

# Fiber Crops

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Fibers are everywhere around us and they are essential materials supporting our daily lives. Most fibers that we use in our daily activities are derived from fiber crops. In this entry, we introduce how fibers are classified, describe the main fiber crops in the world, and summarize their distributions and main usages by humans.

Keywords: Natural Fiber ; Hemp ; Ramie ; Flax ; Diseases ; Pests

## Introduction

Broadly defined, fiber (or fibre) refers to any material that's significantly longer than it is wide. These substances can be naturally derived, artificially made by humans, or a mixture of natural and artificial materials. Natural fibers can be derived from different sources such as from geological processes (e.g. mineral fibers such as the asbestos group), animals (e.g. silk, fur, and wool made of proteins), and plants (e.g. wood fiber and crop fiber made of primarily cellulose but often in combination with lignin). Commercial plant fibers are derived from either trees or fiber crops. Trees for fiber production are typically grown for many years before they are harvested for wood fiber. In contrast, fiber crops are generally harvested after a single growing season. About 2000 species of plants from around the world have been used as sources of natural plant fibers for commercial applications. However, only a small number of these plant species are commercially cultivated, and these cultivated species produce nearly 90% of the world's natural fiber for human usage <sup>[1][2]</sup>.

Fiber crops are an important group of economic crops. They produce fiber as raw materials for a diversity of applications. To be economically viable, fiber crops must be able to produce large quantities of cellulose that can be relatively easily extracted for downstream processing. Based on the United Nations Food and Agriculture Organization (UN FAO) data, Asia and America are the main production areas of fiber crops in the world, with the Americas producing about 50% of the global total fiber, and Asia producing about 33% of the global output.

According to the part(s) of the plant from which fibers are extracted, fiber crops can be divided into the following types: seed fiber (e.g. cotton, coconut husk coir, kapok, milkweed, and luffa), bast fiber (e.g. flax, hemp, kenaf, jute, nettle, and ramie), leaf fiber (e.g. sisal, abaca, yucca, phormium, bowstring hemp, and henequen), grass fiber (e.g. silver grass, reed, and bamboo), palm fiber (e.g. windmill palm, Palmyra palm), and woody fiber (jarrah). Table 1 summarizes the main fiber crops, including their geographic and ecological distributions <sup>[2]</sup>. However, it should be noted that aside from being sources of natural fiber, most fiber crops also contain other parts that have been used for a diversity of purposes, including food and food additives for humans, animal feed, raw materials for biofuel production, and fuel for heating <sup>[1][3][4]</sup>.

In addition to the above-mentioned roles of fiber crops to humans and human welfare, the medicinal properties of several traditional fiber crops are also attracting increasing attention. For example, hemp (*Cannabis sativa*) of the bast fiber category contains a diversity of pharmacologically active compounds, some of which have been used to treat chronic rheumatic arthritis, glaucoma, asthma and mental disorders in humans <sup>[5]</sup>. Flax has medicinal values as a skin moisturizer, pain relief, and in treatments of lung disease and diuresis <sup>[4]</sup>. Similarly, ramie, another bast fiber crop, can stanch bleeding, relieve pain, reduce inflammation, and slow cancer cell proliferations <sup>[4][6]</sup>.

Being biodegradable, crop fibers have also been used as alternatives to xenobiotic compounds such as plastics. For example, hemp and ramie fibers have been developed into environment-friendly mulch for crop and vegetable fields. Such mulch has several desirably properties, including being biodegradable, having strong permeability and high-water retention ability, and promoting the growth of beneficial soil microorganisms. Indeed, such natural fiber-based mulch has been considered an ideal substitute for petroleum-based polyethylene plastic covers <sup>[7]</sup>. Table 1 shows the main commercial use of the selected crop fibers.

**Table 1.** Major types of commercial fiber crops and their distributions around the world.

Group	Crop	Main Distribution	Growth Habitat	Main Applications
Seed fiber	Cotton ( <i>Gossypium hirsutum</i> )	China, USA, India, Brazil, Mexico	Thermophilic plant, sandy loam, loam and light clay with better heat transfer and permeability	Textiles, cottonseed oil
	Sponge gourd ( <i>Luffa cylindrica</i> )	China, Japan, Korea, India (Kerala, Andhra Pradesh)	Requires 150 to 200 warm days to mature	Used as a bath or kitchen sponge and food
Bast fiber	Hemp ( <i>Cannabis sativa</i> )	China, Canada, USA, Europe, East Asia, Nepal	Grows at 16–27 °C, sufficient rain at the first six weeks of growth, short day length.	Textiles, hempseed oil, prescription drug
	Ramie ( <i>Boehmeria nivea</i> )	China, Brazil, Philippines, India, Vietnam, Laos, Cambodia	Sandy soil and warm, wet climates, rainfall averaging at least 75 to 130 mm per month	Textiles, soil and water conservation, medicine
	Flax ( <i>Linum usitatissimum</i> )	France, Russia, Netherlands, Belarus, Belgium, Canada, Kazakhstan, China, India	Well-drained loam and cool, moist temperate climates	Linen, flax yarn, flax seed, linseed oil
Leaf fiber	Sisal ( <i>Agave sisalana</i> )	Brazil, Tanzania, Kenya, Madagascar, China, Mexico, Haiti, Venezuela, Morocco, South Africa	In the tropical and temperate zones with mean temperature at 25 °C with sufficient sunshine	Making rope, twine, paper, cloth, wall covering and dartboards
Grass fiber	Silvergrass ( <i>Miscanthus sinensis</i> )	China, Japan, Korea, USA	In temperate regions around the world	Ornamental plant, bioenergy production
	Reed ( <i>Phragmites australis</i> )	Northern Hemisphere	In lakes and rivershores, marshes, coastal brackish swamps, and lagoons	Used in phytoremediation, protecting shoreline from bank erosion, and serving as a food source or habitat protection for arthropods, birds and mammals.
Palm fiber	Windmill Palm ( <i>Trachycarpus fortunei</i> )	China, Japan, India, Burma	Warm and humid climate	Making rope, coir raincoat, brown bandage, carpet, brush and filling material for sofa, medicine, ornament

Group	Crop	Main Distribution	Growth Habitat	Main Applications
Woody fiber	Jarrah ( <i>Eucalyptus marginata</i> )	Australia	Rainfall isohyet exceeds 600 mm, grows in soils derived from ironstone	Structural material for bridges, wharves, railway sleepers, ship building and telegraph poles, medicine

Among the cultivated fiber crops, cotton (*Gossypium* spp.) is the most dominant in terms of world fiber production. The current estimate for world production of cotton is about 25 million tons <sup>[8]</sup>. Among the four types of cotton, *Gossypium hirsutum*, commonly known as upland cotton, Mexican cotton and Bourbon cotton, accounts for ~90% of the world's total cotton production. India, USA, and China are the world's top three producers of cotton, with USA being the largest cotton exporter. Hemp fiber is stronger and more durable than almost any other natural fiber. However, hemp is a minor global crop in term of fiber production, with approximately 91,055 hectares (ha) planted in 2016. However, due to its food and medicinal properties, the value of hemp market was estimated to be very high, at \$3.9 billion in 2017 and the hemp seed segment is predicted to grow at a compound annual growth rate of 17.1% through at least 2025 <sup>[5][9]</sup>. Similarly, the strength of flax fiber of the bast fiber category is twice that of cotton fiber and five times that of wool fiber. Under wet conditions, the strength of flax fiber is increased by 20%, ideal for use associated with aquatic environments <sup>[4][9]</sup>. Based on the UN FAO statistics (<http://www.fao.org/faostat/>, FAOSTAT), in 2018, world production of flax (linseed) was 3.18 million tons, led by Kazakhstan with 29% of the global total. Ramie is another important fiber crop of the bast fiber category. Ramie is one of the oldest fiber crops, having been used for at least six thousand years, and is primarily used for fabric production. More than 90% of the world's ramie planting area is in China <sup>[10]</sup>. In addition, sisal is also an important member of fiber crops. Global production of sisal fiber in 2018 amounted to ~198,000 tons of which Brazil, the largest producing country, produced over 80,000 tons.

Like other crops, fiber crops are also susceptible to a variety of infectious diseases and pest infestations <sup>[11]</sup>. Some of the common disease agents include species in fungal genera *Alternaria*, *Colletotrichum*, *Fusarium*, and *Verticillium* etc. <sup>[12]</sup>, and in the oomycete genera *Phytophthora* and *Pythium* <sup>[13]</sup>. In hemp, the dominant pest is hemp flea beetle <sup>[14]</sup>. Molecular markers are playing increasingly important roles in understanding the diversity and epidemiology of these pathogens and pests <sup>[11][12][13][14]</sup>.

## Conclusion

Fiber crops have played significant roles throughout human history. While technological advances over the last two centuries have resulted in artificial fibers replacing a significant proportion of natural plant fiber for human usages, due to our increased recognition of their environmental and human health benefits, there is a renewed interest for natural fibers from fiber crops in many parts of the world.

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