



Growing Hemp for the Future

A global fiber guide

Contents

1. Foreword	4
2. Executive Summary	6
3. Background Regarding Industrial Hemp	8
4. Hemp’s Benefits and Concerns	11
a. Benefits	12
b. Concerns	14
c. Considerations	15
5. Hemp Production Around the World	18
a. Fiber hemp production around the world	18
b. Historic legal status of hemp in the leading production regions	26
6. Pesticide and Fertilizer Restrictions and Hemp	28
a. Pesticides approved for growing hemp	28
b. Fertilizer use and hemp	29
7. Hemp Production Standards	30
8. Hemp Textile Processing & Manufacturing	32
a. Spotlight on hemp processing	33
9. Conclusion	36
10. Recommendations	38
11. Appendices	40
Appendix A: Hemp production standards at-a-glance	40
Appendix B: Global and national hemp organizations	46
12. Methodology	48
a. Global production data sources	48
b. Pesticides	49
c. Processing/manufacturing data	50
d. Conversion factors used	50
13. Acknowledgements	51
14. References	52

1. Foreword

There has been considerable excitement about the resurrection of hemp. It's a crop with a multitude of uses which also enables textile brands to "tick off" several of the sustainability criteria they are looking for in a fiber – low input, with strong environmental attributes, and durable.

Hemp production is expanding primarily due to recent legalization in countries around the world. This coincides with the global textile industry increasingly using hemp fibers.¹ At the same time, agencies, universities, companies, and organizations are rapidly scaling up their research into the best varieties and agricultural practices for hemp production.

With this expanded interest and growth, there are several environmental issues to consider. Historically, hemp has been grown with low input production methods, meaning no use of synthetic pesticides and fertilizers, and with low or little irrigation. At present, the crop has relatively few pests, however, there's a risk of increased pest pressure as hemp is grown more widely. Such risks range from diseases and insect pests² to weeds,³ especially if hemp is grown as a monoculture.⁴ This could potentially result in the expanded use of conventional pesticides (including herbicides, insecticides, fungicides, among others) which can cause a range of health and environmental issues. While hardy, the plant may not be immune from problems that plague other natural fiber crops such as cotton, potentially leading to extensive pesticide use.⁵

“We hope this report will provide readers with facts and considerations to build and guide hemp fiber programs in the years to come. As the saying goes, “hindsight is foresight.”

In addition, hemp is a “nitrophile” – it thrives off nitrogen.⁶ This could pose risks as the use of fossil fuel-based synthetic nitrogen fertilizer on other crops has resulted in ground and surface water contamination⁷ as well as greenhouse gas emissions that can have long-term detrimental impacts on the climate.⁸ These concerns indicate the need to preclude health and environmental risks that could accompany hemp's expanded production.

In some cases, hemp is being grown organically; in others, farmers or brands indicate that the hemp they grow or source is produced in a “regenerative” manner. However, due to the lack of a standardized definition of “[regenerative agriculture](#),” given its context-specific nature, there is a risk of making claims that could be considered “[greenwashing](#).”

Some consideration must also be given to the potential human rights impacts of hemp production. In some regions where hemp is grown, child labor and other worker rights implications may be concerns, whereas in other regions, there may be Indigenous rights and land rights to consider. Any hemp production should also strive to minimize its negative impacts on local communities and ecosystems.

Given the potential benefits associated with hemp production – including improving biodiversity and soil health – as well as the potential of hemp production expanding, Textile Exchange is utilizing this report to consolidate information about the benefits and concerns regarding its production, where it is grown, its historic legal status, which pesticides are permitted for use in different countries, as well as which standards support sustainability claims that could be applied

to its production. This includes a review of the sectors handling hemp fiber that are certified to the Organic Content Standard (OCS) and Global Organic Textile Standard (GOTS).

We also make the case for growing and processing the fiber so that it meets Textile Exchange's [definition](#) of “preferred” fibers and raw materials, representing a forward-thinking stance from which both current and future generations will benefit. This would allow us to avoid lessons learned from the production of other fiber crops that have become heavily treated with synthetic pesticides and fertilizers.

We believe that – if done right – the production and use of hemp fiber has great potential to support the achievement of our [Climate+](#) goals which call for the reduction of greenhouse gas emissions from fiber and raw material production by 45% by 2030 while also improving soil health, water, and biodiversity in the pre-spinning phase.

We hope this report will provide readers with facts and considerations to build and guide hemp fiber programs in the years to come. As the saying goes, “hindsight is foresight.” We have a unique opportunity to establish a major crop “intentionally” – anticipating problems that could be avoided and instead building the hemp industry in a sustainable manner, bringing about measurable beneficial outcomes instead.

– Sandra Marquardt, Fiber Crops Senior Manager, Textile Exchange

About Textile Exchange

Textile Exchange is a global non-profit driving positive impact on climate change across the fashion, textile, and apparel industry. We guide a growing community of brands, manufacturers and farmers towards more purposeful production, right from the start of the supply chain.

Its goal is to help the industry achieve a 45% reduction in the emissions that come from producing fibers and raw materials by 2030. To get there, we are keeping our focus holistic and interconnected, accelerating the adoption of practices that improve the state of our water, soil health, and biodiversity too.

For real change to happen, everyone needs a clear path to positive impact. That's why we believe that approachable, step-by-step instruction paired with collective action can change the system to make preferred fibers and materials an accessible default, mobilizing leaders through attainable strategies, proven solutions, and a driven community.

At Textile Exchange, materials matter. To learn more, visit textileexchange.org.

2. Executive Summary

Hemp is an increasingly popular⁹ bast fiber which can improve soil health with its long tap root,¹⁰ support biodiversity,¹¹ suppress weeds, and increase yields among subsequent crops¹² – all while being low-input. After decades of being prohibited for production in countries around the world,¹³ few conventional pesticides are currently authorized for use on the crop (see section 6). But if hemp production expands, that could change as the crop becomes more widely available to pests.

In this report, Textile Exchange looks at the production of hemp fiber in countries around the world in both leading and “up and coming” production regions. We also found that biological pesticides are to date the primary pesticides permitted for use although several conventional pesticides – including some considered “Highly Hazardous”¹⁴ – have been approved. We learned that the processing of hemp to the Organic Content Standard and the Global Organic Textile Standard is primarily undertaken in China, India, Portugal, and Turkey. Lastly, we identified several standards that could be used to substantiate sustainability claims regarding how the crop is grown.

It’s important to note that, given the relative infancy of the hemp industry, there is limited information supporting several of the production sustainability claims regarding the crop’s attributes and even identifying where and how much fiber hemp is grown internationally. We urge that as the fiber hemp sector expands, significant improvements be made to undertake and make public traceable information that supports such statements and identifies production information. This would include increased research to substantiate claims, improved tracking of production to benchmark trends and facilitate sourcing, and entities becoming certified to standards that set high standards for production practices while providing a chain of custody from the field to the finished product.

Perhaps most importantly, we urge governments, industry, institutions, and farmers alike to avoid allowing conventional pesticides and synthetic fertilizers to become the norm in hemp production – as has already become the case with several major crops in the US.¹⁵ We have the opportunity to consciously determine how this crop should be grown, thoughtfully reinventing the agricultural wheel.

We invite the hemp sector to join together and with us as we collectively navigate fiber hemp’s future.

Key findings

- While data is incomplete, the leading hemp fiber countries by volume appear to be France, China, North Korea (estimated), Poland, and the United States (US).
- Sixty years of FAO data (1961-2021) indicates that 2021 fiber hemp production by volume was approximately the same level as in 1961 but grown on far less land with far greater efficiency, resulting in higher yields.
- Unlike other crops which have become reliant on synthetic pesticides, biological pesticides are to date the primary pesticides governments permit for use on fiber hemp.
- Research is underway to add conventional pesticides to the limited fiber hemp pest management toolkit. Some pesticides that meet the United Nation’s “Highly Hazardous”¹⁶ [definition](#) have already been approved for use on hemp in some countries. Availability and use of synthetic pesticides is likely to expand without industry commitment to exploring alternatives to such inputs.
- Improvements need to be made to undertake and make public data that supports sustainability statements and identifies fiber hemp production regions and quantities.
- According to LCA accounting rules – developed to help ensure consistency in the footprinting of products and processes – it is not possible to account for carbon sequestration if the carbon is sequestered for less than 100 years.

Textile Exchange Preferred Fibers and Materials: Definitions

The principles below lay out a framework for the long-term transformation of textile raw materials.

While these principles may be aspirational today, the direction of travel for materials to be considered “[preferred](#)” should be in-line with outcomes that will lead to the ultimate achievement of these principles.

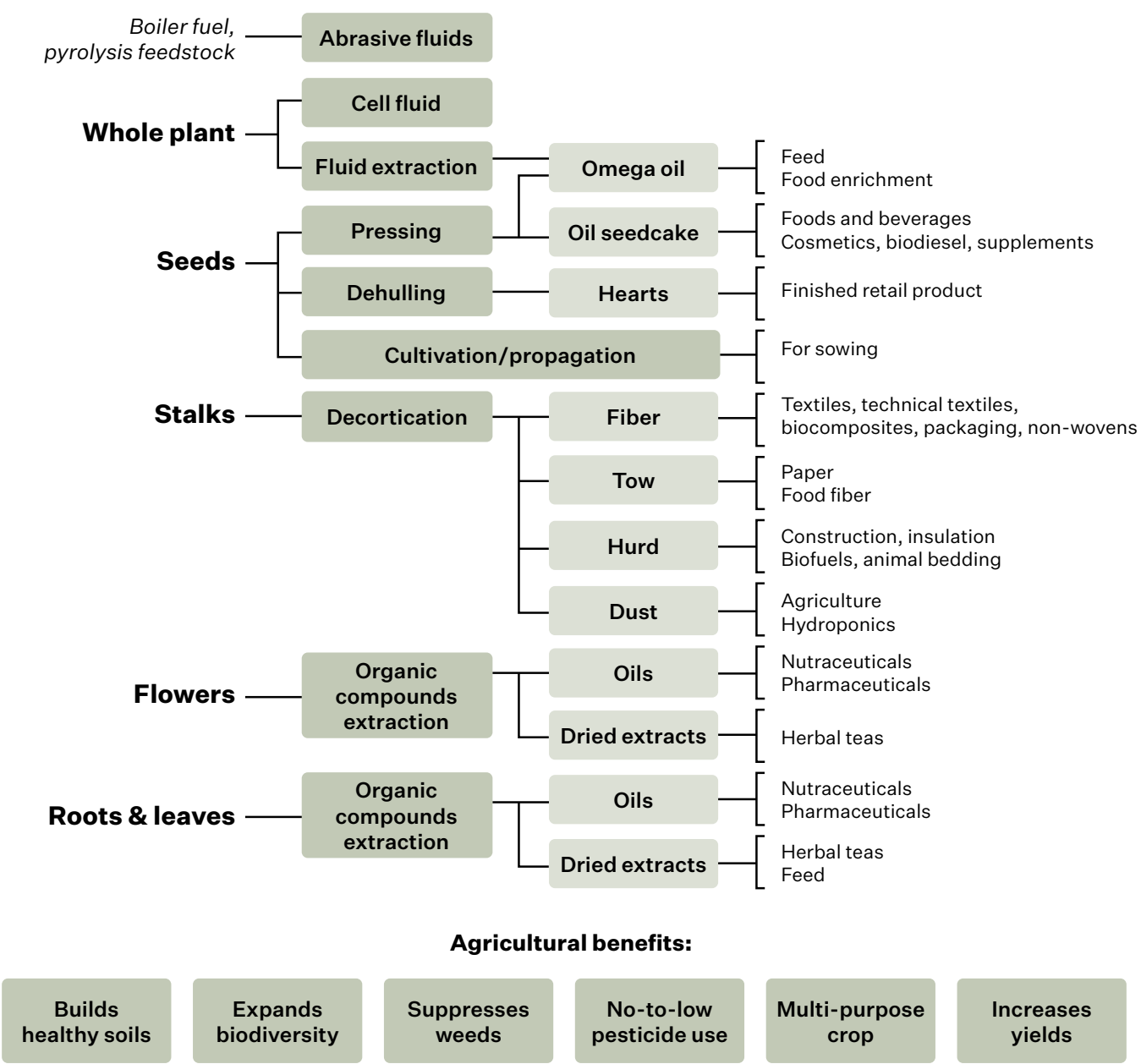
Note that not all principles apply to hemp. Instead, these are overarching directional principles that we believe apply to all fibers and materials.

- | | | |
|--|---|--|
| <ul style="list-style-type: none">• Natural ecosystems and species are protected and restored.• Agricultural systems and soils are regenerated.• No virgin fossil-based resources are used as feedstocks.• Material production transitions from fossil-based energy sources to renewable energy.• No natural ecosystems are converted or deforested. | <ul style="list-style-type: none">• Water resources are responsibly managed in line with contextual limits.• Chemicals of concern and other pollutants are properly managed and eliminated from environmental discharges and runoff.• Animals are managed in accordance with the Five Provisions of Animal Welfare.• Human rights are universally respected. | <ul style="list-style-type: none">• Farmers, herders, raw materials producers, and processors are empowered to build more equitable fiber systems.• Finite resources are safeguarded for future generations.• Production mitigates and builds resilience to climate change.• Supply chains are transparent and accountable. |
|--|---|--|

3. Background Regarding Industrial Hemp

Hemp is grown for its seed, fiber, and flower, or as a multi-purpose crop (oilseed and fiber, for example). A unique plant, it has spawned markets for a wide variety of products, ranging from textiles, clothing, rope, home furnishings, industrial oils, cosmetics, to food and pharmaceuticals.¹⁷ The uses and derivative products of hemp are so diverse that hemp globally may well intersect more markets and industries than any other crop.¹⁸

Figure 1. The many uses and agricultural benefits of industrial hemp¹⁹

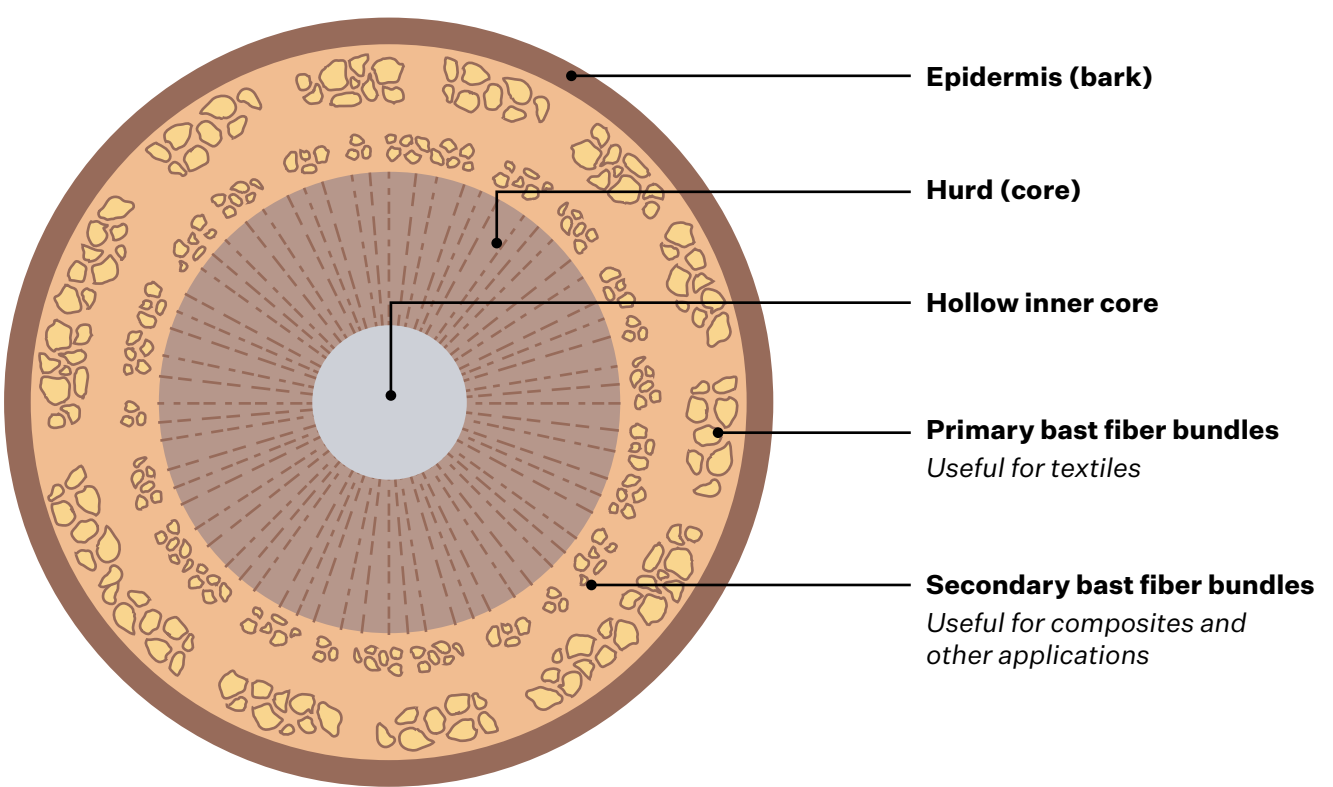


Textile Exchange, based on UNCTAD diagram

Hemp is defined as “a Cannabis sativa L. plant — or any part of the plant — in which the concentration of tetrahydrocannabinol (THC) in the flowers and leaves of the inflorescence is not more than the regulated maximum level established by authorities having jurisdiction.” Industrial hemp should not be confused with marijuana, which is a variety of Cannabis sativa L. with elevated levels of THC (up to 20%).²⁰

Hemp is a bast fiber in the Cannabaceae family. The fiber-producing part of the plant is made up of strands that run the length of the plant, surrounding the “hurd,” or woody core of the stem, and covered by a thin, gummy varnish that creates the delicate “bark” of the plant. Pectin adheres the fibers to the air-filled, woody core and lignin binds the fibers in bundles along the stalk.²¹

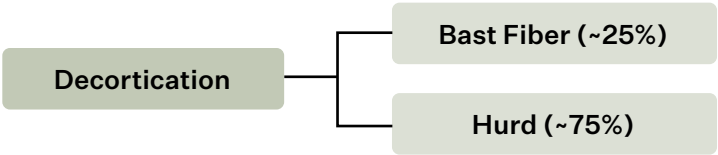
Figure 2. An inside look at a fiber hemp stalk



Industrial hemp grown for fiber is an annual broadleaf plant with a deep taproot. It is densely sowed and grows quickly up to 3–5 meters (approximately 10–15 feet), resulting in tall, slender plants with long, strong bast fibers²² (~25%) on the outside and the shorter hurd fibers – or particles - (~75%) in the stalk.²³

4. Hemp’s Benefits and Concerns

Figure 3: Percent of post-decortication hemp becoming bast fiber vs. hurd



Hemp is useful and beneficial in many different crop rotations. For example, in China, a leading producer of fiber hemp, farmers rotate hemp with crops including soybeans, tobacco, wheat, and corn.²⁴

Hemp fibers have numerous uses ranging from apparel and home textiles to paper, carpeting, construction and insulation materials, auto parts, composites, and much more. Once considered a waste byproduct, it is now used in animal bedding, material inputs, papermaking, and oil absorbents.²⁵

Today in the textile sector, hemp is found in a range of apparel – whether casual, formal, or workwear – as well as sheets, towels, shoes, tote bags, drapes, carpets, and much more. The fiber is stronger than cotton; durable; anti-microbial and UV resistant; naturally resistant to mold, mildew, and rot; readily accepts dyes; softens after each washing without fiber degradation; and breathable. Given that it can have a rather harsh hand and does not drape well, for apparel it is best utilized in blends with softer fibers (such as cotton, silk, or wool).²⁶ Pure hemp has a similar texture to new linen, softening with each wash and wear.²⁷

There is also a burgeoning nonwoven hemp sector, including feminine hygiene products and wipes.



Much has been claimed – but not always substantiated - of hemp as an “ideal” crop.

Hemp does indeed provide many positive attributes such as building healthy soils which can reduce soil erosion, expanding biodiversity, providing weed suppression with increased yields in subsequent crops, needing no-to-low pest management inputs (see below), being effective for phytoremediation, representing a multi-purpose plant that enables farmers to grow multiple co-products from a single hemp crop, and benefiting farmers, workers, and local communities.

However, without restrictions on which pesticides may be used or recommendations for minimal fertilizer applications and natural soil building practices, it could become another input-intensive crop resulting in the same extent of greenhouse gas emissions as well as pesticide and fertilizer contamination of the environment as represented by other natural fibers such as cotton.²⁸

Below we discuss some of its benefits as well as challenges regarding its production. We also address unknowns – after all, data is limited, possibly due to the decades during which it was illegal to grow hemp. Researchers warn that the hemp industry is plagued by large information gaps that have developed regarding production, pest management, and economic impact.²⁹



a. Benefits

- **Hemp production has numerous ecologically beneficial attributes.** The table below outlines the benefits of hemp and its bast fiber cousin flax (“linseed”) and demonstrates how it performs better compared to most other major crops (in Europe’s temperate Atlantic Central and Lusitanian Zones).³⁰

Figure 4: Ecological benefits of hemp and other crops in Europe³¹

		Nutrient depletion	Pesticides	Erosion	Soil compaction	Water consumption	Biodiversity	Agro-biodiversity
Environmental impact:	Hemp	A	A	A/B	A	B	B	A
	Permanent pasture	A	A	A	A	A	A	A
	Short rotation coppice (poplar, willow)	A	A	A	A	B	A/B	A
	Winter grains	A	A	A	A	A	B	B
	Linseed	A	B	A/B	A	A	A/B	A
	Alfalfa	B	A	A	A/B	A/B	A/B	A
	Grass	B	B	B	A/B	A	B/C	A
	Switchgrass	?	?	A	A	A	B	A
	Mustard	A/B	B	A/B	A	B	B	A
	Sorghum	A	B/C	A	A	A/C	B	B
	Wheat	A	B	A	A	B	B/C	C
	Sunflower	A/B	B	B/C	A	B	A/B	B
	Rapeseed	B/C	C	B	A	n/a	B/C	A/B
A = Lowest								
B = Medium								
C = Worst								
	Sugarbeet	B/C	B	C	C	A/C	B	B
	Maize	C	C	C	B	A/B	C	B/C
	Potato	B/C	B	C	C	C	B/C	C

- **Hemp is low input.** Hemp is considered a low-maintenance crop that currently requires little by way of inputs, including pesticides, during the growing season.³² Due to its vigorous growth, shading capacity, and disease resistance, hemp can be, and is being, grown without the use of pesticides – particularly synthetic ones – in many countries (see section 6). Given the limited need for inputs, hemp is an ideal crop for organic agriculture.³³
- **Hemp can be a beneficial rotational crop, providing weed suppression and increasing yields.** Crops grown in rotation with hemp have been shown to have both less weed pressure and up to 10-20% increased yields in subsequent crops such as corn, soybeans, tobacco, and wheat.^{34 35} This makes it an important rotational crop and could also reduce the energy needed to manage weeds.

- **Hemp can be beneficial to biodiversity.** Hemp is considered superior to numerous other annual row crops in terms of limiting damage to biodiversity, though it does not compare well to perennial or winter annual forage sod crops that are often composed of multiple species, including nitrogen-fixing legumes.³⁶ In addition, as hemp is widely grown with limited or no synthetic pesticides (see Section 5), the use of such inputs during production does not pose an extensive risk to biodiversity.
- **Hemp is beneficial to bees.** Being wind-pollinated, hemp plants produce large amounts of pollen that are attractive to bees. Hemp flowering during a period of limited pollen availability (such as late US summers) can make hemp flowers a valuable source of pollen for many species (16-23) of foraging bees.³⁷ This can also help to sustain agroecosystem-wide pollination services for other crops in the landscape.^{38 39}
- **Hemp’s roots improve soil health, prevent erosion.** Hemp’s extensive and deep root⁴⁰ penetrates deep into the soil providing aeration, while simultaneously building soil aggregate and preventing soil erosion.⁴¹ In addition, the roots decay before the next planting season, providing aeration and fertilization to the soil.⁴²
- **Hemp is effective for phytoremediation of heavy metals, chemicals, and radiation in soil.** Hemp has been used to extract heavy metals, dioxin, pesticides, radioactive materials, and more from polluted soil after the cultivation of these plants on degraded land. (Note: Additional research is suggested to develop a clear understanding of how efficiently different hemp cultivars can take up metals.) In some cases, the fiber could be reused in other products, pollutants can be extracted, or it may need to be disposed of as hazardous waste.⁴³
- **As a multi-purpose plant, farmers can grow multiple co-products from a single hemp crop.** As an example, a farmer can yield both grain (oilseed) and fiber from a single commercial hemp crop. Further, a fiber hemp crop produces multiple types of products – both fiber and hurd – both of which have very different material applications.⁴⁴ Benefits of multi-purpose hemp production include greater economic sustainability, with farmers able to use the same land to produce more than one crop at the same time (farmers can potentially earn more from the same crop with the same inputs costs), and greater environmental sustainability as farmers are using the same amount of water as well as the same amount of pest and soil fertility inputs.⁴⁵
- **Hemp production can bring several potential benefits to farmers, workers, and local communities.** As a beneficial rotational crop for farmers, diversifying agricultural activities can help mitigate risks associated with market fluctuations, pests, and weather conditions. Hemp cultivation has the potential to provide fair employment opportunities for workers when labor risks are appropriately managed. Local communities may benefit from the growth of this relatively less impactful crop and the effects on local water supply, biodiversity, and soil health. Benefits can vary depending on local regulations, market demand, infrastructure, and community engagement.

b. Concerns

- **Hemp has high fertilization needs, posing risks to air and water.** Recommended rates for fiber hemp are up to 112 kg/ha (100 pounds/acre) of nitrogen alone in North Carolina,⁴⁶ the leading US state for fiber grown in the open by total production weight in 2021.⁴⁷ This is equal to or more than the state’s nitrogen use per land unit recommendations for cotton (56-78 kg per hectare or 50-70 pounds per acre) and soybeans (90-112 kg/ha or 80-100 pounds/acre). It’s also almost the level recommended (135-179 kg/ha or 120-160 pounds/acre) for conventional corn (grain) production in that state.⁴⁸ Some recommendations go as high as 224 kg/ha (200 pounds per acre).⁴⁹ In France, the recommended amount of nitrogen fertilizer for hemp is 100 kg/ha (~90 lbs/acre).⁵⁰

Fertilizers can be lost to the environment through volatilization into the air, leaching into ground water, emission from soil to air, and runoff into surface water.⁵¹ Studies show that globally, nitrogen use efficiency – the percent amount of nitrogen remaining following crop production⁵² – is only 46%.⁵³ Excess nutrients are subject to various fate and transport processes that deliver the residual nitrogen to locations where it is not needed and resource degradation can occur.⁵⁴ When nitrogen in its active form, such as in fertilizer, is exposed to soil, microbial reactions take place that release nitrous oxide. This gas is 300 times more potent at warming the atmosphere than carbon dioxide. It also remains active in the atmosphere for more than 100 years.⁵⁵ Note: Use of leguminous cover crops, compost, and/or organic fertilizers such as bloodmeal can provide the equivalent amount of nitrogen while also building the soil and preventing less off-site migration.⁵⁶

- **Greenhouse gas emissions may increase with increased mechanization.** As farming continues to industrialize and mechanize across hemp producing countries, and thus rely less on labor intensive farming, energy intensive harvesting and processing equipment may increasingly be used. This machinery, most of which runs on fossil fuels, may increase greenhouse gas emissions.⁵⁷
- **Availability and use of synthetic pesticides on fiber hemp is likely to expand without the industry taking precautions to anticipate, prevent, or minimize the potential impacts of agricultural inputs and mitigate adverse effects.**⁵⁸ As we explore in section 6, while few synthetic pesticides are currently permitted for use on hemp – and countries like China don’t even permit the use of biological pesticides – a few countries are beginning to register hazardous pesticides for hemp production. Pesticides are inherently toxic and pose a variety of threats to human health, including increased risk of cancer and damage to the endocrine and nervous systems, kidneys, and liver.⁵⁹ In addition, by their nature, pesticides are potentially toxic to other organisms.⁶⁰ This can include causing impacts to wildlife (including bees),⁶¹ surface- and groundwater contamination,⁶² and pesticide drift.⁶³ In particular, soil fumigants are pesticides that, when applied to soil, form a gas to control a wide range of pests, including nematodes, fungi, bacteria, insects, and weeds.⁶⁴

- **It is essential to ensure that hemp’s production respects the rights and wellbeing of all individuals involved.** As is common with agricultural crop production, there are risks to farmers, workers, and local communities surrounding these supply chains. Adequate due diligence is key to ensuring that human rights risks are well managed. There are risks associated with child labor, forced labor, fair wages, safe working conditions and freedom to associate across agriculture globally. Risks may be higher where regulation is weak or poorly enforced. There are also concerns in some regions surrounding how hemp cultivation may affect land rights, particularly those of Indigenous People, including their right to free, prior, and informed consent regarding any activities that could impact their territories. A key consideration in the promotion of hemp as a crop is ensuring that this does not undermine food security or access.

c. Considerations

i. Old and new models of soil carbon storage

A shifting scientific consensus on the mechanism of long-term soil carbon storage indicates that the industry must proceed with due diligence around claims related to greenhouse gas impact reduction from soil carbon sequestration as well as around carbon credits and markets.

Over the past 10 years, there has been a revolution in soil science’s understanding of how soil carbon behaves in soils and the actual mechanism of “sequestering” carbon. As journalist Gabriel Popkin puts it, this shift is “...akin to what would happen if, in physics, relativity or quantum mechanics were overthrown. Except in this case, almost nobody has heard about it – including many who hope soils can rescue the climate.” One soil scientist told Popkin: “There are a lot of people who are interested in sequestration who haven’t caught up yet.”

The old paradigm proposed that as plant tissue decayed in the soil, the carbon from that tissue became locked into larger, long-chain “humic substances” that were chemically resistant to decomposition by the billions of microbes that are present in each teaspoon of soil. Carbon in the soil was thought to exist in distinct “pools,” with the carbon that was supposedly locked in humic substances representing a long-term stable or “recalcitrant” pool of carbon.

However, with advances in soil imaging technology, this long-held theory has come up against an inconvenient fact. As Lehmann and Kleber state, “these ‘humic substances’ have not been observed by modern analytic techniques,” including spectroscopic methods.

Instead, soil scientists are now developing a new paradigm to explain what is actually being seen in the soil at a microscopic level. This new paradigm proposes that soil microbes can digest any size and type of soil organic carbon molecule – they just have to be able to get at it. In this view, protection of soil carbon occurs when these molecules adhere to soil minerals or soil aggregates – clumps of soil that physically, not chemically, shield soil carbon from digestion by microbes. This new model increases the focus on the critical role of soil microbes, aiming to predict carbon’s

behavior in soils by focusing on the “ability of decomposer organisms to access soil organic matter and on the protection of organic matter from decomposition provided by soil minerals.

At the same time, evidence from modern analytic techniques has led to a second major finding: the dominant component of longer-lasting soil organic carbon is dead microbial biomass, rather than decayed plant material. As Liang et al. note, “this evidence is shifting the research from focusing on ‘humic’ matter to the microbial contribution.” These seemingly academic developments in fact reflect a fundamental change in the underlying assumptions, and the resulting mathematical approaches, used to develop current climate and soil modelling systems.

For information on carbon credits, please refer to [Textile Exchange’s Regenerative Agriculture Landscape Report](#).⁶⁵

ii. Carbon sequestration and hemp fiber products

A key concept related to Life Cycle Assessments (LCAs) and greenhouse gas (GHG) emissions for hemp – particularly important for brands or anyone making a claim about hemp carbon sequestration to understand – is that of “biogenic carbon.” This is carbon contained in biomass that accumulates during plant growth. As a result, many natural fibers and materials store, or “sequester” atmospheric carbon dioxide (CO₂) in the short term.⁶⁶

Carbon is sequestered in plant fibers and fiber products until the end of their life. At the end of the product’s life, it is converted back to CO₂ via microbial degradation or metabolism and other methods of release such as from landfills or incineration. This carbon dioxide is then released back into the atmosphere.

The proportion of carbon that is converted back to carbon dioxide (CO₂) depends on several factors, including what the product is [made into], how it is disposed of, and which organisms are breaking it down.⁶⁷

According to cradle-to-gate LCA accounting rules, developed to help ensure consistency in the footprinting of products and processes, it is not possible to account for carbon sequestration if the carbon is sequestered for less than 100 years.⁶⁸ This is because there is no way of knowing that the carbon is sequestered for more than 100 years in a cradle-to-gate LCA as the end of life is not included. The reporting requirements of three common product carbon footprinting standards/guidance documents for cradle-to-gate scope are listed for [ISO 14067](#), [EU PEF](#), and [PAS 2050](#) in figure 5.

Figure 5: Comparison of product biogenic carbon reporting requirements of three common carbon footprint standards/guidance documents for cradle-to-gate scope.⁶⁹

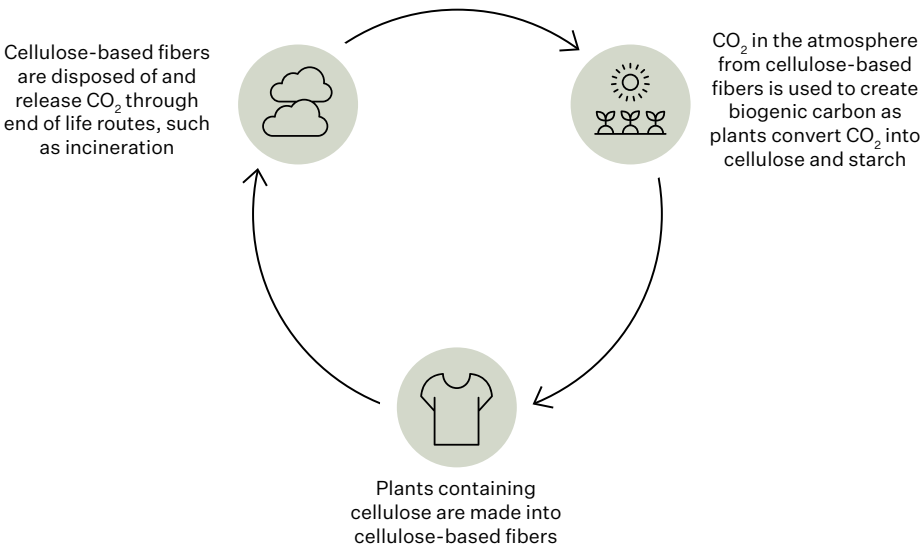
Parameter	ISO 14067: 2018	EU PEFv6.3	PAS 2050
Biogenic carbon storage in product	To be reported as additional information only	To be reported separately as additional information if product carbon storage >100 years	Mandatory to include carbon storage in the net GHG calculations when product carbon storage >100 years

This means it is not possible to include carbon sequestration across natural fibers, including hemp fibers, when calculating GHG emissions for natural fiber products. (Nor acceptable to make such claims in promotional media which could lead to greenwashing concerns.)

Separate to biogenic carbon sequestered in hemp fibers, hemp cultivation may lead to carbon sequestration in soils. The extent to which carbon sequestered in soils in this system can be accounted for is not well defined.⁷⁰ More guidance is needed for the hemp and the fibers and material industry regarding how to account for soil carbon sequestration. Once finalized in 2023, the [GHG Protocol Land Sector Removals Guidance](#) will help by providing methods for accounting for land sector carbon removals from systems such as hemp cultivation.

According to LCA accounting rules – developed to help ensure consistency in the footprinting of products and processes – it is not possible to account for carbon sequestration if the carbon is sequestered for less than 100 years.⁷¹

Figure 6: Biogenic carbon cycle for cellulose-based fibers⁷²



5. Hemp Production Around the World

Below, we provide an overview of fiber hemp production globally as well as in several specific countries around the world: China, France, and the US, as well as North Korea, Poland, and other countries in the European Union, Latin America, and Turkey.

Foremost, we turned to [FAOSTAT](#) – the United Nations Food and Agriculture Organization statistical database – which provides free access to food and agriculture statistics (including crop, livestock, and forestry sub-sectors) for over 245 countries and territories.

However, while extensive, the FAOSTAT is incomplete and does not include hemp-related data for numerous fiber hemp-growing countries, including the United States and Canada,⁷³ as well as Australia⁷⁴ and countries in Africa.⁷⁵ In addition, some of its information – regarding North Korea, for example – is based on estimates.

As a result, we also looked to a few government sources and incorporated their information into our findings. This includes information from the US Department of Agriculture (USDA) and from the Turkish Statistical Institute (TURKSTAT). We note that currently it is not possible to separate organic versus conventional fiber hemp production figures – organic hemp figures are included with all fiber hemp data. For more information on our data gathering, please see the Methodology section.

Ultimately, there is no single source for data pertaining to the production area and quantity of hemp and definitions are sometimes incomplete and even conflicting. Hence, the below global estimates are just that, but they serve as important benchmarking indicators. (See the Recommendations section.)

The data included reflects an overview of fiber hemp production globally and provides no value-based judgments on the environmental or social contexts of sourcing from the mentioned countries.

a. Fiber hemp production around the world

i. Global and regional fiber hemp production overview

According to FAO, US, and Turkish databases, roughly 21 countries grew fiber hemp in 2021. The countries were: Austria, Bulgaria, Chile, China, Czechia, Democratic People’s Republic of Korea (North Korea), France, Germany, Greece, Italy, Japan, Lithuania, the Netherlands, Poland, Republic of Korea (South Korea), Romania, Russian Federation, Spain, Turkey, Ukraine, and the United States.

The FAO data shows us that in 2021, fiber hemp had an estimated global production volume of 287,318 tonnes (6.3 million pounds) which was harvested from 74,307 hectares (183,617 acres) in 20 countries. Yields ranged from a low of 300 kilograms per hectare (kg/ha) (268 pounds (lbs)/acre) in Czechia to 7,850 kg/ha (6,987 lbs/acre) in Italy and 7,812 kg/ha (6,970 lbs/acre) in both France and the Netherlands.⁷⁶

In addition, the US has become a significant fiber hemp-producing country (see “United States” below). USDA data indicates that fiber hemp was harvested from 5,138 hectares (12,690 acres), yielding 15 million kilograms (33.2 million pounds) of fiber hemp.⁷⁷

Data from TURKSTAT demonstrated that 21 tonnes (46,200 lbs) of fiber hemp were harvested in Turkey in 2021.⁷⁸

Thus, a rough estimate, based on incomplete data, is that global fiber hemp production in 2021 – with FAOSTAT, USDA, and TURKSTAT data combined – would be roughly 302,000 tonnes (665,000 lbs.) grown on 79,000 hectares (196,000 acres). This does not include the fiber hemp production data for countries where production is taking place, but for which no data is available.

Figure 7: Countries with fiber hemp production by volume in 2021 (FAOSTAT, USDA, TURKSTAT)

Country	Tonnes	Pounds	Percent	Rank
France	143,110	314,842,000	47%	1
China	72,878	160,331,996	24%	2
United States	15,113	33,249,000	5%	3
North Korea	15,097	33,212,564	5%	4
Poland	15,080	33,176,000	5%	5
Netherlands	13,280	29,216,000	4%	6
Austria	10,700	23,540,000	4%	7
Italy	4,710	10,362,000	2%	8
Chile	4,216	9,274,276	1%	9
Romania	2,770	6,094,000	1%	10
Lithuania	1,800	3,960,000	1%	11
Russian Federation	1,322	2,909,060	0%	12
Spain	1,160	2,552,000	0%	13
Ukraine	738	1,622,522	0%	14
Greece	220	484,000	0%	15
Bulgaria	160	352,000	0%	16
Czechia	60	132,000	0%	17
Turkey	21	46,200	0%	18
South Korea	16	35,508	0%	19
Japan	1	1,188	0%	20
Global	302,451	665,392,314	-	-

Figure 8: Countries with fiber hemp production by area in 2021 (FAOSTAT, USDA, TURKSTAT)

Country	Hectares	Acres	Percent	Rank
North Korea	21,657	53,493	27%	1
France	18,320	45,250	23%	2
China	11,306	27,926	14%	3
United States	5,138	12,690	6%	4
Germany	4,600	11,362	6%	5
Chile	4,476	11,056	6%	6
Russian Federation	3,488	8,615	4%	7
Poland	2,120	5,236	3%	8
Austria	1,880	4,644	2%	9
Netherlands	1,700	4,199	2%	10
Ukraine	1,507	3,722	2%	11
Lithuania	870	2,149	1%	12
Romania	690	1,704	1%	13
Italy	600	1,482	1%	14
Spain	460	1,136	1%	15
Czechia	200	494	0%	16
Bulgaria	160	395	0%	17
Greece	130	321	0%	18
Turkey	32	80	0%	19
South Korea	11	27	0%	20
Japan	1	2	0%	21
Global	79,346	195,985	-	-

Figure 9: Countries’ fiber hemp production by yield in 2021 (FAOSTAT, USDA, TURKSTAT)

Country	Kilograms/ha	Pounds/acre	Rank
Italy	7,850	6,987	1
Netherlands	7,812	6,952	2
France	7,812	6,952	3
Poland	7,113	6,331	4
China	6,446	5,737	5
Austria	5,691	5,065	6
Romania	4,014	3,573	7
United States	2,942	2,620	8
Spain	2,522	2,244	9
Lithuania	2,069	1,841	10
Greece	1,692	1,506	11
South Korea	1,467	1,306	12
Bulgaria	1,000	890	13
Chile	942	838	14
North Korea	697	620	15
Turkey	648	577	16
Japan	540	481	17
Ukraine	489	436	18
Russian Federation	379	337	19
Czechia	300	267	20

When we analyze the 60 years of FAOSTAT data (1961-2021) available, we see that:

- After a low in fiber hemp production by volume in 1990, there has been an increase, though inconsistent, to 2021.
- Total fiber hemp production (in tonnes) was just 4% more in 1961 than in 2021. However, fiber hemp was harvested from 84% less land in 2021 than in 1961 with 510% greater yield in 2021.
- The high point for both fiber hemp production volume and hectares came in 1965 at 340,821 tonnes (7.5 million pounds) and 581,181 ha (1.4 million acres)
- The greatest average fiber hemp yield per unit of land was in 2017 (4,012 kg/ha or 3,573 lbs/ acres). However, in recent years individual countries have almost doubled that – in 2021, Italy reportedly had fiber hemp yields of 7,850 kg/ha (6,987 pounds/acre).

Below are charts demonstrating fiber hemp production by volume, land area, and yield from 1961-2021, according to FAO data.

Figure 10: FAO global fiber hemp production 1961–2021 by volume (tonnes)

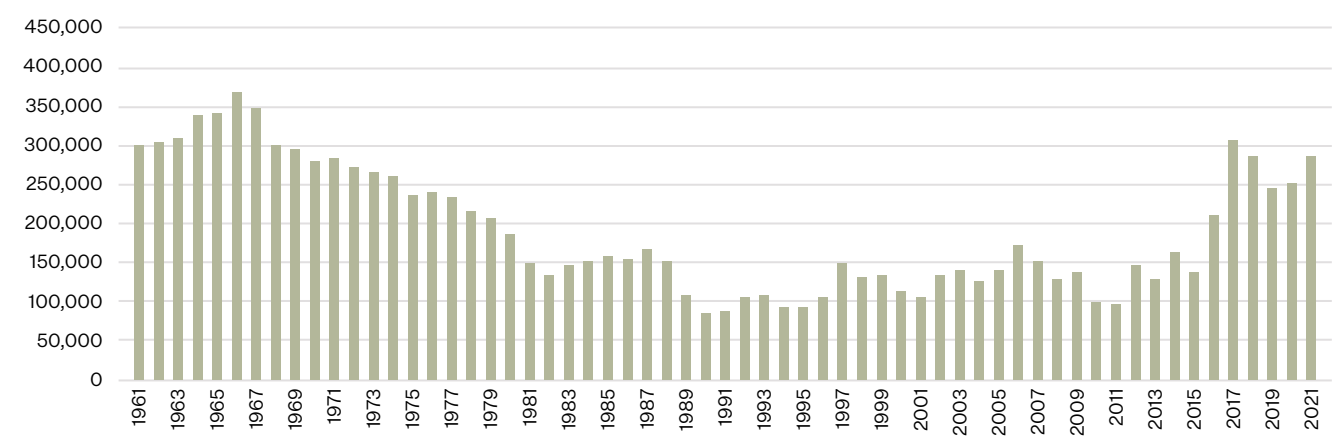


Figure 11: FAO global fiber hemp production 1961–2021 by area (hectares)

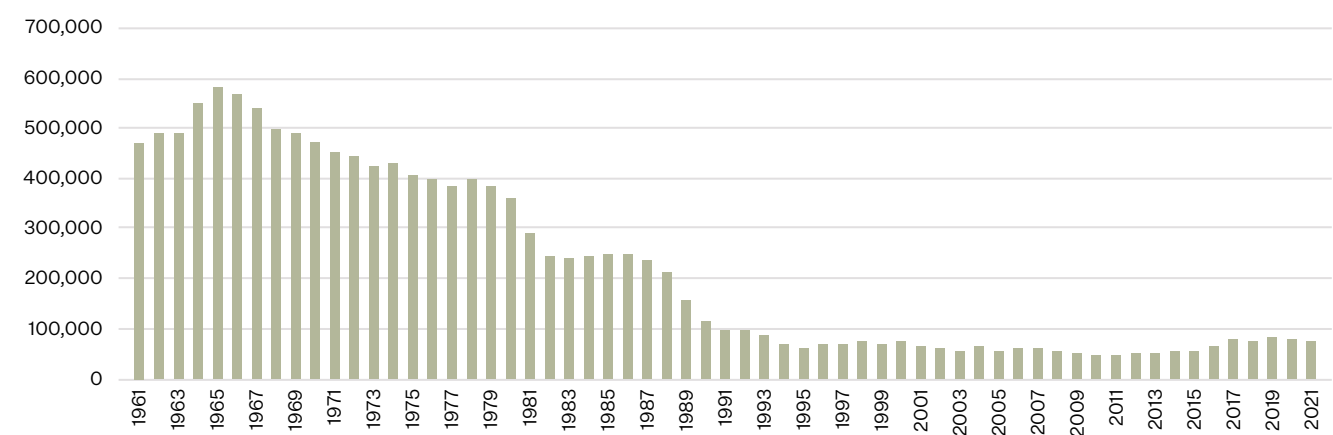
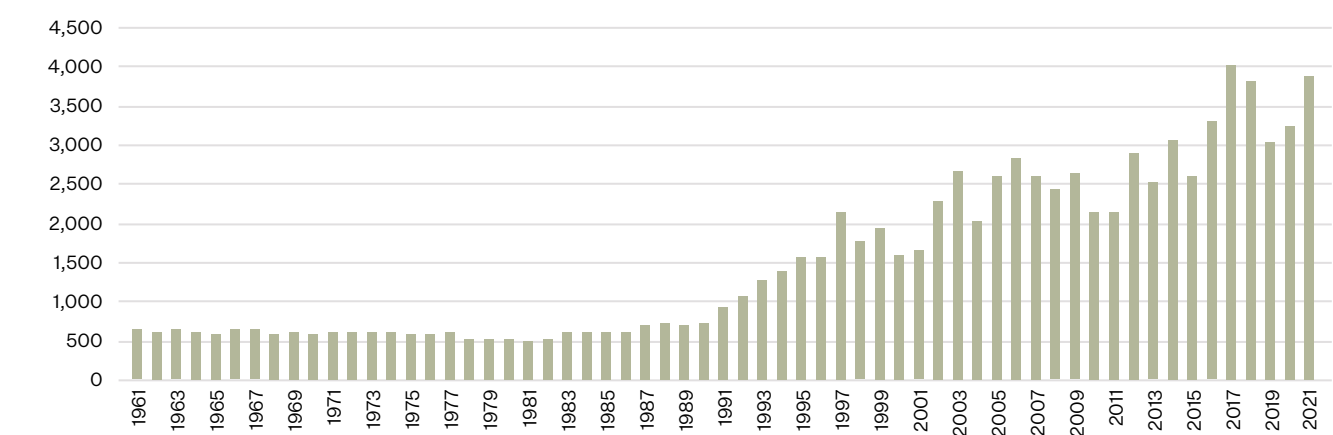


Figure 12: FAO global fiber hemp production 1961–2021 by yield (kilograms per hectare)



USDA publishes national annual and weekly hemp reports

In 2022, the US Department of Agriculture (USDA) released its first National Hemp Report documenting 2021 acreage, yield, production, price, and value of hemp (including fiber) in the United States.⁷⁹ That is the basis for the data in this report. (See section 5.)

Note that in April 2023, USDA released its 2022 hemp production report. However, as the rest of the per-country data in this report is from 2021, we chose to use that year’s data in this overview.

In 2023, USDA launched a National Weekly Hemp Report which contains retail advertised prices of hemp products nationally and by region, along with volumes and cost, insurance, and freight (CIF) values of hemp imports into the United States.

“USDA has recognized the hemp industry’s need for timely market information,” says Under Secretary for Marketing and Regulatory Programs Jenny Lester Moffitt.⁸⁰

Both publications are available [here](#).

ii. Leading and up-and-coming fiber hemp producing countries and regions

Based on data from the FAO⁸¹ and the USDA Department of Agriculture,⁸² the following countries (in alphabetical order) were among the reportedly top fiber hemp producing countries by volume in 2021: China, France, North Korea (based on estimated figures), Poland and the United States.

Below we highlight several of the leading countries and regions based on FAO, USDA, and/or TURKSTAT data.

France

According to FAO data, farmers in France grew 143,110 tonnes (314,842,000 pounds) of fiber hemp on 18,320 hectares (45,250 acres) with 7,812 kg/ha (6,952 lbs/acre) – making it the leading fiber hemp-producing country globally by quantity, second by area, and third in yield behind Italy and the Netherlands for the greatest yields in Europe as well as globally.⁸³

When analyzing FAO, USDA, and TURKSTAT data, it appears that in 2021, France was by far the leading fiber hemp-producing country globally by volume, growing 47% of the fiber on 21% of the land area in fiber hemp production. In 2020, about 7% of French hemp cultivation was organic.⁸⁴

Most hemp is grown in the Grand Est region in northeastern France,⁸⁵ and the cooperatives processing the fiber hemp are all located within 150 km of hemp farms.⁸⁶ French hemp is grown primarily for industrial purposes; the major applications of French hemp include paper, construction materials (such as insulation and concrete), plastic composites, and food.⁸⁷ Only about 1% is used for textiles.⁸⁸

China

There is no official Chinese government data on hemp production,⁸⁹ but according to FAO estimates, in 2021, China grew 72,878 tonnes (1.6 million pounds) – or an estimated quarter of the world’s supply – on 11,306 hectares (27,926 acres) with a yield of 6,446 kg/ha (5,737 lbs/acre). This made China the second-largest fiber hemp-producing country by volume, third by area, and fifth by yield. China’s fiber hemp yields appear to have tripled between 2010 and 2021, from 2,133 kg/ha to 6,446 kg/ha.⁹⁰

Chinese hemp production is located primarily in the northern province of Heilongjiang and the southwestern province of Yunnan and, to a lesser degree, Anhui (in the east) and Gansu provinces (in the northeast).⁹¹ An overwhelming share of China’s hemp market is dedicated to textile production, a history of which extends at least 5,000 years. Consequently, China enjoys a completely developed hemp-processing infrastructure, which allows the country to produce clothing and textiles at rates and levels of quality that US (and other) producers are currently incapable of meeting and will remain hard-pressed to compete with.⁹²

North Korea

FAO’s (incomplete) figures for fiber hemp production indicate that North Korea is the largest fiber hemp producer by area, third-largest by volume, and 16th by yield. However, these figures are FAO estimates as no official statistics exist.⁹³

European Union

According to FAOSTAT, USDA, and TURKSTAT figures, several EU countries in addition to France are up-and-coming players. Italy had limited fiber hemp production (ranked eighth) but had the highest yields globally. Poland ranked fifth for volume and fourth for yield, and the Netherlands ranked sixth for volume and second for yields globally. While these countries may be some of the highest-ranked countries, other EU countries were the smallest, such as Bulgaria (16th for volume and 13th for yield) and Czechia (17th for volume and 20th for yield).

United States

The cultivation of industrial hemp was legalized in the United States in 2018.⁹⁴ In 2021, US industrial hemp farmers planted a total of 21,924 hectares (54,152 acres). Of that, 5,138 hectares (12,690 acres) yielded 15 million kilograms (33.2 million pounds) for an average yield of 2,942 kg/ha (2,620 pounds/acre). Other industrial hemp products in the US include flower, grain, and seed.⁹⁵

Note: 2022 production data is also available showing that in that year, production of hemp grown in the open for fiber was estimated at 9,525 tonnes (21.0 million pounds), down 37% from 2021. The area harvested for hemp grown in the open for fiber in the United States was estimated at 2,772 hectares (6,850 acres), down 46% from last season. The average yield for 2022 hemp grown in the open for fiber was estimated at 3,441 kg/ha (3,070 pounds/acre), up 499 kg/ha (450 pounds/acre) from last year. The value of hemp grown in the open for fiber totaled \$28.3 million, down 32% from 2021).⁹⁶

If blended with the FAO statistics, the US appears to have been the third largest fiber hemp-producing country by volume, fourth by land area, and eighth by yield.

Latin America

Since 2013, several Latin American countries have legalized the production of industrial hemp, including Argentina,⁹⁷ Colombia,⁹⁸ Costa Rica,⁹⁹ Paraguay, and Ecuador and Uruguay. Latin American fiber hemp is in its infancy, with grain cultivars more developed.¹⁰⁰

Chile was the only Latin American country included in FAOSTAT fiber hemp figures. According to those estimates, Chile ranked ninth for volume, sixth by area, and 14th for hemp fiber yields in 2021. (These figures may not be accurate, however. According to the Latin American Hemp Industry Association (LAIHA), Chile’s law that dictates the regulatory framework for the production of the cannabis species in the country is [Law 20.000](#), a drug law permitting the production of medicinal cannabis only. LAIHA notes that the country granted a limited number of fiber and grain hemp production special exemptions but only for approximately 10 hectares of hemp.¹⁰¹)

Countries in South America are expected to become major players in the global hemp market over the next several years. However, South American hemp growers, especially in the equatorial countries, must grapple with high humidity and tropical temperatures, two factors that are thought to contribute to pushing a hemp crop’s THC levels above legal limits.¹⁰²

Turkey

There is conflicting information regarding how much fiber hemp was grown in Turkey in 2021. According to the FAO, in 2021, just two hectares of hemp fiber were harvested for a total of 1.5 tonnes (*imputed value) and 943 kg/ha yield. However, TURKSTAT, the Turkish Statistical Institute sources, states that 21 tonnes (46,200 pounds) of hemp fiber were produced in 2021 on 32 hectares (80 acres) for a yield of 648 kg/ha (577 lbs/acre).

The amount of fiber hemp grown in Turkey appears to have increased in 2022, with 31 tonnes grown on 26.5 hectares, resulting in almost double the yield from 2021.¹⁰³

Since 2016, the Turkish government has permitted the production of industrial hemp in 19 provinces. The Ministry of Food, Agriculture, and Livestock may also grant permission to grow cannabis in other provinces if production is purely for “scientific purposes.”¹⁰⁴

While hemp fiber production is still limited, Turkey plays a leading role in hemp manufacturing. (See section 8.)

b. Historic legal status of hemp in the leading production regions

Production of hemp is not yet legal worldwide, but countries worldwide are increasingly authorizing their farmers to grow the crop.

In France, hemp was never officially outlawed, but production shrank dramatically in the 20th century due to imported cotton and the introduction of synthetic fibers.¹⁰⁵ In 1990, France specifically authorized the cultivation, import, export, and use of hemp provided only the fibers and seeds of the plant were used – flowers and leaves were banned for retail sales until late 2022.¹⁰⁶

China's dominance in the hemp production and processing sector market can be attributed in part to its long tradition of growing hemp, and the fact that it was banned for only 25 years,¹⁰⁷ versus effectively over 80 years in the United States.¹⁰⁸

The Marijuana Tax Act of 1937 effectively ended hemp farming in the US though it didn't officially make it illegal. Hemp was briefly grown in the US during World War II for making rope. Later the Controlled Substances Act of 1970 required a Drug Enforcement Administration (DEA) permit to grow hemp, but by then no industrial hemp was being grown in the US. The 2018 Farm Bill finally permitted the production of hemp in the US.¹⁰⁹

Prohibitions and restrictions served to halt much of the research into appropriate varieties and production practices for different regions, as well as the development – or even basic maintenance – of machinery, from decortication to the finer processing stages. As a result, much of the research and development is only being undertaken now, although brands expect it to already have been addressed.



6. Pesticide and Fertilizer Restrictions and Hemp

“With hemp production, the textile industry needs to apply hindsight as foresight. We must learn from the pesticide and fertilizer issues we’ve faced with other fibers, applying that knowledge to prepare for the future.”

– Matt Dwyer, Patagonia Vice President of Product Impact and Innovation

Pesticides include herbicides, insecticides, fungicides, fumigants, and other substances or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest or used as a plant regulator, defoliant, or desiccant.¹¹⁰

Pesticide products contain both “active” and “inert” ingredients. An “[active ingredient](#)” prevents, destroys, repels, or mitigates a pest, or is a plant regulator, defoliant, desiccant, or nitrogen stabilizer. All other ingredients are called “[inert ingredients](#).” They are important for product performance and usability.¹¹¹

The term “inert” does not imply that the chemical is nontoxic.¹¹² Inert ingredients can be and are frequently chemically and biologically active substances, as well as hazardous and toxic to the environment.¹¹³ Examples of inert ingredients include adjuvants, emulsifiers, solvents, carriers, aerosol propellants, fragrances, and dyes.¹¹⁴

Pesticides and fertilizers are regulated differently, with more extensive oversight regarding pesticide permitting.

a. Pesticides approved for growing hemp

As of April 2023, primarily or only biological pesticides are permitted for use on hemp in several countries such as the US,¹¹⁵ the UK,¹¹⁶ and China – one of largest producers of hemp fiber in the world¹¹⁷ which hasn’t registered any pesticides for hemp.¹¹⁸

However, some countries, including reported fiber hemp production leaders France and the Netherlands, permit the use of several conventional pesticides on fiber hemp, including some considered “Highly Hazardous.”¹¹⁹

The number of conventional pesticide registrations for hemp in just these two countries serves as an indicator of future registrations globally unless efforts are made during these early stages in hemp’s renaissance to grow the crop in a sustainable manner.

Below is a status overview of pesticide use in several fiber hemp-growing countries – China, France, the Netherlands, Turkey, the UK, and the US.

China

Both governmental and external data indicate no pesticides are approved for hemp production.¹²⁰

France

France has authorized 13 pesticide products (three biological active ingredients and four conventional) for use on hemp grown in France. Four of the products contain a blend of napropamide, clomazone, and dimethachlone, and another four contain tefluthrin as an active ingredient.¹²¹ Tefluthrin is a WHO Class Ib “Highly Hazardous” pesticide ingredient,¹²² due to its toxicity to bees.¹²³ While the pesticides are registered, they reportedly are not used, at least not by the leading cooperatives.¹²⁴

The Netherlands

The Netherlands has authorized 81 pesticide products for use on hemp. These are based on 27 active ingredients: nine biological and 18 conventional – including beer. Five are “Highly Hazardous Pesticides”: aluminum phosphide, deltamethrin, glyphosate, tebuconazole, and tefluthrin. Of the products, 33% (27) have glyphosate as the active ingredient, which is considered a Highly Hazardous Pesticide. Other conventional active ingredients permitted include azoxystrobin, clethodim, clopyralid, fludioxonil, fluopyram, iron phosphate, isoxaben, metalaxyl-M, propaquizafop, prosulfocarb, prothioconazole, spirotetramat, and trifloxystrobin.

Turkey

No pesticides are registered for use on hemp at the time of publication.¹²⁵

United Kingdom

Only one active ingredient – the biopesticide ferric (iron) phosphate – is authorized for use on hemp in the UK. All the products containing the chemical are slug baits (molluscicides).¹²⁶ Until recently, slug baits containing metaldehyde were also allowed, but the UK prohibited it effective March 31, 2022, to protect wildlife.¹²⁷

United States

The US Environmental Protection Agency (EPA) has approved approximately 46 active ingredients (99 pesticide products) for use in hemp farming. All but one are biological pesticides. The sole conventional pesticide – the preemergent herbicide ethalfluralin – was only in April 2023 allowed to be used on hemp.¹²⁸ (Note: See Methodology.) Universities are ramping up their research into pesticides to expand hemp’s pest management toolbox.¹²⁹

b. Fertilizer use and hemp

There do not appear to be any restrictions on the amount or type of fertilizers that can be applied to hemp, at least in the US. Recent EU regulations address terminology, quality, toxic contaminant levels, and claims, but do not limit quantities.¹³⁰

The lack of availability due to global conflict in leading fertilizer production regions and rapidly increasing costs may drive more interest in using compost and manure as natural alternatives. Compost and manure also serve to increase water capacity, build soil, improve air quality, and sequester carbon.¹³¹

7. Hemp Production Standards

Companies making claims about responsible practices and sustainable production are better protected when they are part of an independent verification program. Such programs include organic, Regenerative Organic Certified, Preferred by Nature Framework, and the ISCC. The programs address key components of Textile Exchange’s Climate+ strategy including pesticide and fertilizer use, irrigation/water use, greenhouse gas mitigation, soil health, biodiversity, and land use change as well as human rights.

The programs prohibit the use of pesticides deemed extremely (1a) or highly hazardous (1b) by the World Health Organization (WHO), as well as those banned by international conventions, including the following conventions:

- [Montreal Protocol on Substances that Deplete the Ozone Layer](#)
- [Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade](#)
- [Stockholm Convention on Persistent Organic Pollutants](#)

Other than the Preferred by Nature Sustainability Framework, the programs also prohibit the use of synthetic fertilizers.

Textile Exchange is currently developing a unified standard system that is incorporating the Climate+ impact areas alongside human rights and livelihoods, in raw material production criteria. The first development is focused on cotton for fiber crops with a plan to learn from testing and implementation, then adapt the criteria for hemp production in a future version of the standard.

Please see Appendix A for a description of each standard and its environmental requirements for key impact areas of Textile Exchange’s Climate+ strategy.



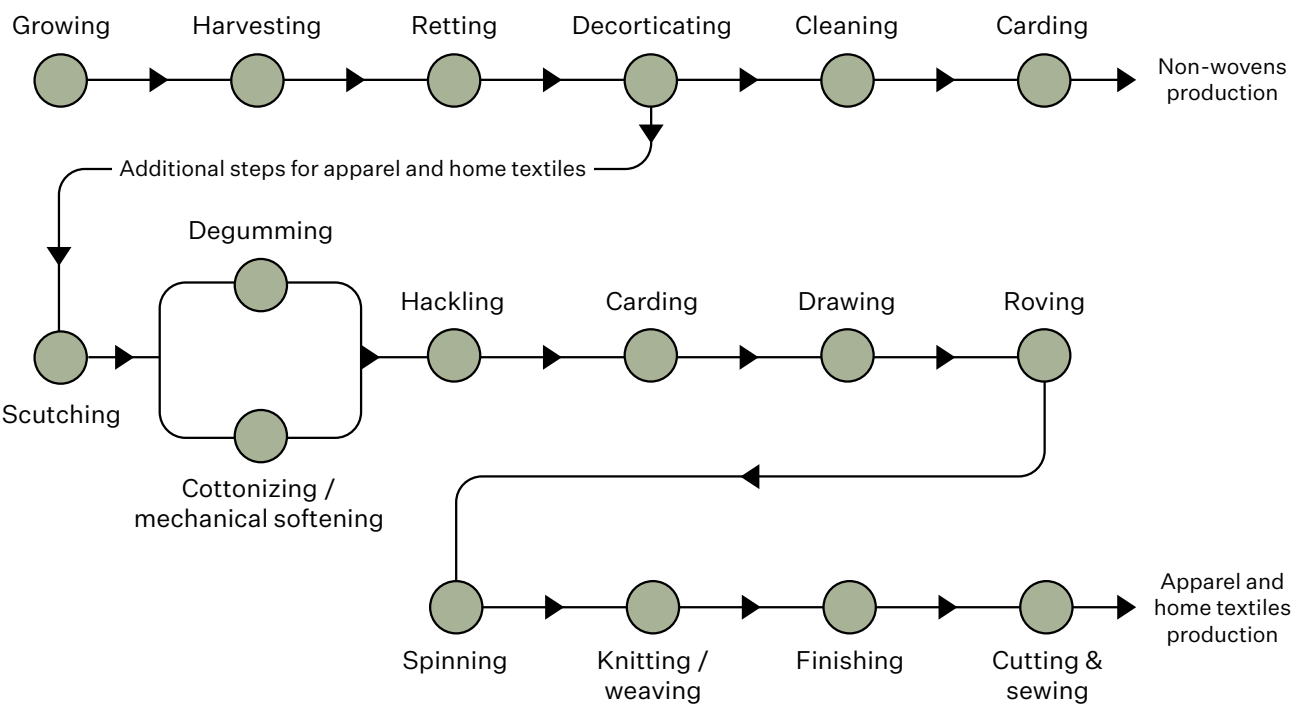
8. Hemp Textile Processing & Manufacturing

Below we provide a brief overview of the processing stages and a few of the primary standards in place for hemp processing that enable traceability.

There are multiple production and post-harvest processing stages before hemp fiber becomes a finished textile product.

- For apparel and home textiles, these include retting, decortication, scutching (for long fiber), degumming, cottonizing/mechanical softening (if not degummed), hackling, carding, drawing, roving, spinning, knitting/ weaving, finishing (including bleaching and dyeing), and cutting and sewing.¹³²
- For non-wovens, there are far fewer stages. These include retting, decortication, cleaning, carding, and nonwoven fabric production.¹³³

Figure 13: Following the hemp from field to finished product



To learn more about the production and processing of conventional or organic hemp textiles, in March 2022 Textile Exchange undertook a preliminary internal review of companies that work with hemp and that had been certified by either of the two key voluntary standards in the market for organic textiles - Textile Exchange’s [Organic Content Standard](#) (OCS) and Global Standard gGmbH’s [Global Organic Textile Standard](#) (GOTS).

While the standards have different scopes – GOTS addresses the social and environmental responsibility of processing stages, while OCS solely verifies organic content – both address chain of custody from field to finished product, recognize fiber coming from farms that are organic and/or in-conversion, and consider the retting stage the first stage of processing.¹³⁴

Some companies turn to the OCS if they wish to use less than the 70% minimum organic content that GOTS requires, as the OCS permits organic content claims from 5-100% organic content. Conventional hemp is allowed in the OCS in conjunction with organic fibers, however, conventional hemp is only permitted in GOTS certified products so long as it is not blended with organic hemp and it makes up less than 30% of the fiber content.¹³⁵

We found that:

- Certified companies represent all stages of post-farm hemp production from decortication through retailing. Many companies perform more than one stage of processing.
- Products incorporating hemp included yarns and fabrics, home textiles, and baby, children’s, men’s, and women’s apparel.
- China, India, Portugal, and Turkey are the primary regions for hemp processing and manufacturing among OCS- and GOTS-certified companies that work with hemp.

a. Spotlight on hemp processing

i. Hemp fiber processing in the EU

According to the Alliance for European Flax-Linen and Hemp, in 2023 there are numerous mills offering various stages of post-harvest processing throughout Europe.¹³⁶

For fiber extraction, there are 12 decortication facilities specific to short fiber hemp: six in France, two in Germany, two in the Netherlands, and one each in Romania and Lithuania. For scutching, there are 72 flax facilities that are capable of processing long-fiber hemp as well. They are located in France, Belgium, and the Netherlands, the Western Europe region that accounts for three-quarters of global flax production.¹³⁷

The next processing stages are the same as the flax-linen mills. These include:

- *Long fiber hackling*: Seven in France, Lithuania, Poland, and The Netherlands
- *Long fiber spinning*: in France, Italy, Lithuania, Poland
- *Semi-long fiber carding-combing*: Six in Belgium, France, Lithuania, and Poland
- *Semi-long fiber spinning*: Five in France and Poland
- *Cottonizing*: Six in Belgium, France, and Lithuania
- *Short (cottonized) fiber spinning*: One in Spain

Fiber hemp processing capabilities depend on the different types and intended uses of the fiber. The different sectors have different levels of maturity based on the amount of research and development into agricultural technical practices and dedicated field machinery that has taken place. For example, traditional hemp processing has had decades of R&D addressing paper-grade fiber type suitable for the paper, construction, and composite industries, but this capacity is just developing for textiles.

Hemp short fibers can be “cottonized,” meaning shortening and refining the fibers to blend with cotton then spinning them on cotton systems (ring or open-end) to develop different yarn counts. The fiber supply and processing capabilities have reached commercial levels at operations such as [La Chanvriere](#), [Marmara Hemp](#), and [Vanneste](#) for the cottonized fiber, and [Intercot](#) for spinning.

Hemp semi-long fiber can be processed through carding and combing and dry-spinning, similar to flax. This enables the manufacturing of both 100% hemp yarn, as well as blends with wool to make thick yarns.

Hemp long fiber processing (hackling and wet spinning) is quite similar to that for flax long fiber. In 2022 innovative agricultural machinery was developed that enables on-the-ground retting similar to flax that is necessary to extract long fiber and produce 100% flax yarn in fine yarn counts.

To develop long hemp fiber on an industrial scale, from the field to fabric manufacturing and recycling, the [European Interreg North West Europe](#) (a program co-funded by the European Union) in early 2023 launched the [HEMP4CIRCULARITY](#) project – Hemp as a driver of circularity in the textile industry: from field to recycled fibre. Production of long-fiber hemp is an opportunity to develop a new option that complements the already existing value chain for flax-linen. The three-year project (2023-2026) is managed by Valbiom and involves 11 partners from Belgium, France, Germany, and The Netherlands, including the Alliance for European Flax—Linen and Hemp. In addition, associated partners include the European Industrial Hemp Association.

ii. Hemp fiber processing in the US

It is estimated that in 2023, 20 decorticators will be in production in the US – six with a focus on bast fiber that are operating at three tonnes per hour or more. The others are smaller, mainly focusing on hurd, and/or still in the R&D stages. Having more decorticators not only increases production capacity but opens opportunities for second-level processors and manufacturers. Another eight to ten decorticators are developing or considering installing new decortication facilities within the next five years with four to six highly likely to successfully enter the market. Acreage will be the primary determinant of production, however, and processors must be proactive to procure acreage. Once bast fiber quality and farm production is more developed, scales and markets are expected to expand rapidly, and processors will begin to increase acreage requirements. As a result, much of the anticipated growth in the next five years is in years three to five.¹³⁸



Image: Fiber hemp being harvested in France. Credit: Valbiom.

9. Conclusion

The future of hemp production is at a watershed moment. Restrictions on this once-stigmatized crop are being lifted around the world, and people have an increased awareness of the concerns accompanying input-intensive agriculture. There is much excitement about the sustainability potential of this fiber crop, but growing, sourcing, or wearing hemp won't be a solution in itself – it will all depend on how that hemp is grown.

As there are few conventional pesticides authorized for hemp's production globally, the industry can develop production practices from scratch that work in harmony with nature and bring about measurable benefits for this newly reappreciated fiber crop. We encourage governments, brands, and farmers alike to set up systems that will result in high quality raw material with low toxicity inputs and maximum benefits to the environment.

If we conduct business as usual, the same negative impacts on communities and the environment could well occur from the practices that are common in conventional agriculture today. And this poses the question – if the promise of hemp's sustainability attributes starts to diminish, will the market still be interested in the fiber? Consumers and brands alike have been attracted to this fiber's "natural" reputation¹³⁹ could simply move on, looking for the next innovation to scale.

This is a material with a lot of sustainability potential, and the industry has an opportunity to shape its production system from the soil up. By working collaboratively and applying learnings from the past, we can leverage its holistic benefits to meet our climate and nature targets.



10. Recommendations

Below we provide recommendations for governments, brands, NGOs/academia, farmers, and consumers, focusing primarily on actions each should take to meet Textile Exchange’s Climate+ strategy.

Governments:

- Encourage and support research into the use of natural, organic, and regenerative farming practices for hemp production which prioritize soil regeneration and avoid the use of hazardous pesticides and fertilizers. Such research should also address increased soil health and biodiversity, as well as improved water use and quality.
- Develop, disclose, and monitor annual global, publicly available hemp pesticide and fertilizer use data to facilitate production practice measurement tracking and encourage the adoption of responsible farming practices.
- Document the global production of fiber hemp by country, volume, unit of land measurement, method of production (is it organic?) and price – and report the information publicly each year. Provide that information to FAOSTAT and other institutions to make reporting as expansive and well-documented as possible.
- Establish and enforce robust regulations and standards to protect labor rights, and Indigenous and local community rights, including provisions to protect against environmental contamination.

Brands:

- Demonstrate commitment to responsible fiber sourcing by having a clear supply chain and sourcing policy. Develop internal policies that prioritize and support organic, preferred, or regenerative farming practices that avoid the use of Highly Hazardous Pesticides and synthetic fertilizers for hemp production.
- Know your farmer. Foster long-term relationships with farmers, investing in organic and regenerative agriculture projects developed in partnership with them to support responsible farming practices and fair prices.
- Have a reliable system and process in place to verify sustainability claims and ensure traceability in the sourcing of hemp (and other raw materials) through to finished products. This can be done through certification to recognized standards such as the OCS or GOTS. In the future, Textile Exchange’s unified standard system under current development is planned to include hemp production practices with tracking and handling of the certified material through the Content Claim Standard (CCS). Tracer technology can also be used but should be used together with a chain of custody and traceability system. (See tracer background [here](#).)
- Further develop environmental and social due diligence systems. Monitoring potential and actual impacts within fiber and material supply chains and supporting remediation where brands have caused or contributed to negative impacts.

NGOs:

- Work with government, academia, farmers/farm organizations, trade associations, and researchers to develop Best Management Practices, pesticide and fertilizer use policies, and production information (pesticide/fertilizer use, location, area, quantity, etc.)
- Promote the benefits of responsible hemp production by facilitating research and education into production practices as well as legal claims that will enable the supply chain to avoid greenwashing risks.

Academia:

- Continue – and expand - research and education to help growers adopt organic and regenerative methods of hemp production which do not rely on the use of synthetic pesticides and fertilizers and take into consideration environmental health as well as the health and safety of workers and rural communities.
- Support research into hemp’s benefits and sustainability concerns addressed in this report to enable brands to avoid greenwashing, build due diligence systems, and ensure responsible sourcing practices.
- Establish fertilizer use recommendations based on the most recent research, prioritizing soil building practices such as the use of cover crops, compost, and manure.

Farmers:

- Prioritize organic and regenerative farming practices that preclude the use of Highly Hazardous Pesticides and synthetic fertilizers while promoting soil health and biodiversity.
- Participate in innovative projects developed in partnership with brands and NGOs to support responsible farming practices and promote environmental and social stewardship.

Consumers:

- Support companies that prioritize organic and regenerative hemp programs that promote responsible farming practices and environmental stewardship while protecting human rights.

11. Appendices

Appendix A: Hemp production standards at-a-glance

i. Organic and Regenerative Organic Certified

According to the criteria or “Norms” of the International Federation of Organic Agriculture Movements (IFOAM), organic production is a system that sustains the health of soils, ecosystems, and people. It relies on ecological processes, biodiversity, and cycles adapted to local conditions, rather than the use of inputs with adverse effects.¹⁴⁰ In this report, the term “organic” refers to practices addressed in IFOAM’s [“Family of Standards.”](#)¹⁴¹ The [Regenerative Organic Certified](#) standard includes additional provisions addressing animal welfare and social fairness.

Third-party certification organizations verify that organic producers meet strict regulations addressing methods and materials allowed in organic production.

Pesticides and Fertilizers:

According to the criteria or “Norms” of the International Federation of Organic Agriculture Movements (IFOAM), under organic standards, the use of synthetic fertilizers is prohibited during organic hemp production as are pesticides that are not on a list based on international organic standards.¹⁴² The organic production system strives to minimize external inputs and to make use of on-farm resources (e.g., animal and green manures, biomass, organic fertilizers, and botanical preparations for pest control).

(DOT) Irrigation/Water Use:

There are no restrictions. However, the use of cover crops and other soil building requirements (see below) can help improve water efficiency.¹⁴³ Soils on organic farms tend to have higher water-holding capacity, porosity, and aggregate stability than conventionally managed soils due to increased soil organic matter and comparatively healthier soil structure, which can lead to yield advantages in extreme weather events such as droughts and flooding, meaning that organic may fare better as our planet continues to experience climate change.¹⁴⁴ Organic practices also prevent the contamination of both surface and ground water given the restrictions on pesticide and fertilizer inputs.

GHGs:

Organic agriculture contributes to the mitigation of climate change by prohibiting the use of synthetic fertilizers such as nitrogen. Instead, all the nitrogen on organic farms comes from recycled sources like compost or manure or from new reactive nitrogen from nitrogen-fixing bacteria in the roots of cover crops or other legumes.¹⁴⁵ Regardless of organic or conventional production, diesel and electricity used in agriculture are significant contributors to GHG emissions.¹⁴⁶

Soil Health:

Organic crop production systems are intended to conserve or improve the soil’s structure, organic matter, fertility, and biodiversity. Soil organic matter, microbial activity and general soil health and fertility must be improved if low and maintained or improved if satisfactory. Nutrients and fertility products must be applied in a way that does not harm soil, water, and biodiversity.

Biodiversity:

Operators must design and implement measures to maintain and improve landscape and enhance biodiversity quality, by maintaining on-farm wildlife refuge habitats or establishing them where none exist. In addition, clearing or destruction of High Conservation Value Areas - areas that have been identified as having outstanding and critical importance due to their environmental, socioeconomic, biodiversity or landscape values - is prohibited.

Land-Use Change:

The IFOAM Norms prohibit the clearing or destruction of High Conservation Value Areas. Regenerative Organic Certified prohibits operations from clearing primary, untouched forest or old-growth secondary forests nor converting wetlands, peatlands, or protected grasslands into agricultural production from January 1, 2015 forward.

Human Rights:

Organic operations may not violate human rights and they must provide fair working conditions for employees and contracted workers.

ii. Preferred by Nature Sustainability Framework

The [Preferred by Nature Sustainability Framework](#) provides a single framework that can be used across different commodities and sectors and for different stages in the supply chain. The latest revisions to the framework align with the draft requirements of the proposed EU Regulation on deforestation-free supply chains.

The framework covers four principles: responsible management and business practices, respect for human rights and wellbeing, protection of nature and the environment, and reduction of greenhouse gases.

Pesticides:

Prohibited chemicals include those listed in Annex A or B of the Stockholm Convention or are recommended for inclusion in Annex A or B by the Persistent Organic Pollutants Review Committee; listed in the Montreal Protocol; listed in Annex III of the Rotterdam Convention or recommended for inclusion in Annex III by the Chemical Review Committee; listed in classes Ia and Ib under the World Health Organization’s Recommended Classification of Pesticides by Hazard; classified as reproductive toxicity category 1 or 2, carcinogenic toxicity category 1 or 2, or mutagenic toxicity category 1, according to the Globally Harmonized System (GHS) of Classification and Labelling of Chemicals.¹⁴⁷

Fertilizers:

No restriction on fertilizer type. Natural water bodies must be protected from chemical, fertilizer, and slurry drift and run-off. In addition, the amount, timing, and application of fertilizers must be adjusted to plant nutrient needs and to minimize nutrient loss to the surrounding environment.

Irrigation/Water Use:

Water should be used efficiently, but no specific requirements exist beyond complying with legal requirements.

GHGs:

Producers must identify significant greenhouse gas emission sources from management practices, land-use changes, livestock, energy, sourcing, and use of materials.

Soil Health:

Erosion should be reduced through practices such as ground cover, mulch, protection and re-vegetation of steep areas, terracing or filter strips to protect soils.

Biodiversity:

Riparian buffer zones and areas of high conservation value (e.g., endangered species and ecosystems or critical ecosystem services) must be monitored and protected.

Land-Use Changes:

Natural forests or other natural ecosystems cannot be converted to agriculture, plantation forestry, or other land uses.¹⁴⁸

Human Rights:

Child labor, modern slavery, and discrimination are prohibited. Producers should respect workers’ rights, Indigenous Peoples rights and Community rights, provide safe workplaces and gender equality.¹⁴⁹

iii. ISCC

[International Sustainability & Carbon Certification](#) (ISCC) is a certification for traceable and deforestation-free supply chains that want to address socially and economically sustainable production of fiber, food, feed, and biomaterials.¹⁵⁰ The ISCC sustainability requirements for farms and plantations address both ecological and social criteria, including the protection of biodiverse and carbon-rich areas, good agricultural practices, safe working conditions, compliance with human labor and land rights, compliance with laws and international treaties, and good land management practices that encourage continuous improvement.¹⁵¹

Pesticides:

Chemicals – including pesticides - listed in the Stockholm Convention on Persistent Organic Pollutants and Annex III of the Rotterdam Convention must not be applied on any (owned and leased) farm or plantation land. Chemicals listed in the WHO 1a and 1b were to be phased out by January 2023. In cases where there are no alternatives to a chemical WHO 1a and 1b substance, an external expert must be consulted to confirm this. Appropriate handling, storage and disposing of pesticides products is required.

Fertilizers:

ISCC prohibits the use of synthetic fertilizers, only approving high quality organic and mineral fertilizers used accordingly to the soil’s nutritional needs and soil organic matter balance and application recording. Additional requirements address sustainable fertilizer handling, storage, and application conditions of the fertilizers (e.g., fertilizers with high nitrogen content may only be applied on absorptive soils, with weather conditions and buffer zones taken into account.

Irrigation/Water Use:

ISCC requires respect for existing water rights and justifies irrigation in the context of social and environmental science. A water management plan that aims to minimize negative impacts on water quality and quantity is required and application of good agricultural practices should be implemented to improve water quality, efficient water usage, and sustainable water source conditions. Water consumption must be monitored according to that plan.

GHGs:

ISCC urges farmers to make energy consumption as efficient as possible to reduce GHG emissions. Farmers must have a plan for reducing the use of fossil fuel and increasing the use of renewable energy sources such as biofuels, biogas, or solar or wind energy. For ISCC EU System users, the calculation of greenhouse gas emissions is required, while for ISCC PLUS, this is voluntary via an “ISCC PLUS add-on option.” ISCC growers calculate their GHG emissions for cultivation, land-use change (if applicable), transportation, and processing. Farmers have different options to reduce GHG emissions, such as switching to organic fertilizer or reducing inputs. Auditors verify these GHG calculations during farm audits with changing samples of farmers.

Soil Health:

Farms must have a soil management plan that addresses erosion prevention and control, as well as maintenance and improvement of soil nutrient balance, organic matter, pH, and biodiversity. Topographical, regional, and landscape conditions should be considered for the implementation of measures at a local condition. These measures can include crop rotation, intercropping, and optimum plant space to improve soil fertility and avoid soil erosion and compaction.

Biodiversity:

The standard requires conservation of natural resources and biodiversity on cultivation areas. The environmental impacts in new cultivation areas or the intensive agricultural purpose in uncultivated land or semi-natural areas, among others, are assessed in an environmental impact assessment to minimize, for example, land and soil characteristics and rare and endangered species. Farms and plantations must set up a Biodiversity Action Plan (BAP) to protect biodiversity, specifically pollinators.

Land-Use Changes:

As of January 2008, no land use change (LUC) has been permitted for areas with high biodiversity or high carbon stock (e.g., wetlands, primary or highly biodiverse forests, and peatlands).

Human Rights:

The standard includes extensive requirements related to basic human and labor rights as well as provisions for responsible community relations. Criteria cover rural and social development concerning the farm/plantation’s responsibility towards surrounding communities. Further, employment conditions are elaborated that are based on but not limited to core ILO standards.



Appendix B: Global and national hemp organizations

Alliance for European Flax-Linen & Hemp

The Alliance for European Flax-Linen & Hemp is the only European agro-industrial organization federating all the stages of production and transformation of flax and hemp. The Alliance coordinates roughly 10,000 member companies in 14 EU countries, focusing on the innovation, environmental impact, and performance of these natural fibers. The organization spearheaded the EUROPEAN FLAX® and MASTERS OF LINEN® traceability labels.

allianceflaxlinenhemp.eu

Canadian Hemp Trade Alliance

The Canadian Hemp Trade Alliance is a national industry association that promotes the Canadian hemp industry by sharing information, promoting the use of nutritional and industrial hemp products (“food, feed, fiber, and fractions”), developing standards, and coordinating research. Its members include farmers, processors, manufacturers, researchers, entrepreneurs, and marketers.

hemptrade.ca

Chinese Bast and Leaf Fibers Textile Association

The Chinese Bast and Leaf Fibers Textile Association is the official organization for all bast fibers, including hemp, flax, and ramie. Its focus is to serve as a bridge and link between members and government departments, convey and implement the government’s intentions, reflect the wishes and requirements of enterprises, safeguard the rights and interests of members in accordance with laws and policies, and otherwise provide members with various services.

cblfta.org.cn

European Industrial Hemp Association (EIHA)

Based in Brussels, the European Industrial Hemp Association represents more than 200 producers, processors, and traders working with hemp fibers, shives, seeds, leaves, and cannabinoids on the European market. Its role is to monitor international and EU hemp-related policies, to provide decision-makers with accurate and reliable information on hemp, and to steer the renaissance of a strong EU supply chain.

eiha.org

Federation of Industrial Hemp Organizations (FIHO)

FIHO is an international alliance of hemp industry associations from around the world. The group, which launched in March 2022, aims to bring together industry leaders, market expertise, and resources to speak with one voice on hemp issues at the global level in order to promote the production, processing, marketing, and trade of hemp and to make hemp a mainstream global agricultural commodity.

fiho.org

InterChanvre

InterChanvre is the “interprofessional” organization of the French hemp industry. Its objectives are to unite industry players; represent and defend industry interests and stakeholders in technical, economic, and political circles; support scientific and technical research in the sector; and promote the environmental benefits of hemp, the industry, and its markets.

interchanvre.org/interchanvre

Latin America Industrial Hemp Association

LAIHA supports the emerging hemp industry in Latin America. The organization advocates for fair and clear regulatory frameworks in Latin American countries, collects and shares production data, and works to build a regional processing network.

laiha.org

National Industrial Hemp Council

The National Industrial Hemp Council, launched in 2019, promotes the production and use of industrial hemp in North America and around the world. The Council proactively interacts with federal legislative and regulatory bodies, advocates together with fellow hemp-focused trade associations and non-profits, assists its members with networking and business promotion, and educates businesses, brands, and consumers on the benefits of industrial hemp and its expanding market applications. The NIHC also works to establish international, standardized regulatory frameworks to encourage investment and growth of the hemp industry.

nihcoa.com

12. Methodology

Data for this global fiber guide was collected from government reports and databases, academic papers, organizational database, Textile Exchange and external subject matter experts, published standards, company and industry association websites, and other publicly available sources.

a. Global production data sources

Data on global hemp production was gathered primarily from the U.N. Food and Agriculture Organization Corporate Statistical Database (FAOSTAT)¹⁵² using 2021 data (the most recent) updated in March 2023. Several fiber hemp growing countries and regions are not included in the FAO data, so those figures were supplemented with data from the [US Department of Agriculture](#) and [TURKSTAT](#) – the Turkish Statistical Institute – two other publicly available sources. Where there were discrepancies between the estimates from FAO and other sources, this was noted in the text.

We note that other reports have focused on [data](#) from [Eurostat](#) – the Statistical Office of the European Union (EU). We chose to use FAOSTAT instead as it:

- includes countries from around the world while Eurostat focuses on the 27 EU member states and additional European countries.
- separates fiber hemp from hempseed and associated products, e.g., hempseed oil and hempseed cake.
- provides information on fiber hemp back to 1961 while Eurostat data goes back to 2000.

i. Definitions:

Data included in this report adheres to the following definitions published by the respective data source.

FAOSTAT

FAO Item Code	CPC Code	FAO Item	FAO Description
777	01929.02	True hemp, raw or retted	This plant is cultivated for seed as well as for fibre. The fibre is obtained from the stem of the plant. Trade data include raw, retted, scutched, combed fibre, tow and waste.

FAOSTAT Commodity List (FCL). [stats.fao.org/classifications/FCL/0777](#). Accessed 5.25.2023.

Central Product Classification (CPC). Version 2.1. Table 5.3, CPC expanded for agricultural statistics, pp. 587. [unstats.un.org/unsd/classifications/unsdclassifications/cpcv21.pdf](#). Accessed 5.25.2023.

FAOSTAT Search Tool: [fao.org/faostat/en/#search/true hemp](#). Accessed 5.25.2023.

USDA NASS

USDA NASS Data Item

HEMP, INDUSTRIAL, IN THE OPEN, FIBER - PRODUCTION, MEASURED IN LB
HEMP, INDUSTRIAL, IN THE OPEN, FIBER - ACRES HARVESTED
HEMP, INDUSTRIAL, IN THE OPEN, FIBER - YIELD, MEASURED IN LBS / ACRE

United States Department of Agriculture. National Agricultural Statistical Service. Quick Stats. ([quickstats.nass.usda.gov](#)) Accessed 5/18/2023.

Data item search criteria: Program: Survey → Sector: Crops → Group: Field Crops → Commodity: Hemp → Category → Production OR Acres Harvested OR Yield → Data Item → Geographic Level → Year.

Turkish Statistical Institute (TURKSTAT)

TURKSTAT Data Portal Item

[01.16.19.00.02] Hemp, Fiber “Kenevir, lif”

Data Item Search Criteria: [tuik.gov.tr](#): Statistics → Agriculture → Databases → Crop Production Statistics → Cereals and other Vegetable products → Click OK → Production Quantity → Kenevir, lif [Note: The search does not work for English] → Choose [01.16.19.00.02] Hemp, Fiber → Choose Units → Click ‘Add Indicators’ → Click ‘Forward’ → Choose years → Click ‘Forward’ → Choose Level = Turkey → Click ‘Generate Report.’

b. Pesticides

Pesticide registration data was gathered from country-specific public databases that list pesticides authorized for use in (industrial) hemp production. For an analysis of their toxicity concerns, we turned to the Pesticide Action Network (PAN) International 2021 [List of Highly Hazardous Pesticides](#). This list draws upon the following: The Globally Harmonized System of Classification and Labelling of Chemicals (GHS), the World Health Organization’s (WHO) Recommended Classification of Pesticides by Hazard, the International Agency for Research on Cancer (IARC), the US Environmental Protection Agency (EPA) Office of Pesticide Programs’ List of Chemicals Evaluated for Carcinogenic Potential, EU categorization of endocrine disruptors, EPA classification for bee toxicity, and more.

When counting registered active ingredients, we counted only one of the same ingredients – for example, we counted only the same bacillus strain versus multiple strains. If multiple active ingredients are listed in one formulation, we counted each active ingredient separately. Multiple salts of the same ingredient (ex: mono- and di-potassium salts) were counted as one ingredient, for example [here](#).

Note: The status of pesticide registration in the United States is somewhat unclear. An EPA data base called [APPRIL](#) indicates there may be four conventional pesticides registered for hemp: borax, ethalfuralin, piperonyl butoxide, and potassium laurate, but only one- ethalfuralin – was listed on EPA’s [Pesticide Products Registered for Use on Hemp](#) at the time the report was published in July, 2023.

c. Processing/manufacturing data

Textile Exchange undertook an internal analysis of OCS- and GOTS-certified companies in March 2022 to determine which companies used organic or conventional hemp in their products. Of these companies, we further analyzed them by organic status, country, type of products in which hemp was used (e.g., apparel, home textiles, fabric, yarn) and type of processing the company performed (e.g., spinning, weaving, dyeing, etc.). In some cases, processing stage information was not provided or available in the OCS database, in which case it was ascertained from the company website or other online sources.

d. Conversion factors used

Given that we were working in both Imperial and metric units, we used the following conversion factors:

- Conversion from kilogram (kg) to pound (lb): 2.2lbs/kg
- Conversion from tonnes to pounds: 2200 pounds/tonne
- Conversion from kilogram (kg) to tonnes: 1000 kg/tonne
- Conversion from hectares to acres: 2.47 acres/ha
- Conversion from kg/ha to lbs/acre: 1 kg/ha equivalent to 0.89 lbs/acre

13. Acknowledgements

Authors:

- Sandra Marquardt, Senior Manager, Cotton and Fiber Crops
- Liz Savage, Consultant

Contact:

materials@textileexchange.org

External reviewers:

We thank the following individuals and organizations for their input into this report. The accuracy of the final statements is the responsibility of Textile Exchange:

- Alliance for Flax-Linen and Hemp
- CottonConnect
- European Industrial Hemp Association
- International Hemp Association
- Marco Fugazza of the United Nations Conference on Trade and Development (UNCTAD)

We would also like to thank the following for their contributions:

- Bear Fiber
- FyberX
- David Gould
- ISCC
- Latin America Industrial Hemp Association
- PanXchange
- Preferred by Nature Sustainability Framework

Additional thanks:

- Dr. Heather Grab, Cornell University
- Dr. Jeffrey Steiner, Oregon State University
- Dr. David Suchoff, North Carolina State University

14. References

- 1 US Department of Agriculture Foreign Agriculture Service. August 23, 2022. European Union: Market Trends and Regulations for Industrial Hemp in the European Union. <https://www.fas.usda.gov/data/european-union-market-trends-and-regulations-industrial-hemp-european-union>
- 2 National Library of Medicine. Emerging diseases of Cannabis sativa and sustainable management. February 27, 2021. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8451794/>
- 3 Cornell University. 2022. 2022 Weeds and Weed Management. <https://hemp.cals.cornell.edu/resources/reports-factsheets/2022-cornell-hemp-field-day-handouts/2022-weeds-and-weed-management/>
- 4 Texas A&M AgriLife Extension. 2021. Hemp Diseases in Texas. <https://agrilife.org/plantclinic/files/2021/09/PLPM-PU-085proof-HEMP-diseases.pdf>
- 5 US Department of Agriculture National Agricultural Statistics Services. ND. Quick Stats. <https://quickstats.nass.usda.gov/>
- 6 Journal of the International Hemp Association. 1999. A comparison of the biodiversity friendliness of crops with special reference to hemp (Cannabis sativa L.). <http://www.internationalhempassociation.org/jiha/jiha6206.html>
- 7 US Department of Agriculture. ND. Fertilizers and Pesticides. <https://www.ers.usda.gov/topics/farm-practices-management/fertilizers-pesticides>
- 8 US Environmental Protection Agency. ND. Accessed September 14, 2022. Overview of Greenhouse Gasses. <https://www.epa.gov/ghgemissions/overview-greenhouse-gases>
- 9 European Industrial Hemp Association. 2021. Fibre Hemp Supply Chain. Unpublished.
- 10 Plant and Soil. 2008. Characterization of Hemp (Cannabis Sativa L.) Roots Under Different Growing Conditions. <https://doi.org/10.1007/s1104-008-9695-0>
- 11 Journal of the International Hemp Association. 1999. A comparison of the biodiversity friendliness of crops with special reference to hemp (Cannabis sativa L.). <http://www.internationalhempassociation.org/jiha/jiha6206.html>
- 12 Rodale Institute. January 20, 2020. Industrial Hemp Trial – Year 3 Results. <https://rodaleinstitute.org/science/articles/industrial-hemp-trial-year-3-results/>
- 13 United Nations Conference on Trade and Development (UNCTAD). 2022. Commodities at a Glance: Special Issue on Hemp. https://unctad.org/system/files/official-document/ditccom2022d1_en.pdf
- 14 United Nations Environment Programme. ND. Highly Hazardous Pesticides. <https://www.unep.org/explore-topics/chemicals-waste/what-we-do/emerging-issues/highly-hazardous-pesticides-hhps> and Pesticide Action Network International. 2021. PAN International List of Highly Hazardous Pesticides. <https://www.pan-uk.org/site/wp-content/uploads/PAN-HHP-List-2021.pdf>
- 15 US Department of Agriculture National Agricultural Statistics Services. ND. Quick Stats. <https://quickstats.nass.usda.gov/>
- 16 United Nations Environment Programme. ND. Highly Hazardous Pesticides. <https://www.unep.org/explore-topics/chemicals-waste/what-we-do/emerging-issues/highly-hazardous-pesticides-hhps> and Pesticide Action Network International. 2021. PAN International List of Highly Hazardous Pesticides. <https://www.pan-uk.org/site/wp-content/uploads/PAN-HHP-List-2021.pdf>
- 17 Molecules. 2020. Industrial Hemp (Cannabis sativa subsp. sativa) as an Emerging Source for Value-Added Functional Food Ingredients and Nutraceuticals. <https://www.mdpi.com/1420-3049/25/18/4078>
- 18 Hemp Business Journal. 2019. The Global State of Hemp: 2019 Global Industry Outlook. <https://cdn2.hubspot.net/hubfs/3324860/NFD-TheGlobalStateofHemp-ES.pdf>
- 19 Oecotextiles. 2010. Characteristics of Hemp. <https://oecotextiles.blog/2010/06/02/characteristics-of-hemp/>
- 20 Federation of International Hemp Organizations. ND. About Hemp. <https://fiho.org/about-hemp/>
- 21 Fibershed. 2019. Hemp Production: Review of Literature with Specified Scope. <http://fibershed.org/wp-content/uploads/2019/01/hemp-literature-review-Jan2019.pdf>
- 22 US Congressional Research Service. March 22, 2019. Defining Hemp: A Fact Sheet. <https://fas.org/sgp/crs/misc/R44742.pdf>
- 23 University of Missouri Extension. December 2019. Value Chains for the Missouri Industrial Hemp Industry. <https://extension.missouri.edu/publications/mx76>
- 24 US Department of Agriculture, Foreign Agriculture Service. February 24, 2020. 2019 Hemp Annual Report: China. <https://www.fas.usda.gov/data/china-2019-hemp-annual-report>
- 25 Congressional Research Service. June 22, 2018. Hemp as an agricultural commodity. <https://fas.org/sgp/crs/misc/RL32725.pdf>
- 26 Fabric Link. ND. Accessed August 4, 2021. Fiber University: Hemp fiber characteristics. <https://www.fabriclink.com/University/Hemp.cfm>
- 27 Council of Fashion Designers of America (CFDA). ND. Accessed October 1, 2021. Hemp. <https://cfda.com/resources/materials/detail/hemp>
- 28 US Department of Agriculture National Agricultural Statistics Services. ND. Quick Stats. <https://quickstats.nass.usda.gov/>
- 29 Hemp Industry Daily. May 7, 2018. Myth-busting: Hemp needs more water than many think. <https://hempindustrydaily.com/myth-busting-hemp-needs-more-water-than-many-think/>
- 30 European Environment Agency. 2007. Estimating the Environmentally Compatible Bioenergy Potential from Agriculture. https://www.eea.europa.eu/publications/technical_report_2007_12
- 31 European Environment Agency. 2007. Estimating the Environmentally Compatible Bioenergy Potential from Agriculture. https://www.eea.europa.eu/publications/technical_report_2007_12 and Nova Institute. 2011. Ecological Benefits of Hemp and Flax Cultivation and Products. https://eiha.org/media/attach/643/11-05-13_Ecological_benefits_of_hemp_and_flax.pdf
- 32 Stockholm Environment Institute. 2005. Ecological Footprint and Water Analysis of Cotton, Hemp and Polyester. <https://mediamanager.sei.org/documents/Publications/SEI-Report-EcologicalFootprintAndWaterAnalysisOfCottonHempAndPolyester-2005.pdf>
- 33 Nova Institute. 2011. Ecological Benefits of Hemp and Flax Cultivation and Products. https://eiha.org/media/attach/643/11-05-13_Ecological_benefits_of_hemp_and_flax.pdf
- 34 US Department of Agriculture, Foreign Agriculture Service. February 24, 2020. 2019 Hemp Annual Report: China. <https://www.fas.usda.gov/data/china-2019-hemp-annual-report>
- 35 Rodale Institute. January 20, 2020. Industrial Hemp Trial – Year 3 Results. <https://rodaleinstitute.org/science/articles/industrial-hemp-trial-year-3-results/>
- 36 MDPI. 1995. Industrial Hemp (Cannabis sativa L.) Agronomy and Utilization: A Review. <https://www.mdpi.com/2073-4395/13/3/931>

- 37 Biomass and Bioenergy. 2019. Bee diversity and abundance on flowers of industrial hemp (*Cannabis sativa* L.). https://www.researchgate.net/publication/331022395_Bee_diversity_and_abundance_on_flowers_of_industrial_hemp_Cannabis_sativa_L_2019_Biomass_and_Bioenergy_122_331-335
- 38 Environmental Entomology. 2020. The Bee Community of *Cannabis sativa* and Corresponding Effects of Landscape Composition. <https://pubmed.ncbi.nlm.nih.gov/31789341/>
- 39 Cornell College of Agricultura and Life Sciences. ND. Hemp and Bees: Field Hemp as a Pollen Source for Bees in the NYS Landscape. <https://hemp.cals.cornell.edu/resource/hemp-and-bees-pollen-source-nys-landscape/>
- 40 Plant Soil. 2008. Characterization of Hemp (*Cannabis sativa* L.) Roots Under Different Groing Conditions. <https://doi.org/10.1007/s1104-008-9695-0>
- 41 Chemistry Proceedings. 2022. Benefits of Cultivating Industrial Hemp (*Cannabis sativa* ssp. *sativa*)—A Versatile Plant for a Sustainable Future. <https://www.mdpi.com/2673-4583/10/1/14>
- 42 Journal of the International Hemp Association. 1999. A Comparison of the Biodiversity Friendliness of Crops with Special Reference to Hemp (*Cannabis sativa* L.). <http://www.internationalhempassociation.org/jiha/jiha6206.html>
- 43 Plants. 2022. Potential of Industrial Hemp for Phytoremediation of Heavy Metals. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8912475/>
- 44 Industrial Hemp Association. May 16. 2023. Personal Communication.
- 45 European Industrial Hemp Association. May 4, 2023. Personal Communication.
- 46 North Carolina State. February 2021. Hemp Fertility - Field and Greenhouse. <https://hemp.ces.ncsu.edu/hemp-fertility/>
- 47 US Department of Agriculture. February 17, 2022. National Hemp Report. <https://downloads.usda.library.cornell.edu/usda-esmis/files/gf06h2430/xd07hw825/v692v917t/hempan22.pdf>
- 48 North Carolina Department of Agriculture and Consumer Services. 2016. Crop Fertilization Based on North Carolina Soil Tests. <https://www.ncagr.gov/agronomi/obt23f.htm>
- 49 International Hemp. ND. Industrial Hemp Farming 101. <https://www.international-hemp.com/blog/2020/3/4/industrial-hemp-farming-101>
- 50 Terres Innovia. 2020. Hemp – Grow Guide 2020. <https://www.terresinnovia.fr/o/commerce-media/products/454195/guide-chanvre/453714/Guide%20de%20culture%20chanvre%202020.pdf>
- 51 US Department of Agriculture. ND. Fertilizers and Pesticides. <https://www.ers.usda.gov/topics/farm-practices-management/fertilizers-pesticides/>
- 52 US Department of Agriculture. 2007. Nitrogen Efficiency and Management. <https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=18563.wba>
- 53 Naturefood. July 15, 2021. Quantification of Global and National Nitrogen Budgets for Crop Production. <https://www.nature.com/articles/s43016-021-00318-5>
- 54 US Department of Agriculture. 2007. Nitrogen Efficiency and Management. <https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=18563.wba>
- 55 United Nations Environment Programme. 2023. Four Reasons Why the World Needs to Limit Nitrogen Pollution. <https://www.unep.org/news-and-stories/story/four-reasons-why-world-needs-limit-nitrogen-pollution>
- 56 Rodale Institute. 2023. Growing Hemp as a Multipurpose Crop in Organic Cropping Systems. <https://www.youtube.com/watch?v=Czafdhayk20> and Personal Communication. May 5, 2023.
- 57 Journal of the International Hemp Association. 1999. A Comparison of the Biodiversity Friendliness of Crops with Special Reference to Hemp (*Cannabis sativa* L.). <http://www.internationalhempassociation.org/jiha/jiha6206.html>
- 58 United Nations Global Compact. ND. The Ten Principles of the UN Global Compact. <https://unglobalcompact.org/what-is-gc/mission/principles/principle-7>
- 59 US Environmental Protection Agency. ND. Pesticides’ Impact on Air Quality. <https://www.epa.gov/indoor-air-quality-iaq/pesticides-impact-indoor-air-quality>
- 60 World Health Organization. 2020. Chemical Safety: Pesticides. <https://www.who.int/news-room/questions-and-answers/item/chemical-safety-pesticides>
- 61 US Environmental Protection Agency. ND. Tips for Reducing Pesticide Impacts on Wildlife. <https://www.epa.gov/safepestcontrol/tips-reducing-pesticide-impacts-wildlife>
- 62 US Geological Survey. June 5, 2018. Pesticides in Groundwater. <https://www.usgs.gov/special-topics/water-science-school/science/pesticides-groundwater>
- 63 US Environmental Protection Agency. ND. Introduction to Pesticide Drift. <https://www.epa.gov/reducing-pesticide-drift/introduction-pesticide-drift>
- 64 US Environmental Protection Agency. 2022. What are Soil Fumigants? <https://www.epa.gov/soil-fumigants/what-are-soil-fumigants>
- 65 Textile Exchange. 2022. Regenerative Agriculture Landscape Report. <https://textileexchange.org/app/uploads/2022/01/Regenerative-Agriculture-Landscape-Analysis.pdf>
- 66 Higg. 2021. Higg MSI FAQ. <https://howtohigg.org/higg-msi/faq/>
- 67 Textile Exchange. September 15, 2022. Personal communication with Dr. David Suchoff, North Carolina State University.
- 68 European Commission. 2012. Product Environmental Footprint (PEF) Guide: Annex X. <https://ec.europa.eu/environment/eussd/pdf/footprint/PEF%20methodology%20final%20draft.pdf>
- 69 UN Fashion Industry Charter for Climate Action. April 2021. Identifying Low Carbon Sources of Cotton and Polyester Fibers (figure 28). https://unfccc.int/sites/default/files/resource/UCC_Cotton_Pet_report.pdf
- 70 Textile Exchange. 2022. Regenerative Agriculture Landscape Analysis. <https://textileexchange.org/knowledge-center/reports/regenerative-agriculture-landscape-analysis/>
- 71 European Commission. 2012. Product Environmental Footprint (PEF) Guide. <https://ec.europa.eu/environment/eussd/pdf/footprint/PEF%20methodology%20final%20draft.pdf>
- 72 Textile Exchange. 2022. The Sustainability of Biosynthetics Report (adapted from Figure 1). https://textileexchange.org/app/uploads/2022/05/Textile-Exchange_The-Sustainability-of-Biosynthetics.pdf
- 73 United Nations Conference on Trade and Development (UNCTAD). 2022. Commodities at a Glance: Special Issue on Hemp. https://unctad.org/system/files/official-document/ditccom2022d1_en.pdf
- 74 ABC News. October 24, 2022. Hemp industry gears for ‘game-changing’ growth after easing of regulation gives green light to farmers. <https://www.abc.net.au/news/rural/2022-10-25/hemp-industry-growth-regulation-changes/101568960>

- 75 Farmers Review Africa. December 8, 2022. Africa's cannabis industry sees significant growth. <https://farmersreviewafrica.com/africas-cannabis-industry-sees-significant-growth-report/>
- 76 Food and Agriculture Organization of the United Nations. Accessed April 7, 2023. FAOSTAT. <https://www.fao.org/faostat/en/#data/QCL>
- 77 US Department of Agriculture. 2022. National Hemp Report. <https://usda.library.cornell.edu/concern/publications/gf06h2430?locale=en>
- 78 Turkish Statistics Institution. April 2023. Production of Cereals and Other Crops. <https://data.tuik.gov.tr/Search/Search?text=kenevir>
- 79 US Department of Agriculture. 2022. National Hemp Report. <https://usda.library.cornell.edu/concern/publications/gf06h2430?locale=en>
- 80 US Department of Agriculture. 2023. USDA Issues First National Hemp Report. <https://www.ams.usda.gov/press-release/usda-issues-first-national-hemp-report>
- 81 Food and Agriculture Organization of the United Nations. Accessed April 7, 2023. FAOSTAT. <https://www.fao.org/faostat/en/#data/QCL>
- 82 United States Department of Agriculture. April 19, 2023. National Hemp Report. <https://release.nass.usda.gov/reports/hempan22.pdf>
- 83 Food and Agriculture Organization of the United Nations. Accessed April 7, 2023. FAOSTAT. <https://www.fao.org/faostat/en/#data/QCL>
- 84 United States Department of Agriculture Foreign Agriculture Service. August 03, 2021. Industrial Hemp in France. https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Industrial%20Hemp%20in%20France_Paris_France_07-31-2021.pdf
- 85 United States Department of Agriculture Foreign Agriculture Service. August 03, 2021. Industrial Hemp in France. https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Industrial%20Hemp%20in%20France_Paris_France_07-31-2021.pdf
- 86 InterChanvre. 2022. Miser sur le Chanvre Pour Une Economie Performante et Décarbonée. https://normandie.chambres-agriculture.fr/fileadmin/user_upload/Normandie/506_Fichiers-communs/PDF/FILIERES/2022-03_InterChanvre.pdf
- 87 United States Department of Agriculture Foreign Agriculture Service. August 03, 2021. Industrial Hemp in France. https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Industrial%20Hemp%20in%20France_Paris_France_07-31-2021.pdf
- 88 Interchanvre. 2020. Le Chanvre: Une Culture « Verte » Incroyable. https://www.interchanvre.org/documents/1.Interchanvre/202005_PPT_Le%20Chanvre.pdf; and Interchanvre. 2022. Quelle Solution Pour Obtenir la Neutralité Carbone? https://www.interchanvre.org/documents/congres_all_hemp/2022-05-30_Tables_rondes_AM.pdf
- 89 US Department of Agriculture Foreign Agriculture Service. February 24, 2020. 2019 Hemp Annual Report: China. <https://www.fas.usda.gov/data/china-2019-hemp-annual-report>
- 90 Food and Agriculture Organization of the United Nations. ND. Accessed April 7, 2023. FAOSTAT. <https://www.fao.org/faostat/en/#data/QCL>
- 91 US Department of Agriculture Foreign Agriculture Service. February 24, 2020. 2019 Hemp Annual Report: China. <https://www.fas.usda.gov/data/china-2019-hemp-annual-report>
- 92 New Frontier Data. July 24, 2019. After a 5,000-Year Tradition, China Taking a New Look at Hemp's Potential. <https://newfrontierdata.com/cannabis-insights/after-a-5000-year-tradition-china-taking-a-new-look-at-hemp-potential/>
- 93 Food and Agriculture Organization of the United Nations. Accessed April 7, 2023. FAOSTAT. <https://www.fao.org/faostat/en/#data/QCL> and United Nations Conference on Trade and Development (UNCTAD). 2023. Personal Communication with Marco Fugazza. May 16, 2023.
- 94 United States Department of Agriculture. ND. Accessed April 12, 2022. Farm Bill. <https://www.usda.gov/farmbill>
- 95 United States Department of Agriculture. April 19, 2023. National Hemp Report. <https://release.nass.usda.gov/reports/hempan22.pdf>
- 96 United States Department of Agriculture. February 17, 2022. National Hemp Report. <https://downloads.usda.library.cornell.edu/usda-esmis/files/gf06h2430/76538f824/w9506f61g/hempan23.pdf>
- 97 La Prensa Latina. May 27, 2022. Argentina enters cannabis, hemp market in hope to recover economy. <https://www.laprensa-latina.com/argentina-enters-cannabis-hemp-market-in-hope-to-recover-economy/>
- 98 United States Department of Agriculture Foreign Agriculture Service. January 04, 2022. 2021 Colombia Hemp Annual Report. https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=2021%20Colombia%20Hemp%20Annual%20Report%20%20_Bogota_Colombia_12-29-2021.pdf
- 99 Hemp Today. September 15, 2023. <https://hemptoday.net/simple-costa-rican-hemp-rules-set-thc-limit-at-1-0-make-licenses-widely-available/> and The Tico Times. November 6, 2022. Costa Rica Authorizes First Hemp Plantation. <https://ticotimes.net/2022/11/06/costa-rica-authorizes-first-hemp-plantation>
- 100 Hemp Benchmarks. February 02, 2022. The Latin American Hemp Market: A Work in Progress with Great Potential. <https://www.hempbenchmarks.com/hemp-market-insider/the-latin-american-hemp-market/>
- 101 Latin America Industrial Hemp Association. June 28, 2023. Personal Communication.
- 102 Hemp Benchmarks. February 02, 2022. The Latin American Hemp Market: A Work in Progress with Great Potential. <https://www.hempbenchmarks.com/hemp-market-insider/the-latin-american-hemp-market/>
- 103 Turkish Statistics Institution. April 2023. Production of Cereals and Other Crops. <https://data.tuik.gov.tr/Search/Search?text=kenevir>
- 104 Independent. October 16, 2016. Turkey Legalizes Controlled Cannabis Production in 19 Provinces. <https://www.independent.co.uk/news/world/europe/turkey-legalises-controlled-cannabis-production-19-provinces-a7364026.html> and Resmi Gazete. September 29, 2016. Marijuana Cultivation and Control. <https://www.resmigazete.gov.tr/eskiler/2016/09/20160929-3.htm>
- 105 United States Department of Agriculture Foreign Agriculture Service. August 03, 2021. Industrial Hemp in France. https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Industrial%20Hemp%20in%20France_Paris_France_07-31-2021.pdf

- 106 Squire Patton Boggs. January 9, 2023. Highest French Administrative Court Lifts the Ban on CBD Flowers and Leaves. <https://www.triagehealthlawblog.com/cannabis-hemp/highest-french-administrative-court-lifts-the-ban-on-cbd-flowers-and-leaves/>
- 107 US Department of Agriculture Foreign Agriculture Service. February 24, 2020. 2019 Hemp Annual Report: China. <https://www.fas.usda.gov/data/china-2019-hemp-annual-report>
- 108 Congressional Research Service. June 22, 2018. Hemp as an agricultural commodity. <https://fas.org/sgp/crs/misc/RL32725.pdf>
- 109 Congressional Research Service. June 22, 2018. Hemp as an agricultural commodity. <https://fas.org/sgp/crs/misc/RL32725.pdf>
- 110 US Environmental Protection Agency. ND. What is a Pesticide? <https://www.epa.gov/minimum-risk-pesticides/what-pesticide>
- 111 US Environmental Protection Agency. July 18, 2022. Basic Information About Pesticide Ingredients. <https://www.epa.gov/ingredients-used-pesticide-products/basic-information-about-pesticide-ingredients#active>
- 112 US Environmental Protection Agency. 2015. Inert Ingredient Frequently Asked Questions. <https://www.epa.gov/sites/default/files/2015-12/documents/faqs.pdf>
- 113 US Environmental Protection Agency. 2010. Inerts in Pesticides Allowed for Use in Organic Production. <https://www.ams.usda.gov/sites/default/files/media/NOP%20Final%20Rec%20on%20Inerts%20in%20Pesticides.pdf>
- 114 US Environmental Protection Agency. September 14, 2022. Inert Ingredients Overview and Guidance. <https://www.epa.gov/pesticide-registration/inert-ingredients-overview-and-guidance>
- 115 US Environmental Protection Agency. 2022. Pesticide Products Registered for Use on Hemp. <https://www.epa.gov/pesticide-registration/pesticide-products-registered-use-hemp>
- 116 UK Health Safety Executive. March 19, 2023. Plant Protection Products with Authorization for use in Great Britain and Northern Ireland. <https://secure.pesticides.gov.uk/pestreg/ProdSearch.asp>
- 117 US Department of Agriculture Foreign Agriculture Service. February 24, 2020. 2019 Hemp Annual Report: China. <https://www.fas.usda.gov/data/china-2019-hemp-annual-report>
- 118 China Pesticide Information Network, Institute Control of Chemicals, Ministry of Agriculture. Personal communication. September 5, 2022.
- 119 United Nations Environment Programme. ND. Highly Hazardous Pesticides. <https://www.unep.org/explore-topics/chemicals-waste/what-we-do/emerging-issues/highly-hazardous-pesticides-hhps> and Pesticide Action Network International. 2021. PAN International List of Highly Hazardous Pesticides. <https://www.pan-uk.org/site/wp-content/uploads/PAN-HHP-List-2021.pdf>
- 120 China Pesticide Information Network, Institute Control of Chemicals, Ministry of Agriculture. Personal communication. September 5, 2022. <http://www.chinapesticide.org.cn> and Agropages. ND. China Pesticide Registration Watch. Accessed September 1, 2022. <https://data.agropages.com/>
- 121 ANSES. ND. Accessed March 19, 2023. E-Phy. <https://ephy.anses.fr/>
- 122 World Health Organization. 2020. The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification, 2019 edition. <https://apps.who.int/iris/bitstream/handle/10665/332193/9789240005662-eng.pdf>
- 123 Pesticide Action Network International. 2021. PAN International List of Highly Hazardous Pesticides. <https://www.pan-uk.org/site/wp-content/uploads/PAN-HHP-List-2021.pdf>
- 124 Interchanvre. 2020. Charte d'engagement du Label Chenevis Francais. https://interchanvre.org/documents/5.actu_presse/documents_de_reference/202002_Charte_label_chenevis_francais.pdf and Alliance for Flax-Linen and Hemp. July 13, 2023. Personal communication.
- 125 Republic of Turkey, Ministry of Food, Agriculture, and Livestock. ND. Accessed April 11, 2023. Plant Protections Product Database. <https://bku.tarimorman.gov.tr/Kullanım/TavsiyeAlternatif?csrt=3462561088005179350>
- 126 Health and Safety Executive. ND. Accessed March 17, 2023. Plant Protection Products with Authorisation for use in Great Britain and Northern Ireland. <https://secure.pesticides.gov.uk/pestreg/prodsearch.asp>
- 127 Department for Environment, Food & Rural Affairs, Health and Safety Executive, and Victoria Prentis. September 18, 2020. Outdoor use of metaldehyde to be banned to protect wildlife. <https://www.gov.uk/government/news/outdoor-use-of-metaldehyde-to-be-banned-to-protect-wildlife>
- 128 United States Environmental Protection Agency. April 13, 2023. Pesticide Products Registered for Use on Hemp. <https://www.epa.gov/pesticide-registration/pesticide-products-registered-use-hemp>
- 129 Cornell CAL. N/A. 2022 Weeds and Weed Management. <https://hemp.cals.cornell.edu/resources/reports-factsheets/2022-cornell-hemp-field-day-handouts/2022-weeds-and-weed-management/> and Greenhouse Product News. August 20, 2022. <https://gpnmag.com/news/scientists-focus-on-weed-control-to-support-hemp-market/>
- 130 EUR-Lex. ND. Safe and Effective Fertilizer Products on the EU Market. <https://eur-lex.europa.eu/EN/legal-content/summary/safe-and-effective-fertilising-products-on-the-eu-market.html>
- 131 UCLA Institute of Environment and Sustainability. 2020. Carbon Sequestration Through Compost. <https://www.ioes.ucla.edu/project/carbon-sequestration-through-compost/>
- 132 International Hemp. 2023. The Process of Turning Hemp Fiber into Apparel. <https://www.international-hemp.com/blog/2023/3/24/the-processing-of-turning-hemp-fiber-into-apparel>
- 133 Bast Fibre Technology. Personal Communication. April 17, 2022.
- 134 Global Organic Textile Standard gGmbH. 2021. First Processing Stages. <https://global-standard.org/certification-and-labelling/who-needs-to-be-certified/first-processing-stages>; and Textile Exchange. July 13, 2020. Organic Content Standard 3.0 User Manual. <https://textileexchange.org/app/uploads/2021/02/OCS-201-V3.1-OCS-User-Manual.pdf>
- 135 Global Organic Textile Standard. March 1, 2020. Global Organic Textile Standard (GOTS) Version 6.0. https://global-standard.org/images/resource-library/documents/standard-and-manual/gots_version_6_0_en1.pdf
- 136 Alliance for European Flax-Linen and Hemp. 2023. Personal Communication and Directory of European Flax™ and Masters of Linen™ certified companies. <https://news.europeanflax.com/en/directory-certified-companies>
- 137 Alliance for European Flax-Linen and Hemp. 2023. Flax Growing and Expertise. <https://news.europeanflax.com/en/flax-growing-expertise>
- 138 PanXchange. 2022. US Industrial Hemp Fiber Processor Capacity Margins Report. <https://panxchange.com/us-industrial-hemp-fiber-processor-capacity-margins-report/> and May 24, 2023. Personal Communication

- 139 Sourcing Journal. February 23, 2023. Here's Why These Brands Are Leaning Into Natural Fibers. <https://sourcingjournal.com/topics/lifestyle-monitor/cotton-incorporated-natural-fibers-eileen-fisher-madewell-pacsun-fashion-418927/>
- 140 IFOAM. ND. Definition of Organic Agriculture. <https://www.ifoam.bio/en/organic-landmarks/definition-organic-agriculture>
- 141 IFOAM. ND. IFOAM Family of Standards. <https://www.ifoam.bio/our-work/how/standards-certification/organic-guarantee-system/ifoam-family-standards>
- 142 IFOAM. 2014. The IFOAM Norms for Organic Production and Processing. <https://www.ifoam.bio/sites/default/files/2020-09/IFOAM%20Norms%20July%202014%20Edits%202019.pdf>
- 143 Textile Exchange. 2021. Organic Cotton Market Report. https://textileexchange.org/wp-content/uploads/2021/07/Textile-Exchange_Organic-Cotton-Market-Report_2021.pdf
- 144 The Organic Center. March 2020. Organic Farming Practices for Improving Soil Health. https://www.organic-center.org/sites/default/files/project/2020/03/soil-health-review_shadetully.pdf
- 145 The Organic Center. April 9, 2020. Organic agriculture – the recycling bin for nitrogen. <https://www.organic-center.org/research/press-release-organic-agriculture-%E2%80%93-recycling-bin-nitrogen>
- 146 US Environmental Protection Agency. ND. Accessed August 17, 2020. Sources of Greenhouse Gas Emissions. <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions#agriculture>
- 147 Preferred by Nature. December 15, 2021. Sustainability Programme Terms and Definitions (v 1.2). <https://preferredbynature.org/sites/default/files/sustainability-framework/SP-09%20SF%20Terms%20%26%20Definitions%20V1.2.pdf>
- 148 Preferred by Nature. April 2022. Sustainability Framework V1.23. <https://preferredbynature.org/library/standard/sustainability-framework>
- 149 Preferred by Nature. April 2022. Sustainability Framework V1.23. <https://preferredbynature.org/library/standard/sustainability-framework>
- 150 Textile Exchange. 2020. 2025 Sustainable Cotton Challenge: Second Annual Report 2020. https://textileexchange.org/app/uploads/2021/05/2025_Sustainable-Cotton-Challenge-Report_20201.pdf
- 151 ISCC. 2021. Agricultural Biomass: ISCC Principle 1. https://www.iscc-system.org/wp-content/uploads/2022/05/ISCC_EU_202-1_Agricultural-Biomass_ISCC-Principle-1-v4.0.pdf and ISCC. 2021. Agricultural Biomass: ISCC Principle 2-6. https://www.iscc-system.org/wp-content/uploads/2022/08/202_2_Agricultural-Biomass_ISCC-Principles-2-6_v1.1_August_2.pdf
- 152 Food and Agriculture Organization of the United Nations. ND. Accessed April 7, 2023. FAOSTAT. <https://www.fao.org/faostat/en/#data/QCL>