/>

Linen Tail: <http://www.linetales.com/>

Keep House: <http://www.keepphouse.ca/>

Rain Goose Textiles: <http://www.raingoose.com/>

Petits Mots: <http://www.petitsmots.ca/>

Bryn Walker: <http://www.brynwalker.com/index.htm>

Hollyhock: <http://hollyhockuk.com/>

Good Linens: <http://www.goodlinens.com/>
Arcadian Dreams: <http://arcadiandreams.co/index>
Linen Patch: <http://www.linen-patch.com/>
McBurney and Black: <http://www.mcburneyandblack.com/home>
Linens Linens: <http://www.linenlinens.com/index.html>
PLANET: <http://www.planetclothingonline.com/index.html>
LaVen Fashions: <http://www.lavenfashions.com/index.php>
LinenMe: <http://www.linenme.com/news/>
Monde Enterprise: <http://www.mondelinen.com/en/product/index.asp>
Linen Linens: <http://www.linenlinens.com/index.html>
Shop Frog Linen: <http://www.shop-foglinen.com/>
Baltic Flax: <http://www.baltic-flax.com/flax-fibres/cottonised-flax>
Couture Lin: <http://www.couturelin.com/>
Fabric store: <http://www.fabrics-store.com/>
Online Fabric Store: <https://www.onlinefabricstore.net/>
World Linen & Textile Company: <http://www.worldlinen.com/index.htm>

Linen yarn suppliers

FIR Group: <http://fir-group.com/>
Hungaro-Len:
http://www.hungarolen.hu/index.php?option=com_content&view=frontpage&Itemid=1&lang=en
Safilin: <http://www.safilin.fr/>
Spinnerij-Lambrecht: <http://www.spinnerij-lambrecht.be/site/products.php?l=en>
Shi Bui: <http://www.shibuiknits.com/Yarn/Colorways.php?Yarn=Linen>
EuroFlax: <http://www.louet.com/category/Euroflax/Euroflax>
Rowan Pure Linen Yarn: <http://www.paradisefibres.com/rowan-pure-linen-yarn.html>
Lit Yarn: <http://www.goodyarnshop.com/index/linen/0-6>
Halcyon Yarn: <https://halcyonyarn.com/yarn/1781010M/newport-162-linen-yarn>

Conferences and associations

Nova Scotia Fibre Festival: <http://www.fibreartsfestival.com/>

The Fibre Festival of New England: <http://www.thebige.com/ese/fibre-festival/>

The National Needlearts Association: <http://www.tnna.org/group/YarnGroup>

World of Threads Festivals: <http://www.worldofthreadsfestival.com/festival.html>

The Stahlstown Flax Scutching Festival: <http://www.flaxscutching.org/>

EarthHand Gleaners Society: <http://earthand.com/>

China Bast and Leaf Fibres Textile Association: <http://www.cblfta.org.cn/>

Manitoba Flax Growers Association: <http://mfga.ca/>

Flax Council Of Canada: <http://flaxcouncil.ca/>

Saskatchewan Flax Development: <http://www.saskflax.com/>

Textile Society of America: <http://textilesocietyofamerica.org/>

College Art Association: <http://www.collegeart.org/>

Universities Art Association of Canada: <http://www.uaac-aauc.com/en>

The Cohousing Association of the United States: <http://www.cohousing.org/>

Slow Textiles Group: <http://slowtextiles.blogspot.ca/>

Dyeing

Woad Extraction: <http://www.woad.org.uk/html/extraction.html>

Fat Hen Wild Wool: <http://fathenwildwool.blogspot.ca/2012/10/woad-wonderful-woad-growing-and-dyeing.html>

Wearing Woad: <http://www.wearingwoad.com/woad-part-1-when-to-harvest/>

Local Color Dyes: <http://localcolordyes.com/blog/2015/11/22/more-about-flax-seed-maturity/>

Textiles

All Fibre Arts: <http://www.allfibrearts.com/cs/classes.htm>

Textile Fibrespace: <http://www.textilefibrespace.com/trade/>

Teonline: <http://www.teonline.com/knowledge-centre/fibre-yarn-threads.html>

Journals, magazines, and blogs

FibreARTS: <http://www.fibrearts.com/>

Fibre Art Now: <http://fibreartnow.net/>

Society of Wood Science and Technology: <http://www.swst.org/publications/wfs/>

Springer: <http://www.springer.com/chemistry/polymer+science/journal/12221>

Journal of Natural Fibres: http://www.researchgate.net/journal/1544-0478_Journal_of_Natural_Fibres

International Fibre Journal: <http://www.ifj.com/>

Textile Artist: <http://www.textileartist.org/the-best-textile-art-magazines/>

Agricultural Utilization Research Institute: <http://www.auri.org/news/ag-innovation-news/>

Cordwainers Garden: <https://cordwainersgarden.wordpress.com/>

Ecouterre: <http://www.ecouterre.com/category/textiles/>

Seeds of Fashion: <http://www.seedsoffashion.com/>

Flax to Linen: <http://flaxtolinenvictoriabc.blogspot.ca/>

Red Thread Studio: <http://lainie.typepad.com/>

Papermaking

Paperslurry's tutorial on how to make your own mould and deckle:

<http://paperslurry.com/2014/08/01/make-mould/>

Paperslurry's papermaking with plants poster:

<http://paperslurry.com/2014/08/20/hand-papermaking-with-plants-illustrated-infographic/>

Liz-anna's Lakeside Studio: <http://liz-annaslakesidestudio.blogspot.ca/2010/06/papermaking-tutorial.html>

Hand Papermaking's "Harvesting Fibres" article:

<http://newsletter.handpapermaking.org/beginner/beg72.htm>

Hand Papermaking's "Sources of Fibre and Pulp" article:

<http://newsletter.handpapermaking.org/beginner/beg17.htm>

Hand Papermaking's "Methods of Beating Fibre" article:

<http://newsletter.handpapermaking.org/beginner/beg33.htm>

Hand Papermaking's "Assessing Your Pulp and Paper" article:

<http://newsletter.handpapermaking.org/beginner/beg88.htm>

Hand Papermaking's "Sheet Formation & Uniformity" articles:
<http://newsletter.handpapermaking.org/beginner/beg53.htm>

Small-scale seed processing

Organic Seed Processing: Threshing, Cleaning, and Storage:

<http://www.extension.org/pages/18350/organic-seed-processing:-threshing-cleaning-and-storage#.VV57fflVikp>

Seed Extraction and Cleaning:

<http://www.fao.org/docrep/006/q2190e/Q2190E05.htm>

Small-Scale Organic Seed Production PDF:

<http://certifiedorganic.bc.ca/programs/osdp/l-066%20Seed%20Handbook%20v5.pdf>

Small Scale Grain and Pulse Production:

<http://grainsandpulses.blogspot.ca/2008/05/cleaning-up.html>

How do I thresh grain on a small scale?: <http://www.islandgrains.com/how-do-i-thresh-grain-on-a-small-scale/>

Cleaning Blue Flax Seeds forum:

<http://forums.gardenweb.com/discussions/2147726/cleaning-blue-flax-seeds-linum-narbonense>

It's Not Too Early to Think of Seed Cleaning:

http://www.organicagcentre.ca/NewspaperArticles/na_seed_cleaning_ts_bf.asp

Northern Grain Growers' Flax information PDF: <http://northerngraingrowers.org/wp-content/uploads/FLAX.pdf>

Small-scale seed processing equipment

Grain Processing Equipment: From Field to Bin:

<http://umaine.edu/localwheat/files/2012/06/Grain-Processing-Equipment.pdf>

RGO Sales Inc. - Grain Cleaners Canada:

http://www.rgosales.com/grain_cleaners.html

Hand Tester Kits: http://www.flamangraincleaning.com/products/hand-tester-kits-5#.VV57C_IVikq

Flaman Grain Cleaning & Handling Systems Catalogue:

<http://www.flaman.com/grain/pdfs/flaman-grain-cleaning-product-catalogue-2012-01.pdf>

Lily & Rose Seed Processors: <http://www.organicflaxcanada.com/#!page3/cee5>

History and Primary Processing

Flax Culture, Mavis Atton

Fibre Flax Culture, Upper Canada Village by D.J. Cochrane

Cultural Directions for Fibre Flax, Mary A. Chase

Flax, Oscar Beriau

Flax and Hemp: From the Seed to the Loom, George A. Lowry

Fibre Flax: Planting and Processing Instructions, Richters Herbs

The Linen Craft: Fibre to Fabric, Libeco Lagae

Flax in Flanders throughout the centuries, Bert DeWilde

Base to Tip: Bast-Fibre Weaving in Japan and Its Neighbouring Countries, Hiroi Nobuko

CELC Website and their annual Flax and Hemp Publications

Spinning and Weaving

Flax: From Seed to Linen Yarn, Ritta Sinkkonen Davies, Pembrokeshire Guild

Fibre Facts, Bette Hochberg

Your Handspinning, Elsie G. Davenport

Natural Fibres, Handspinning, Eliza Leadbeater

Linen: Hand spinning and weaving, Patricia Baines

Spin Me Some Flax, Jennifer Green, Journal of Textile Design

Appendix C: Flax Linen Initiatives: Canada, USA, Worldwide

Canada

Currently in Canada there are five initiatives, besides ourselves, that we are aware of:

Earthhand Gleaners in BC, a small collective of passionate people sharing skill and knowledge of the flax plant, how to grow it, process it and how to make rope, yarn, and other functional items with it.

Frank Wheeler, Composite Innovation Centre Manitoba Inc. They are working with flax and hemp. CIC are advancing the development of quality standards and measurement techniques for biomaterials. They are addressing the technology gaps in bast fibre reinforced composites. CIC supports material trade studies and provides design, testing, analysis, and prototyping services to industry. CIC has recently completed the design and prototyping of a mobile lab for Genome Prairie featuring a flax reinforced composite.

Denis Rho researcher with National Research Council working alongside a group of flax seed producers to value add the flax straw waste for the composite industry. Denis has established a processing facility to assist the producers in finding the best process to create the fibre that is needed by the larger firms looking for natural fibres to replace plastics.

SWM in Manitoba uses hammer-mill technology to process 70,000 to 140,000 tons of flax straw per annum to make speciality paper. (Denis Rho is the reference)
(www.swmintl.com)

Upper Canada Fibreshed is a collective of people mostly focussed currently on wool, but with an eye out for growing flax in their region and processing.

USA

Fibreshed (California) - This group of people have carbon sequestration and climate beneficial as main targets for the fibre grown in the community and by producer members. The fibreshed is interactive with all fibres bast and animals and the value chain that follows. They bring together farmers, spinners, weavers, knitters, felters, sewers, and natural dyers. The producers have guidelines to follow.

Fibrevolution (www.fibre-evolution.com)

Shannon and Angela are bringing back Oregon Flax, that was a booming industry in the late 1800's to early 1900's. They have worked in partnership with the Oregon State University doing research. These two women have passion for a regional fibre system, the vision has organic and regenerative farming practices at the forefront. The dream

started in 2012 when they wanted a cool shirt to wear in the summer heat. They are educating the public and building momentum in the agricultural community, with a dream of a scutching mill in the Willamete Valley, Oregon.

Chico Flax in Northern California – <https://chicoflax.com/> Sandy Fisher weavers, and now growers, of flax are working with their climate to see if they can grow flax during the winter months in California. They have had success and have been building a community of flax growers. They have done variety trials for seed selection, are growing, processing and weaving flax. Recently Chico Flax has celebrated the creation of woven fabric from their flax. They are offering community events and participate actively in the fibre-shed movement.

New England Flax and Linen Study Group – works to promote the knowledge and use of flax and linen in the past, present and future. In 2016 they hosted a Flax and Linen Symposium (sold out). They put on events throughout the year and actively support through sharing updates and news of flax activity. They recently completed a project as an affiliate of Fibreshed.

On a side note there is some work being done in the hemp fibre in North America. Some examples of this are Sunstrand, in Kentucky and Alberta working in the construction space with insulation and CoreBoards, and the Alberta BioMaterial Center

Worldwide

CELC (The European Confederation of Flax Hemp) is the organization that represents all stages of production transforming flax into linen. They also represent hemp. They have created marketing campaigns and most recently the “I Love Linen” campaign.

In October 2018 a group in Northern Ireland hosted a **Linen Biennale**, bringing together designers, local businesses, researchers, weavers, artisans, scientists, industry, and anyone interested in linen and bringing Irish linen back. Their theme was Recall, Rethink and Reform. The idea is to stimulate new thinking about Irelands oldest textile products: flax and linen. The Biennale was well attended by people from around the world.

(<https://www.linenbiennalenorthernireland.com/>)