

Linen- The Classic Fibre for Futuristic Fashion

MADHURI NIGAM*¹ AND VIBHA YADAV²

¹Associate Professor and ²Assistant Professor
Lady Irwin College, University of Delhi, New Delhi (India)

ABSTRACT

Linen is manufactured from flax or flaxseed (*Linum usitatissimum*), which is an important and oldest source of food, fibre as well as oilseed in the world. It is lustrous and blends very well with fibres such as; wool, silk, cotton etc. and is used for manufacturing, suitings, shirtings, strong twines, canvas and various in dispensable products for defense purposes. Flax is also being utilized as composite material in automobile and construction industry. Apart from its versatility, flax is also an ecofriendly fibre. It consumes much less amount of water for irrigation and doesn't require insecticides and pesticides as much as cotton. Also, since the entire plant is useful, it gives higher return per hectare thereby being a beneficial crop for farmers. Hence, Linen leaves a smaller environmental impact and therefore, it is also known as an ecofriendly crop. It is a popular textile for consumers due to its strength, lightness and excellent comfort properties and is also a favorite among designers for its classic appeal. At present, India imports flax fibre to meet its domestic requirement. Indian scientists have successfully developed high fibre yielding variety called Tiara (JRF-2) released in 2015. The flax cultivation needs to be popularized among Indian farmers, since Linen is already in much demand among the consumers as a fashionable fibre.

Key Words : Flax, Textile, Fibre, Linen

INTRODUCTION

Linen is the textile made from fibers extracted from the flax or flaxseed plant (*Linum usitatissimum*). The word linen originates from its Latin name *Linum* and the Greek word (λίνον) *linon* (Pandey, 2009). Linen is a highly sought after textile fabric by high-end fashion designers as well as discerning consumers. It has the advantage of superior comfort, breathability and elegance over cotton. It also imparts a graceful luster to the garments, thus making it a popular choice for summers even though it is more expensive than cotton. However, a spurt in consumer's interest in linen has resulted in a sharp growth in demand and consumption of linen in India ([Http://www.brahmsmount.com](http://www.brahmsmount.com), 2019; [Http://indiantextilejournal.com](http://indiantextilejournal.com); Sekhri, 2011). Recent research has also led the development of an indigenous high yield variety of linen called, Tiara (Chaudhary *et al.*, 2015). The invention of this variety can be a boon to the domestic textile industry, which is dependent on mostly imported raw

material for linen. There is a huge potential of converting this under utilized dual-purpose crop into an economic and environmentally beneficial crop.

History:

The history of linen or flax being used as a textile material dates back to thousands of years with some dyed linen fabrics being discovered in a cave in Georgia, dating back to 32-26,000 years (Kwavadze *et al.*, 2009). Use of linen in ancient Egypt and Mesopotamia is also well known ([Http://www.historyofclothing.com](http://www.historyofclothing.com), 2019; Sekhri, 2011). In ancient Egypt Linen was used for wearing as well as in mummification (Sekhri, 2011). Flax was being cultivated by ancient Egyptians, Babylonians, Phoenicians and other civilizations between 5000-4000 BC (Sekhri, 2011). Linen also finds mention in various ancient Indian texts for its beauty, fineness, softness and royal insignia ([Http://agropedia.iitk.ac.in](http://agropedia.iitk.ac.in), 2017). The word "*ksauma*" is referred in Vedas, Upanishads and in ancient literatures as fibre from the bark of linseed called linen. "Immortality

of the linen is evident from the fact that Ayurveda, the oldest collection of knowledge till date, instructs, “*Parivrittam*” with “*ksaumavastra*”, that a new born child must be wrapped in linen clothing and a neonatal intensive care unit must comprise of linen bed covering”. Ancient Indians must have realized the medicinal properties of flax seeds and fiber both, as evident from the *Sushrut Samhita* wherein its medicinal properties are described for food consumption. A fine quality or bleached linen was also known as ‘*dukula*’ in ancient times. It is said that king of *Kashi* presented 500 Linen blankets to Buddha (Http://agropedia.iitk.ac.in, 2017; Sekhri, 2011). Earliest records of a linen industry were found in Egypt dating back 4000 years (www. fergusonsirishlinen.com, 2009). After the probable origins from the middle-east, flax was subsequently introduced to several other world regions including Europe (Zuk *et al.*, 2015).

Area and Production of Flax:

There are usually two types of flax being cultivated- the flax cultivated for oil is called linseed (shorter plant, more branches) whereas the flax cultivated for fibres is called fibrous flax or simply flax (more height, less branches) (Sekhri, 2011; Zuk *et al.*, 2015). Europe is both the largest producer and consumer of linen fabric in the world, followed by Asia Pacific and North America. Asia Pacific market for linen is growing in double digits and is further expected to rise due to increasing demand and purchase power of consumers in developing countries like India and China (Http://agropedia.iitk.ac.in, 2017). The largest planted areas of flax seed are in Canada, U.S, Russia, China and Kazakhstan. The top producers of linseed are represented in Fig. 1.

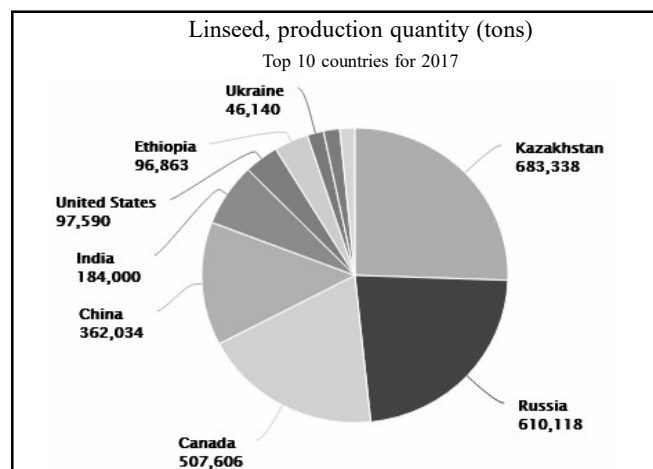


Fig. 1 : Linseed Production (world) (FAOSTAT, n.d.)

Fig. 1 shows that India is the 5th largest producer of linseed. However, at present there is hardly any acreage under cultivation for flax as a fibre in India (Chaudhary *et al.*, 2016). Flax is grown in India primarily for its oil with only a small-scale cultivation of flax fibre in Himachal Pradesh (Https://economictimes.indiatimes.com, 2017; Jhala and Hall, 2010). The major states in India growing flaxseed/linseed are Madhya Pradesh, Uttar Pradesh, Bihar, Chhattisgarh, Maharashtra, Jharkhand, Orissa, Assam, West Bengal, Karnataka, Nagaland, Andhra Pradesh, Rajasthan, Himachal Pradesh and Telangana (Https://flaxcouncil.ca, 2019; Chaudhary *et al.*, 2017). The area harvested, yield and production of flaxseed in India are illustrated in Fig. 2-4.

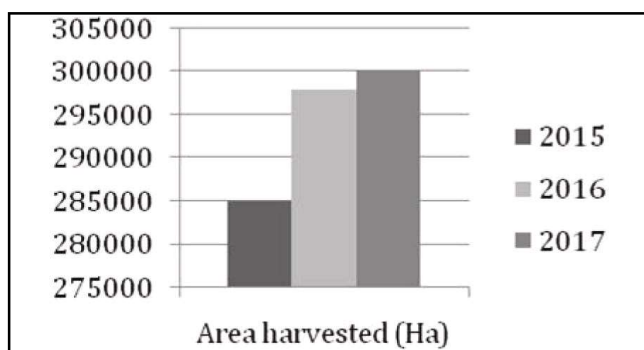


Fig. 2 : Area Harvested for Linseed in India (FAOSTAT, n.d.)

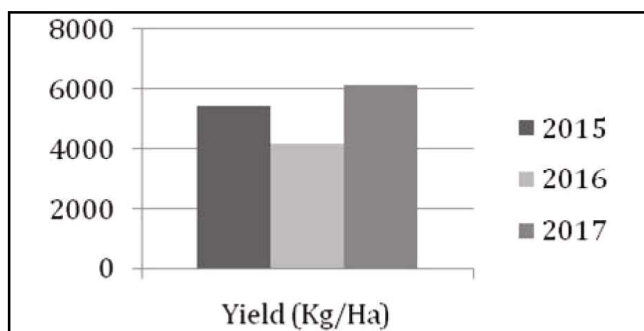


Fig. 3 : Yield of Linseed in India (FAOSTAT, n.d.)

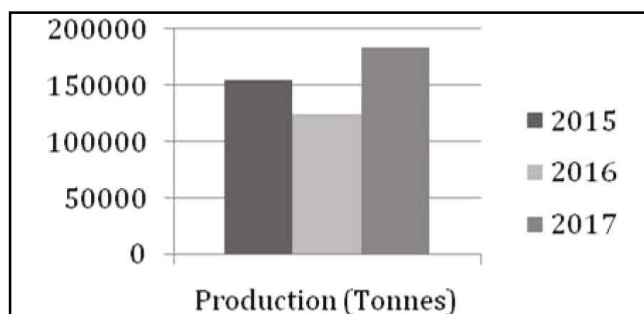


Fig. 4 : Production of Linseed in India (FAOSTAT, n.d.)

In contrast to this, India is the top country producing bast fibres in the world as shown in Fig. 5. This strength in producing bast fibres can be utilized further to produce and popularize a luxury fibre like flax.

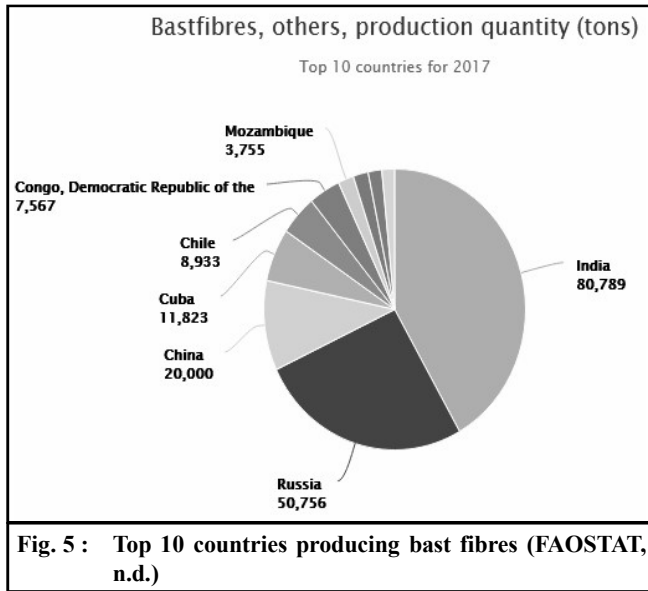


Fig. 5 : Top 10 countries producing bast fibres (FAOSTAT, n.d.)

From 2008-2013, the domestic market for linen has grown three-fold (<http://www.indiantextilejournal.com>, 2016) and it is expected to grow at a moderate pace after the robust growth in recent past as shown in Fig. 6 (FAOSTAT, n.d.)

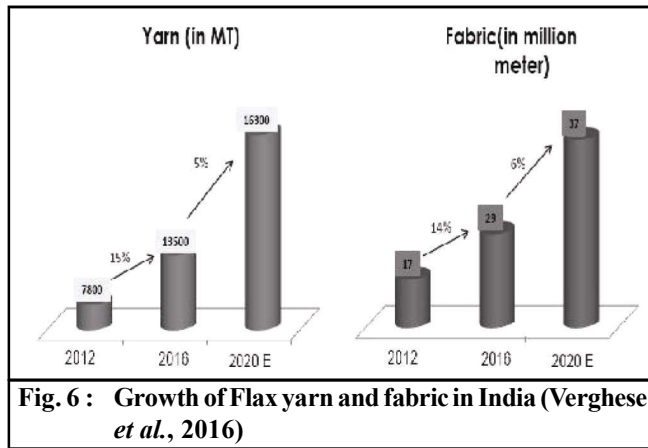


Fig. 6 : Growth of Flax yarn and fabric in India (Verghese et al., 2016)

The consumption of linen in India has reached 20,000 tonne per annum, which is projected to increase to 25,000 tonne in the next two years (<http://www.indian textilejournal.com>, 2016). At present India imports more than Rs. 1000 crores worth of flax fibre from countries like China, Canada, Belgium, Holland and France to meet

the domestic demand (Chaudhary et al., 2016).

Flax cultivation:

Flax is primarily a *Rabi* season crop and in India, it is ideally sown in the last week of October to first week of November, before it gets too cold which can affect the seed germination, fibre yield and fibre quality (Chaudhary et al., 2017). Insects/pests and diseases are not a major deterrent to flax crop. After sowing, first and second hand weeding are done at 21-25 and 40-45 days respectively. Usually, flax crop can be grown in rain-fed and irrigated conditions both, but a higher production can be obtained in irrigated conditions. Two irrigations are recommended at 35 days and at 65 days, after sowing for a good quality fibre (Chaudhary et al., 2017). Flax fibre crop takes around 120-125 days to mature. Flax fibre is harvested before capsules mature, when 2/3rd of the plants portion has turned yellow, and about 2/3rd leaves of plants have fallen. For harvesting, plants are pulled out from the ground and tied in small bundles of 15-20 cm diameter for retting (Chaudhary et al., 2017). Early harvesting delivers tender and fine fibre with low yield, while late harvesting leads to higher yield of poorer quality (Chaudhary et al., 2017).

Flax Processing:

Fibre processing (retting and scutching):

Pulling the plants along with the roots (instead of cutting) helps to achieve longer fibers. The pulled plants are allowed to dry, and the seeds removed. The plants are then subject to the retting process (Dhirhi et al., 2015). The woody-bark of the stem is removed/retted away by immersing the tied bundles in water (20-25cm deep), in concrete tanks. After retting which takes three days (72 hours) to complete, the bundles are washed thoroughly with fresh water and allowed to dry in sun (Chaudhary et al., 2017). When the stems get dried, the fibres are extracted from dried plants, using a hemp-scutching machine (Fig. 7). This scutching machine was developed by CRIJAF, Barrackpore, to separate the dried stems into scutched long fibre (line), short fibre (tow) and shives (Fig. 8). After this the bundles of long fibres are sent to the spinning mills.

Yarn production (spinning):

The long linen fibers, also called as ‘line’ are put through machines, called spreaders, which blend fibers of the same length, lay them parallel and create a sliver

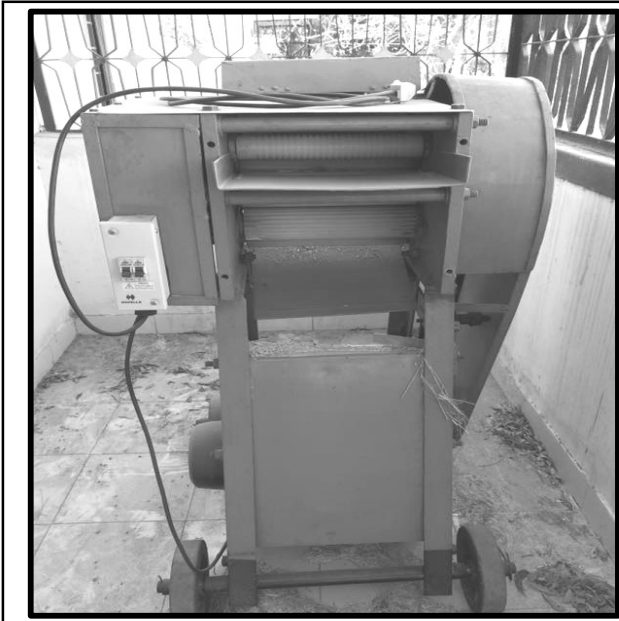


Fig. 7 : CRIJAF scutching machine (Nigam, 2018)

which then passes through a set of rollers, thus delivers a roving¹, ready for spinning. The linen rovings are drawn out into thread and finally wound on bobbins or spools. The fibers are formed into a continuous ribbon, which is constantly pulled and elongated, while being pressed between rollers and combed over fine pins, until the ribbon gets its final twist and strength and is wound on the bobbin. Due to the inelastic nature of flax, humidity and warm conditions are to be maintained, during processing, to make the fiber easier to work into yarn. The linen is wet spun; wherein, the roving runs through a hot water bath that binds the fibers together, thus helps in creating a fine yarn. Dry spinning produces rough, uneven yarn, used to make inexpensive twines or coarse yarns. Moist yarns are wound to large take-up reels and taken to dryers, and wound onto bobbins for weaving or wound into yarn spools. The yarn is then transported for fabric production (www.madehow.com, n.d.). The rovings might also undergo bleaching if required.

Fabric production (Weaving):

Linen fabrics are generally woven, as the yarns are less elastic (Towel, n.d.). Similar to cotton woven fabric, sizing of the flax yarns is done; to produce the fabric of desired quality. The fabric from here goes for further processing such as, dyeing and finishing processes.

The fibres undergo; hackling, spinning and bleaching to produce yarn. The yarns undergo weaving operation; and the fabric production ends with the production of bleached, undyed fabric. Linen may be yarn dyed or piece dyed and generally soft pastel colours are used.

Flax properties and its uses:

Linen is a bast fibre extracted from the stems of flax or flaxseed plant. The fiber ranges in length from 25-150 mm with a diameter of 12-16 micrometers. Linen fibres have a natural luster, and can vary from creamy white to light tan in colour.

Linen lends itself to be an ideal summer fabric in hot and humid climates as it's cool to touch, smooth, lightweight and has high moisture absorbency, making it very comfortable and breathable to wear. Linen fabrics are also very durable, stronger when wet, easily dyed and lint-free. They have low elasticity and they wrinkle easily but also press easily. However, linen fabrics have



Fig. 8 : Scutched long fibres (Nigam, 2018)

1. A roving is a long and narrow bundle of fiber produced during the process of making spun yarn from wool fleece, raw cotton, or other fibres. When sliver is drawn further and given a slight twist, it becomes roving.

excellent color fastness and they get softer with each wash. It is further said to be allergy-free, antistatic, antibacterial and can withstand high temperatures (Sekhri, 2011; [Http://agropedia.iitk.ac.in](http://agropedia.iitk.ac.in), 2017; [Http://www.indiantextilejournal.com](http://www.indiantextilejournal.com), 2016) Linen is stronger than cotton, rayon and wool (Chaudhary *et al.*, 2016) and can absorb up to 20 times its weight in moisture.

A versatile fibre:

The entire flax plant has great economic value as it delivers multiple products (Chaudhary *et al.*, 2016). It is possible to commercially utilize almost every part of the flax plant either directly or after processing, for various purposes like food from flax seed and fibre from stem (Sekhri, 2011; Zuk *et al.*, 2015), thus making it advantageous to grow, over traditional textile crops like cotton. Linen is used for manufacturing, suitings, shirtings, sarees, dresses, home furnishings and fabrics like damask, lace, canvas, cambrics, lawns, drills and buckram. Other popular uses include carpet backing, strong twines, ropes, fishing nets and various indispensable products for defense purposes (Chaudhary *et al.*, 2016; Sekhri, 2011; Jhala and Hall, 2010; Chaudhary *et al.*, 2017). Flax can also be used in “nonwovens and various diversified textile and non-textile applications such as fire extinguishing hose, reinforced plastic, medicinal, geo and chemo textiles” (Chaudhary *et al.*, 2016; [Http://agropedia.iitk.ac.in](http://agropedia.iitk.ac.in), 2017). Flax is also being utilized as biodegradable composite material in automobile and construction industry ([Http://agropedia.iitk.ac.in](http://agropedia.iitk.ac.in), 2017). Further research has shown great potential for use of flax in “implants, wound dressing, alternative antibiotics, anti-atherosclerotic, anti-tumor and anti-inflammatory medical textiles” (Zuk *et al.*, 2015).

Even the by-products of flax; like plant, wood, scraps of seed and fibre flax (shives) are used to manufacture “bio composites, particle boards, quality paper, briquette and furniture. Anti-bedsore property of flax is now being used for the benefits of bed-ridden patients (Kozlowsky, 2009) ([Http://agropedia.iitk.ac.in](http://agropedia.iitk.ac.in), 2017).

Flaxseed is a good source of lignin, mucilage, omega-3, oleic, linoleic acid, and edible fibres’, all of which contain medicinal properties and are perfect raw material for food processing, natural pharmaceuticals, and cosmetic industries. Widespread industrial application of linseed in paint, linseed oil, printing ink, varnish, and linoleum manufacturing is well known ([Https://flaxcouncil.ca](https://flaxcouncil.ca), 2019). Seed hull is also used as animal feed (Jhala and Hall, 2010). Fig. 9 illustrates the versatile usage of flax in

various fields. Linen can also be blended with fibres such as cotton, silk, viscose, wool and bamboo ([Http://agropedia.iitk.ac.in](http://agropedia.iitk.ac.in), 2017) making it as versatile as desired.

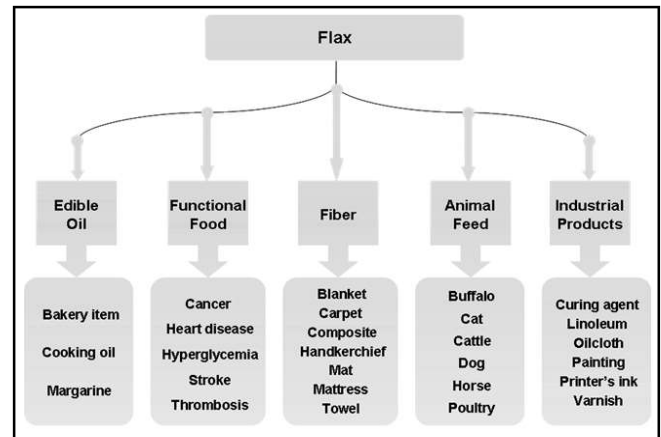


Fig. 9 : Versatile uses of Flax (Jhala and Hall, 2010)

A sustainable fibre:

The emerging trend of sustainable and green fashion and growing consumer awareness about the harmful effects of fast fashion has bolstered the demand for linen further, as it is one of the most eco-friendly and sustainable fibre. It is a greener fibre as compared to traditional textile crops such as cotton. It also requires less pesticides and insecticides and irrigation as compared to cotton. Since almost the entire plant is useful, it gives a much higher return per hectare, making it beneficial crop for farmers. “Flax plants on one hectare absorb more than a 3,7 metric tons of carbon dioxide and convert it into oxygen.” One can also recycle or compost flax, as it is a natural fibre. Linen also is available in many natural colours and shades reducing the need for extra dyeing. Flax also requires very little water as compared to the amount of CO₂ it absorbs. Flax can be cultivated in a way, which leaves no wastage as virtually every part of the plant can be utilized in some way. The waste shives can be used for clipboards and animal bedding. Even the shearing dust generated while shearing fabrics, can be collected and can make a good source for paper and insulating material. Companies like Libeco Home Stores which actively follow green practices, have even got a ‘cradle to cradle’ certificate by closing the production circle due to linen’s versatility. They have even made their weaving process carbon neutral by utilizing solar and wind-energy ([Https://blog.libecohomestores.com](https://blog.libecohomestores.com), 2017). Further, it has been

found in studies that Linen fibre production has a lower Green house Gas emissions (GHG) value of 0.798 kg CO₂/kg of linen fibre as compared to 2.15 kg CO₂/kg of cotton fibre production (includes stages of farming, transport to ginning facility and ginning process itself (Nigam *et al.*, 2016; [Http://eiha.org/media/](http://eiha.org/media/), n.d.). All this contributes to a smaller environmental impact while giving a higher economic output making it an eco-friendly fiber, which does not require intensive usage of precious natural resources for cultivation.

A fashion fibre:

Linen has always been in demand in India for its excellent strength, lightness and comfort properties. It is favored by many fashion designers such as; Manish Malhotra, Mrinalini Gupta, Suket Dhir and Anavila ([Https://timesofindia.indiatimes.com](https://timesofindia.indiatimes.com), 2012; Bhattacharya 2016; Jha n.d.) for its sartorial charm, elegance and classic appeal. Fashion brands and houses like Eka, Raw Mango, Bodice and Grassroot by Anita Dongre are also using linen for their collections (Bhattacharya, 2016). International brands like Marks and Spencer, Max Mara, Hugo Boss, Banana Republic, Peacock Alley, Ralph Lauren and H&M are major operators in the linen fabric market ([Http://www.indiantextilejournal.com](http://www.indiantextilejournal.com), 2016).

The demand for linen has been growing drastically over the past few years due to a spurt in consumer's interest as well as big brands like Colorplus, Allen Solly, Zodiac, Louis Philippe, Benetton and Raymond producing linen fabric. Aditya Birla Group's brand 'Linen Club' also extensively promotes linen, with plans to open 250-300 stores by 2020 ([Https://economictimes.indiatimes.com](https://economictimes.indiatimes.com), 2017). The Aditya Birla Group also supplies linen to brands like Marks and Spencer and H&M ([Http://www.yarnsandfibers.com](http://www.yarnsandfibers.com), 2017). The consumption of linen in India has increased three-fold over the last five years. Not surprisingly, Raymond has set up a 250 crore linen manufacturing plant in Maharashtra (India) (Crossley, n.d.) anticipating the rising future demand and interest. The use of linen as a style statement and for making fashionable accessories has also boosted global market for linen in countries like Brazil, India and China ([Http://agropedia.iitk.ac.in](http://agropedia.iitk.ac.in), 2017; [Http://www.indiantextilejournal.com](http://www.indiantextilejournal.com), 2016). Linen has always been considered a high-end fibre due to its price tag but new linen blends with cheaper fibres have lowered prices to gain mass-market appeal.

An economically beneficial fibre:

Flax as fibre can be economically more lucrative than other natural textile sources in multiple ways. Flax crop for fibre requires only 100-125 days to mature for harvesting as compared to 150-180 days required for a cotton crop (Sekhri 2011; [Http://agropedia.iitk.ac.in](http://agropedia.iitk.ac.in), 2017), thus resulting in a shorter time duration to get produce from agriculture. Flax can grow well in both the peninsular soils of south and alluvial soils of north India ([Http://agropedia.iitk.ac.in](http://agropedia.iitk.ac.in), 2017). Also it must be pointed out that a single cultivation may lead to many different products in the form of fibre, flaxseed, oil, and seed cakes and very little wastage. Even the stem husk discarded after extracting flax (a waste by-product) has found use as a thermal insulator and wood pulp substitute in the paper industry ([Http://www.indiantextilejournal.com](http://www.indiantextilejournal.com), 2016; Zuk *et al.*, 2015).

Future Prospects:

Currently India is a minor producer of flax and imports most of the flax required for domestic market. However, a recent breakthrough in the form of Tiara (JRF-2) can be a game changer in the coming years. This indigenous variety of flax is a high yield crop, which can be cultivated by Indian farmers to cater to the growing demand for flax in Indian markets. Furthermore scientists at Indira Gandhi Krishi Vishwavidyalaya (IGKV) have successfully developed yarn for linen cloth from flax/linseed plant for the first time in India, by extracting flax fibres for linen fabric from linseed plants ([Https://timesofindia.indiatimes.com](https://timesofindia.indiatimes.com), n.d) leading to dual-use of the crop for maximum benefit. This also aims to boost the handloom and textile sector in the country, which currently depends on imported yarn for linen production ([Https://timesofindia.indiatimes.com](https://timesofindia.indiatimes.com), n.d).

Flax is generally regarded as a dual-purpose crop for the main products obtained in the form of seed and fibre. However, most of the flaxseed/linseed cultivation has been used to harvest only flaxseed in India, as the maturing time of fibres and seeds is different for each end use. However, many dual purpose varieties have been released which are suitable for both oil and fibre purposes ([Http://agropedia.iitk.ac.in](http://agropedia.iitk.ac.in), 2017). Also, the different maturing time of seed v/s fibre can be eliminated by factors like good weather conditions, fertilizer usage and timely collection of seeds, which can enable one to utilize the linseed plant for fibre harvesting as well as seeds (Zuk *et al.*, 2015).

Conclusion:

“The main attractions of flax are they are green, sustainable fibres, anti-allergic and anti-bacterial” (<http://www.indiantextilejournal.com>, 2016). There has been sustained growth in the demand for linen in India, which can be capitalized by Indian farmers to their benefit. Currently almost all the area under cultivation for flax is for obtaining flax as a seed and not as a fibre. At present India spends more than Rs. 1000 Crore to import flax from China, Belgium, Canada, Holland and France to meet indigenous demand, especially in the defense sector (Chaudhary *et al.*, 2016). It would save a lot of foreign exchange if India were to meet the domestic demand of such a lucrative crop by producing its own flax fibre using the newly developed indigenous high yield ‘*Tiara*’ (JRF-2) variety (Chaudhary *et al.*, 2016). Another hurdle towards this objective was the difficulty in using the same crop for seed as well as fibre (linseed) as the fibre would get too mature if one waits for the seeds to ripen as flax as a fibre is most desirable before seeds mature, leading to wastage of seed crop. However, scientists at Indira Gandhi Krishi Vishwavidyalaya (IGKV) were able to develop a technique to use the linseed crop for flax fibre extraction (<https://timesofindia.indiatimes.com>, n.d.) leading to dual benefits of fibre and seeds. “A number of dual purpose varieties have been released which is suitable for both fiber and oil purposes” (<http://agropedia.iitk.ac.in>, 2017). By encouraging dual-use, apart from producing flaxseeds, which sell for around Rs. 6000/ quintal, farmers can also sell the fibre for linen production (<https://timesofindia.indiatimes.com>, n.d.), which can have fixed minimum selling price by the government to ensure transfer of benefit to farmers.

The best flax in the world usually comes from three European countries - France, Belgium and Holland. However, due to high labour costs the processing of flax, which includes spinning, processing and weaving, has disappeared from Europe. These processes have shifted phenomenally to Asia (<http://www.indiantextilejournal.com>, 2016), with China being a big gainer from this scenario. China is also one of the major exporters of flax fibre to fulfill the domestic demand in India. However, a recent order by government of India has slapped anti-dumping duty on Chinese exporters in the range of \$1.3 - \$4.83/Kg (Srivats, 2018). Chinese imports also attract a 30% import duty (<http://www.indiantextilejournal.com>, 2016; <http://agropedia.iitk.ac.in>, 2017). This has opened up the opportunity for Indian farmers and textile

companies to build their capacities and get hold of market share, at competitive prices by adopting flax as a dual-purpose crop, which has global appeal.

Europe currently uses 30-32% of the linen produced for home furnishing. This is another potential market for Indian farmers, they can tap and provide the raw material domestically. Flax is a non-abrasive, biodegradable and renewable fibre (Jhala and Hall, 2010), which makes it a classic, green and sustainable fibre, (<http://www.indiantextilejournal.com>, 2016) which can find varied usages in apparel, home furnishing, food, industrial as well as medical textiles. The wide spectrum of flax uses makes it highly likely that flax will become a popular and highly prized plant in the nearest future (Zuk *et al.*, 2015). Flax indeed holds a great futuristic prospect if one wants to pioneer the way towards a better future built on the principles of eco-friendliness, sustainability and zero-waste.

REFERENCES

- Bhattacharya, S. (2016). From Affordable to Haute Couture: 16 Designers Who Are Reworking Handloom Fabrics. Retrieved February 9, 2019, from <http://www.vagabomb.com/Designers-Who-Are-Reworking-Handloom-Fabrics/>
- Chaudhary, B., Tripathi, N.K. and Bhandari, H.R. (n.d.). Production Technology of Flax Fibre Cultivation. Retrieved July 7, 2017, from <http://www.krishisewa.com/articles/production-technology/714-flax-cultivation-technique.html>
- Chaudhry, B., Tripathi, M.K., Pandey, S.K. and Bhandari, H. R. (2016). Uses of Flax (*Linum usitatissimum*) After Harvest. *International Journal of Tropical Agriculture*, (January).
- Crossley, I. (n.d.). Aditya Birla’s Linen Club to open 250-300 stores by 2020. Retrieved February 9, 2019, from <https://in.fashionnetwork.com/news/Aditya-Birla-s-Linen-Club-to-open-250-300-stores-by-2020,972025.html#.XGb5TZMzZo4>
- Dhirhi, N., Shukla, R., Patel, N. B., Sahu, H. and Mehta, N. (2015). Extraction Method of Flax Fibre and its Uses. *Plant Archives*, **15**(2) : 711–716.
- FAOSTAT. (n.d.). Linseed, production quantity (tons) - for all countries. Retrieved February 8, 2019, from <http://www.factfish.com/statistic/linseed, production quantity>
- <https://blog.libecohomestores.com>. (2017). 4 reasons why flax is the fiber of the future. Retrieved February 5, 2019, from <https://blog.libecohomestores.com/sustainability/flax->

- future-fiber/, "https libecohome
- Http://agropedia.iitk.ac.in. (2017). http agro. Retrieved February 8, 2019, from http://agropedia.iitk.ac.in/
- Http://eiha.org/media/. (n.d.). Carbon Footprint of Natural Fibres. Retrieved February 10, 2019, from http://eiha.org/media/2017/01/15-04-Carbon-Footprint-of-Natural-Fibres-nova1.pdf%0D%0D
- Http://www.brahmsmount.com. (2019). Cotton vs. Linen – What’s the Difference?
- Http://www.historyofclothing.com. (2019). history of textile. Retrieved April 12, 2019, from http://www.historyofclothing.com/textile-history/history-of-linen/
- Http://www.indiantextilejournal.com. (2016). LINEN RAGE IS ON! Retrieved February 8, 2019, from http://www.indiantextilejournal.com/News.aspx?nid=AoZTW8wBtkD0fiiJ+DmlaA==&NewsType=LINEN-RAGE-IS-ON!-India-Sector
- Http://www.yarnsandfibers.com. (2017). Linen Club plans to launch premium apparel range. Retrieved February 2, 2019, from http://www.yarnsandfibers.com/news/textile-news/linen-club-plans-launch-premium-apparel-range#.XGMtZzMzZo4
- Https://economictimes.indiatimes.com. (2017). Raymond sets up Rs 250 crore linen manufacturing plant in Maharashtra. Retrieved February 6, 2019, from https://economictimes.indiatimes.com/industry/cons-products/garments-/textiles/raymond-sets-up-rs-250-crore-linen-manufacturing-plant-in-maharashtra/articleshow/62106152.cms
- Https://flaxcouncil.ca. (2019). Flax For a New Millenium. Retrieved February 3, 2019, from ps://flaxcouncil.ca/resources/about-flax/flax-for-a-new-millenium, "https flax council of Canada
- Https://timesofindia.indiatimes.com. (n.d.). https TOI. Retrieved February 2, 2019, from https://timesofindia.indiatimes.com/home/science/agricultural-university-scientists-develop-linen-yarn-for-the-first-time-in-india/articleshow/61206122.cms
- Https://timesofindia.indiatimes.com. (2012). Manish Malhotra launches linen brand. Retrieved February 5, 2019, from https://timesofindia.indiatimes.com/life-style/fashion/designers/Manish-Malhotra-launches-linen-brand/articleshow/12426897.cms
- Jha, S. (n.d.). These 5 designers are weaving a new tale of Indian fashion. Retrieved February 3, 2019, from https://www.indiatoday.in/magazine/supplement/story/20160905-new-stars-of-indian-fashion-rimzim-dadu-mrinalini-gupta-suket-dhir-payal-khandwala-gaurav-jai-gupta-733670-2016-08-26
- Jhala, A.J. and Hall, L.M. (2010). Flax (*Linum usitatissimum* L.): Current Uses and Future Applications. *Australian J. Basic & Applied Sci.*, 4(9) : 4304–4312.
- Kvavadze, E., Bar-yosef, O., Belfer-cohen, A. and Boaretto, E. (2009). 30,000-Year-Old Wild Flax Fibers, (October), 10–11. http://doi.org/10.1126/science.1175404
- Lewis, H., Fitzpatrick, L., Verghese, K., Sonneveld, K., Jordon, R. and Alliance, S. P. (2007). Sustainable Packaging Redefined. *Packaging (Boston, Mass.)*, (November).
- Nigam, M. (2018). *Environmental Impact Analysis Of Selected Textile Products Using Life Cycle Assessment 2018*. University of Delhi.
- Nigam, M., Mandade, P., Chanana, B., Sethi, S., Science, A. and Science, A. (2016). Energy consumption and Carbon footprint of Cotton Yarn Production in textile industry, 7(March), 6–12. Retrieved from http://soeagra.com/iaast/iaastmarch2016/2f.pdf
- Pandey, R. (2009). Etymology of Flax. Retrieved March 13, 2018, from agropedia.iitk.ac.in/content/etymology-flax
- Sekhri, S. (2011). *Textbook of Fabric Science*. PHI Learning Pvt. Ltd. New Delhi.
- Srivats, K.R. (2018). https thehindu. Retrieved February 9, 2019, from https://www.thehindubusinessline.com/economy/anti-dumping-duty-levied-on-flax-yarn-imports-from-china/article25279772.ece
- Technologies, P., Initiatives, N., and Management, N.R. (2015). Trichoderma viride isolate NRCL T 01 for managing litchi-wilt Production of surrogate carp through xenogenic transplantation of germ cells, 21(3). Retrieved from https://icar.org.in/files/ICAR News July-September 2015_Low Res.pdf
- Towel, D. (n.d.). How Linen is Made. Retrieved January 20, 2018, from https://www.decktowel.com/pages/how-linen-is-made-from-flax-to-fabric
- Verghese, T. (2016). FLAX/LINEN, THE SMART GREEN FIBRE FOR BUSINESS. *3rd International CELC Congress*. Retrieved from https://www.mastersoflinen.com/img/pdf3s/Thomas_VARGHESE_Emerging_Indian_Trends_in_Linen_for_CELC_CONGRESS_October_2016-0.pdf
- www.currentbiotica.com. (2016). Scientific Correspondence Flax?: The fibre of linen. *Current Biotica*, 10(1) : 1–4. Retrieved from https://krishi.icar.gov.in/jspui/bitstream/123456789/7996/1/Flax linen.pdf
- www.fergusonsirishlinen.com. (2009). History Of Irish Linen.

Retrieved from <https://www.fergusonsirishlinen.com/pages/index.asp?title2=History-of-Irish-Linen&title1=About-Linen>

www.madehow.com. (n.d.). Linen. Retrieved January 20, 2018, from <http://www.madehow.com/Volume-4/Linen.html>

Zuk, M., Richter, D., Matuła, J., and Szopa, J. (2015). Linseed , the multipurpose plant Linseed , the multipurpose plant. *Industrial Crops & Products*, **75**(May) : 165–177. <http://doi.org/10.1016/j.indcrop.2015.05.005>.
