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Diversity and use of fibre plants in tropical South America

BACHELOR'S THESIS

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Declaration

I hereby declare that I have done this thesis entitled Diversity and use of fibre plants in tropical South America independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTZ.

In Prague 17.04.2024

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Abstract

Fibre plants have been playing an important role in our lives for a long time now. They are utilised in a wide range of industries, such as textile manufacture, cordage production, weaving, paper making, and many others. They are really flexible, cohesive, and strong, but their full potential has not been explored yet. Many people do not know about their other great advantages, like their biodegradability or recyclability. Numerous underutilised plant species exist that have a lot of potential as substitutes for the main crops. These substitute can be more sustainable and environmentally friendly.

This thesis summarised the main uses of fibre plants, focusing on the regions of tropical South America. It explained their ethnobotanical use as well as the economic profit for the local people. Afterwards, the two biggest families of underutilised crops that originated in South America were briefly described. Sadly, there is not that much information about them till this day. They should be more explored and researched in the field of fibre use. Then two tables that illustrate some examples of underutilised fibre plants were provided. It mentions their scientific names as well as their vernacular names, along with their origin and use.

The information was collected from many online databases, including Google Scholar, Web of Science, and Scopus, as well as from printed books like Prosea.

Key words: agrobiodiversity, agroecology, economic botany, industrial crops, natural fibres, Neotropics, plant fibres, tropical crops

Contents

List of tables

List of figures

1. Introduction

1.1 Location of South America

South America is located between 12° northern latitude and 56°southern latitude, 35° western longitude and 81°eastern longitude. It borders with the Atlantic Ocean on the east, the Pacific Ocean on the west and the Caribbean Sea to the northwest. It is geographically defined by the Andes, which stretch along its western edge, shaping South American landscapes and climate. The Amazon basin covers a significant part of this continent's landmass, which is why South America has one of the world´s largest tropical rainforests (Dobrovolná & Tomeš 1998).

Geologically, South America is formed by the South American lithospheric plate, and at the core of continent is the Brazilian platform. The Caribbean Plate makes the connection to Central America.

South America, with a total surface area of around 17.84 million square kilometres, is the fourth biggest continent in the world. The length of the coast is 27,800 km. Isthmus of Panama makes the connection between North and South America. Its region is made up of a variety of landscapes, such as dry deserts, mountains, grasslands, and dense tropical rainforests (Mrázková 2008).

The surface is mostly made up of lowlands and the relief is overall relatively simple. Towards the southern tip of the continent, the landscape transforms into rough terrain with glaciers, fjords, and plains, characterising regions such as Patagonia (Dobrovolná & Tomeš 1998). The Andes are the largest mountain range, continuing from the North American Cordilleras. The lowlands of the Amazon River and its feeders split the Brazilian-Guianan highland in the centre of the continent. The Gran Bajo de Julián depression in Argentina is the lowest point, while the highest mountain is Aconcagua, which is situated in the Andes of Chile (Mrázková 2008).

Figure 1. Physical Map of South America (Cia.gov, 2020)

1.2. Population of South America

After the discovery of South America, immigrants arrived from all over Europe. They were mainly Spaniards and Portuguese, later also Brits and French. The arrival of the new population led slowly to the extinction of the original indigenous people (Mrázková 2008). With more than 430 million inhabitants, South America is currently the fourth-most populated continent worldwide. Across the continent, there are significant differences in population density. Densely populated urban centres contrasting with sparsely inhabited rural areas (Worldometer 2024).

One of the most notable aspects of South America´s population is its diversity, both in terms of ethnicity and culture. Native Americans, European colonists, and recent immigrants from Asia and the Middle East may all be found here (Dobrovolná & Tomeš 1998). For thousands of years, indigenous peoples like the Quechua, Aymara, and Guarani have lived in South America and have managed to retain their own languages, customs, and ways of life (Rivera & Ødegaard 2019).

1.3. Climate of South America

In South America we can find a wide range of climates. The majority of the continent lies within the equatorial and tropical climatic zones. Only in the southern regions of the continent, there is a temperate climate, in some other places we can also find a subtropical climate. Because of the Andes, which neutralise the effect of the Pacific Ocean, the majority of the land is impacted by the Atlantic Ocean (Mrázková 2008).

Near the equator, in places like the Amazon Basin, there is a hot and humid equatorial climate. It is characterised by high temperatures and abundant rainfall throughout the year, with Columbia being the state with the biggest precipitation. Generally, the temperature amplitude is minimal. Moving away from the equator, tropical climates predominate. We can see both wet and dry seasons in these regions, with heavy rainfall during the wet season and drier conditions in the dry season. There are significant temperature amplitudes, even up to forty degrees. A subtropical climate prevails in the southern and central regions of South America. It is defined by four distinct seasons. Summers are mostly very warm and hot, while winters can be cool with occasional frosts. Even further south is a temperate climate, which we can split into arid continental and humid oceanic. The climates of the highlands and the desert are the final two (Dobrovolná & Tomeš 1998). The Andes have a major impact on South America's climate; they are something like a climatic wall. To the west there are dry conditions, to the east there are moist conditions (Compagnucci et al. 2009). Mountainous regions may experience snowfall during the winter months. On the other side is the Atacama Desert, which is one of the driest places on Earth. It is distinguished by exceptionally dry weather and little precipitation (Dobrovolná & Tomeš 1998; Mrázková 2008).

The southern oscillation El Niño affects the climate as well. It directly and strongly affects Ecuador´s coast, Peru, and northern Chile (Campagnucci et al. 2009). This oscillation is a result of interactions between the atmosphere and ocean, and it involves the whole Pacific basin. El Niño events are changing the sea-surface temperature, which makes them warmer or colder than average (Benjamin et al. 2020).

1.4. Ecosystems of South America

South America has some of the most diverse and complex ecosystems on the planet. We can find tropical rainforests, expansive grasslands, mountains, arid deserts, and even coastal mangroves here (Dobrovolná & Tomeš 1998).

The tropical rainforests that are found across the whole Amazon lowland region extend even into the southern parts of the Guianan highlands and the northern parts of the Brazilian highlands. In Brazil, they use the term “selvas” or “hylea” for these forests. They are full of vines and have a rich diversity of species living there, which are adapted to a humid and warm climate. With the biggest trees growing to a height of more than fifty-five metres, we can observe numerous layers. In the floded lowlands of the Amazon River, palms, known as "igapo," dominate (Mrázková 2008).

The Andes, the Atacama Desert, or Patagonia, are home to the grasslands, or Pampas. They are resistant to high altitudes and arid environments (Anjos & de Toledo 2018). Loess and deposits of loess distinguish these extensive flat landscapes. The grasslands of the Pampas are made up of the arid steppes of the moderate continental climate to the east known as dry pampas, and the wet temperate prairies, referred to as humid pampas, to the west (Prado et al. 2015).

The savannas in the tropical belt are affected by seasonal rainfall. They are referred to as "llanos" in the Orinoco River basin and as "campos" in Brazil. Usually grassy, this region is dotted with cacti and plants. Wildfires occur often in the dry season. They are frequently utilised as arable land or as sheep and cattle grazing areas (Mrázková 2008).

The best representation of South America's dry and semi-arid ecosystems may be found in the desserts. The Atacama and Peruvian Deserts are the two most well-known of all (Veblen et al. 2015). They are found in areas with practically no rainfall, for example the western slopes of the Andes and the western coast of the Pacific Ocean. The only source of water for the Atacama Desert is coastal fog (Mrázková 2008).

1.5. Agrobiodiversity and agriculture of South America

Just fifteen percent of the whole continent is made up of arable land. It is so because of the weather and the topography of the area. The amount of arable land did not expand due to outdated and primitive farming methods. Traditionally, tilling the ground in rural farming regions was done by hand without the use of machines. This technique still remains common among the native people in Peru and Bolivia. The Spanish brought new techniques that were typical for them, such as plantation farming with monoculture (Mrázková 2008).

South America is known for its large biodiversity. Many crops thrive in South America's tropical climate. For example, cashews and Brazil nuts are cultivated here. In addition, avocado, papaya, pineapple, and guava are native to tropical South America. The two main cash crops that are grown are cacao and coffee. Brazil was even one of the world's top suppliers of cacao, before a fungus spread in 2000. Till this day, it remains the world's largest exporter of coffee. South America´s moderate climates support various industrial crops and livestock, such as corn or soybeans in the Pampas (Boudreau et al. 2023).

These and many other crops contribute to South America's rich agrobiodiversity and provide a wide range of food options for the local people. Nevertheless, it's crucial to highlight that agrobiodiversity faces risks from issues like climate change, overexploitation, and the cultivation of monoculture crops (Zimmerer & de Haan 2020).

2. Aims of the Thesis

The goal of the thesis was to provide an overview of species of fibre plants, their biodiversity, ecology, and indigenous and industrial uses in the region of tropical South America. The literature review analysed the biodiversity of major fibre crops as well as neglected and underutilised fibre crop species. It focused on native and naturalized species in the region constituting essential components of local agriculture systems or providing products with promising economic value.

The main information and species were described in two structured tables. It gave the common names as well as the vernacular names, origins, and main uses. Later, the two main families that originated in tropical America were named and described.

3. Methodology

The main goal of the thesis was to provide a broad overview of the many varieties and applications of fibre plants. The focus was on the main crops as well as the underutilised ones.

The target plant species were analysed according to their geographic origin and distribution, taxonomy, ethnobotanical importance, and agroecological aspects of their production.

The thesis was a qualitative, systematic literature review. It consisted of a comprehensive information search through scientific literature online databases, primarily the Web of Science, PROTA4U, Scopus, ScienceDirect, and Google Scholar, and taxonomic databases, for example, The World Flora Online. The printed books were also an important source, especially The Plant Resources of Southeast Asia or The Cultivated Plants of the Tropics and Subtropics.

The combination of keywords such as “Fibre plants”, “Tropical South America”, “Tropical crops”, “Natural fibres”, “Industrial crops”, “Agrobiodiversity”, “Agroecology”, “Economic botany”, “Neotropics”, “Use of fibres”, “Textile production”, “Underutilised fibres”, and many more, were used to improve the search for information.

4. Literature Review

4.1. Definition of fibres

Fibres in general are very strong, cohesive, and flexible thin strands. Both natural and synthetic materials can be used to produce them. It is a kind of plant cell with a thicker wall, which strengthens the plant tissue. Fibre plants are cultivated primarily for the purpose of harvesting their fibres (Brink & Escobin 2003).

4.1.1. Natural fibres

Natural fibres are those that are created by plants, geological processes, and animals. Another name for them is cellulosic fibres (Ali 2012). It is so because cellulose, a skeletal polysaccharide that is found in all species of the plant kingdom, is one of the most common naturally occurring fibrous material (Mwaikambo 2006). There are several applications for these fibres, and their use is increasing. To become widely employed as dependable engineering materials for structural components, they must overcome several obstacles. Since natural fibres are renewable and biodegradable, many big companies intend to incorporate them into their products (D´Almeida et al. 2006).

Researchers have used plant fibres as a substitute for steel. Among them were sisal, kenaf, cotton, coir, jute, ramie and many more. Natural fibres are widely accessible and cheap in many countries, and their use can promote sustainable development. They offer various advantages and benefits, including easy usage or handling owing to their flexibility (Ali 2012). They are very soft and less abrasive, which makes the production much simpler since the machine member parts are less worn and deteriorate after (D´Almeida et al. 2006). Another benefit is that they are recyclable and renewable, as I have already stated, but their greatest benefit is that they are inexpensive and widely available. In Europe, flax and hemp receive the most attention. Additionally, lignocellulosic fibres demand less energy during processing and have no carbon dioxide emissions, which does not contribute to the greenhouse effect that causes global warming that much (Aquino et al. 2012).

4.1.1.1. Mechanical properties of natural fibres

The plant cell is a sclerenchyma-elongated cell that has thick, highly lignified cell walls with tapering ends. Although it may be found throughout the plant, it is most common in the stem and leaves. It is also associated with xylem and phloem tissue in addition to sclerenchyma (Grundas & Stepniewski 2013).

4.1.1.2. Types of natural fibres

The fibre is obtained from many plant parts and may be categorised into three primary groups: seed or fruit fibres, bast or stem fibres and leaf fibres. Wood fibres, a subclass of seed fibres, are a special category (Brink & Escobin 2003).

Leaf fibres are obtained from the leaves or leaf stalks of different monocotyledonous plants. These fibres are referred to as hard fibres. Many species from the plant family Musaceae can be found here. The abaca fibre is the most significant. The next one is banana fibre, specifically *Musa ulugurensis*, which produces the high-quality fibres. Plants are harvested immediately before flowering, before any fruits have begun to form, to guarantee the highest quality fibre. With over 250 species, the genus *Agave* is one that we must not overlook. In general, the fibre's properties are similar to those of abaca (Mwaikambo 2006).

Bast or stem fibres, also known as soft fibres, come from the stems of different dicotyledonous plants. Their primary features are flexibility and fineness, which separate them from the coarser leaf fibres. Between the inner woody core and the epidermis are where fibres are found. To harvest, the stem must be cut off near the base. The most important fibre property is its strength, which is used in the manufacture of ropes or bagging materials (Britannica 2023). To the bast fibres belong, for example, ramie, jute, hemp, or flax (Wickens 2001). The jute fibres extracted from the *Corchorus* genus are extremely soft, long, and have a shiny white to brown colour (Ali 2012).

Seed fibres are extended single epidermal hair cells that sprout from the plant's seed (Brink & Escobin 2003). Normally, they consist of only one cell (Mwaikambo 2006). Another term for these cells is trichomes, and the seed fibres are often referred to as ultimate fibres. The most important and most well-known crop is cotton (Wickens 2001).

4.2. Harvesting and processing of fibres

4.2.1. Harvesting of fibres

The harvesting techniques may vary depending on whether the crop will be used for high-quality textile fibre, only for seed fibre, or for both. We look for the best quality when we seek a textile fibre. The stems are often removed by machines, after which they are arranged in windrows for dew or field retting. After that, a second machine arrives, grabs the stems, bundles them, and brings them into the mill. Typically seed are harvested after they have fully developed. However, we must harvest the crop before the seed matures if it is used for more than one reason. These dual-purpose crops have lower-quality fibre, which is mostly applied as pulp or in the production of paper (Economic Research Service 2000). And lastly, the majority of the leaf harvest is done by hand. We have to be careful and ensure that there is sufficient leaf area for the plant to continue growing.

Harvesting annual and perennial plants differs mostly in the amount of time required from planting to harvesting. Whereas perennials require several years to fully mature, annual herbs can be harvested in a few months (Brink & Escobin 2003).

4.2.2. The retting process

Through microbiological enzymatic activity, the retting process removes lignin, pectin, and hemicellulose from the fibre bundles in a biological process (Khalina et al. 2020). For stem fibres, this procedure destroys the chemical connections, which leads to the separation of the fibre from the woody core (Economic Research Service 2000). There are two main types.

We can start with dew retting, sometimes referred to as field retting. This method is typical in areas with limited water supplies, hot daytime temperatures, and heavy dew during the night (Britannica 2023). They are an important moisture component for the microbial breakdown to happen, but the weather must be arid enough for the stems to dry (Economic Research Service 2000). This process combines the activity of bacteria, air, sunlight, and dew-produced fermentation. The active organisms that are used are mostly colonisations of fungi living in the soil (Khalina et al. 2020). The separation of fibres comes around three weeks after the beginning, depending on the climate. This process yields fibres that are darker and of lower quality (Britannica 2023). The advantages include low cost, higher fibre content, and less pollution because it does not require water. However, the quality of such fibres is being affected by climatic conditions. This technique can be used for hemp (Economic Research Service 2000; Khalina et al. 2020).

The second method, known as water retting, involves submerging the plant stems in water. It can be done in ponds or in contemporary tanks where the fibre quality is under our control. Microbial enzymes are the active organisms here, breaking down the pectic component that surrounds the fibres (Brink & Escobin 2003). Throughout the whole process, clean fibre is obtained by monitoring the retting time and changing the old water (Britannica 2023). The fact that it takes a lot of time and money is one of its drawbacks. We also need to educate the employees about the entire process in order to have, the best quality fibre at the end (Economic Research Service 2000).

4.2.3. Pulping

The first step in the process of creating paper is pulping. The goal of this procedure is to break the bond between lignin and fibres while keeping the wood fibre structure untouched. This process can be performed in three methods, which are chemical, mechanical, or biological. We choose based on the type of fibrous material that is being pulped (Mboowa 2024).

Mechanical pulping requires some mechanical energy that transfers the wood chips into pulp. It involves procedures that separate fibres, such as rafiner techniques and grinding (McDonald et al. 2004). Chemical pulping is used when we want to make high-quality paper. High pressure and temperature are required for the chemicals in solution to destroy the lignin and leave just the fibres. They are then more flexible and in closer contact with each other, making the paper significantly stronger (Mboowa 2024). Last but not least, when using the biological method, we need to do a pretreatment, usually with a white-rot fungus or some enzymes degrading the lignin. This method saves a lot of energy (Reid 1991).

4.3. Use of fibres

We can divide the end uses of all fibres into three main groups: apparel, household, and industrial use. Also, the use of polymeric materials as reinforcement has increased within the past 20 years (Mwaikambo 2006).

4.3.1. Textiles

One of the most important uses of non-wood fibres is in textile production. Before the fibre can be woven into textiles, it must in the first place spun into threads. As fabric, we can have cloth for clothing or, material for sacking when we have rougher fibre (Brink & Escobin 2003).

The reason the use of natural fibres is growing is because it is more environmentally beneficial. Cotton remains the most important fibre plant on the market, but we cannot consider it a sustainable crop. It requires excessive amounts of water and chemical care to grow. This explains the growing interest in *Linum usitatissimum*, also known as linen. The plant stem is the source of the fibre, which may be used to make clothing, footwear, or handbags. We can use two techniques for the extraction of the fibre, which are retting or scorching, in order to modify the fibre properties (Han-Yong 2022).

4.3.1.1. Cotton

Along with three other species, cotton is a member of the genus *Gossypium* and the family Malvaceae. Its origin is in Africa. This plant has a deep-root system since it prefers warm weather and is quite sensitive to frost (Espig & Rehm 1991).

Although cotton was originally a perennial crop, nowadays it is more beneficial to grow it as an annual crop. For us to obtain mature fibre from it, it takes around fifty days from the flower to the open ball (Mwaikambo 2006). Harvesting is often done by hand; only weakly branched, low-growing varieties are picked mechanically. The yield of fibre can be up to forty percent for the best cultivars; the less developed ones have about half of that (Espig & Rehm 1991).

The fibre is made up of single-celled hairs that are growing out of outer epidermis cells. Cotton belongs to the seed fibres. When the seed rips, the wall of hairs collapses and they die. The cellulose fibres that make up the wall are arranged in spirals. This explains the characteristic twisting of the dried cotton fibres (Espig & Rehm 1991). Cotton fibres are flexible and can be transformed into a diverse range of fabrics. Cotton textiles are long-lasting, absorbent, simple to dye, washable and comfortable (Weigmann 2024).

4.3.2. Cordage

Making all kinds of ropes, twines, strings, threads or packing cords is known as cordage production. The individual threads must be twisted rather than weaved together (Brink & Escobin 2003). Rope, for instance, is often made up of three or more strands, each of which is constructed of two yarns. The two most important members are jute and sisal. An interesting fact about them is that they are the only two specified for making coffee sacks (Wickens 2001).

The entire procedure may be split into three main phases. The first one is, of course, the planting and harvesting of fibre plants. The amount of time needed for preparation varies depending on the type of plant and its material; if it is grass, it needs more time than a palm. This process includes soaking and beating. The second stage then begins, during which the two bundles are rolled to create linear cordage. The last step is realised only when making a specific object, such as netting (Veldmeijer 2009).

4.3.2.1. Sisal

Agave sisalana belongs to the family Agavaceae and is known by a variety of vernacular names like sisal or hemp. It is a perennial plant that can survive for a long time without water (Espig & Rehm 1991). Sisal has its origins in tropical America, but currently it is grown across the world's tropical regions, mainly in Africa, the Far East, and the West Indies. Fibre from the agave plant is one of the most important and is used globally. Its quick regeneration rates and ability to grow in unusual locations, such as the edges of fields or railway lines, are only two of its numerous advantages. It is regarded as a potential reinforcement for use in composites because of its easy cultivation and little requirement for space or particular growing conditions (Lin et al. 2000).

The sisal fibre is extracted from the leaves and belongs to the hard fibres. It is really firm and straight, yellow in colour. Its strength, elasticity, and extreme resistance are its key characteristics (Ali 2012). We can divide the fibres into three types, which are mechanical, ribbon, and xylem. The first one is the most common. The two biggest producers are Brazil and Tanzania (Lin et al. 2000).

4.3.2.2. Henequen

Another plant from the family Agavaceae is named *Agave fourcroydes*. It is an endemic plant that originated in Mexico, specifically Yucatan, and is known there as henequen (Canché-Escamilla et al. 2014). It has been cultivated since pre-Hispanic times because for its fibres. At the time, it held great social significance for the local population (Marín 2003). The plant, which ´the Mayans´ called "ki", allowed them to produce enough of it to have a respectable and somewhat prosperous life. The produced fibres were mostly used in cordage production for ropes, sacks, carpets, and other things, thanks to their strength and durability. Later in the nineteenth century, with the influx of Spaniards, the plant was brought to the global market, which gave the landowners great benefits and profits. Unfortunately, at the end of the twentieth century, the industry was nearly wiped out (Rioux 2014).

4.3.3. Plaiting and weaving

By interlacing the strands, we may use this method to produce hats, sandals, baskets and so on. We can also take older and tougher strands, which are less flexible, to make mats. *Carludovica palmata*, often known as the Panama hat palm, is commonly used in South America, particularly in Panama, to create famous “Panama hats” (Brink & Escobin 2003).

4.3.3.1. Carludovica palmata

Carludovica palmata, in Ecuador and Panama known as Paja toquilla, in Mexico as “palma jipi”, or in Honduras as “junco”, is a member of the family Cyclanthaceae. This plant has a wide distribution. It is found in areas ranging from subtropical climate to rainforest, from Mexico and Panama to Brazil. It grows on both sides of the Andes as well. This perennial tropical grass resembles a little palm. It can grow up to two or three metres, with the length of its leaves being about four metres in the shape of a fan. They are the main product part that is used from the plant (Dube 2016).

Because it grows in colonies, this plant can be found in open spaces with disturbed soils, either along with the Poaceae or Arecaceae families. Alternatively, it grows next to fruit trees, crop plants, and timber trees in agricultural areas and agroforestry systems. It grows, anywhere between elevations of twenty metres to two thousand metres above sea level in Ecuador.

This plant plays an important role in the local economy for various ethnic groups in the tropical forests of Ecuador. It is used for building, local crafts or medicinal purposes. Making of Panama hats, a family-run business in more than 20 communities in the province of Manabi, is another significant use. In this instance, women are in charge of processing the raw materials and creating the hats, while men are in charge of managing the plants and their cultivation (Gallegos & Burbano 2004). The hats are made out of the young leaves; for one hat, six leaves are normally needed. The texture's consistency and accuracy, which give them strength, flexibility, and water resistance, are their primary advantageous characteristics (Wickens 2001).

Of course, we may use this fibre for other purposes as well. The dried leaf blades are mostly used to make brooms in southern Colombia. Since they don't actually require such a high grade of colour, they first gather the young leaves and lay them out on the ground to dry in the sun. After that, they hanged it over a rope that was strung, chopping off the petioles that remained but leaving the leaf veins coherent. It is necessary to extract the fibre by hand (Bristol 1961).

4.3.4. Paper making

Paper can be made from practically any natural fibrous material. It is evident, that most of the fibres we use are wood-based, yet in some regions, non-wood materials dominate. As a non-wood material, we can have crop residues that remain after the primary product is harvested. For example, some waste fibres are left from the crops for the manufacture of textiles or cordage (Brink & Escobin 2003). When we are making the paper out of the non-wood plants, we are working only with the individual fibre cells. Based on the chemical composition of the plant fibres, we can tell that their pulping is much simpler and less expensive than pulping wood plants.

Another advantage is the thinness of the annual bast fibres. At the end, we can divide the final paper into two main categories: specific tissues like tea-bag paper or electrical base tissue, and hard and strong papers such as dust filter papers or high-quality writing paper (Judt 1993). Of course, we also grow crops primarily for paper production; those are bamboo, abaca, hemp, jute, or kenaf (Brink & Escobin 2003).

4.4. Underutilised plants originated in South America

Underutilised crops, sometimes referred to as neglected crops, are plants that are not grown or used extensively while having a good chance of providing nutrition, food security, or support for sustainable agriculture. These crops are usually very good at adapting to local environments and conditions and can tolerate a variety of stresses. This can all make them more resistant to climate change and more sustainable than the commonly used crops (Li et al. 2020; Singh et al. 2022).

My aim was to compile a list of the majority of underutilised fibre plants that are native to South America (Table 1), as well as the cultivated ones (Table 2). It appears that the two biggest families originated in South America, with the most representatives are Asparagaceae and Malvaceae.

4.4.1. Family Asparagaceae

The Asparagaceae family involves approximately 153 genera with more than 2,500 species. This family is really diverse; we can find it all around the world. In terms of evolution and genetics, the plants are more similar than they are morphologically (Britannica 2023).

4.4.1.1. Genus *Agave*

The genus *Agave* is one of the most important in Mexico due to its biological, economic, and cultural importance. Approximately 150 of the two hundred species of this genus are found in Mexico (Delgado-Lemus et al. 2014). Most agave species are perennial evergreen xerophytes (Davis et al. 2011). The use is still really common among local people. The fibres from around half of the species are used to make nets, clothing, ropes, and other items. It can be applied in traditional medicine, as food, or as a construction material (Delgado-Lemus et al. 2014). They are also widely used in Mexico in the production of alcohol, while the waste products made during the manufacturing of mezcal or tequila are being researched (Maceda et al. 2022). The Mexican communities are benefiting greatly from all of these products, both financially and practically. Unfortunately, knowledge about this genus, its uses and its preparation is decreasing (Delgado-Lemus et al. 2014).

Compared to other major crops, these species have the benefit of being able to thrive in areas of the tropics and subtropics with extremely arid climates or deteriorated soil. As a result, the agave species are suitable for producing biofuel in these regions. That could be a solution for the big-land competition with crops for food production (Davis et al. 2011).

4.4.1.2. Genus *Furcraea*

There are around twenty-four species of the genus *Furcaea* that are native to South America, particularly the Andes in Colombia and Venezuela, and Latin America, ranging from Mexico to Paraguay (Guzman et al. 2023). It is really important for Latin America, both socially and industrially. It is also referred to as mecate, fique, or cabuya there. The production of fibres is the genus's primary use (Medina-Cano et al. 2023).

Concretely *Furcraea foetida*, also known as the Fique plant is a native fibre plant that comes from the Andean region of South America. It is an evergreen, semi-perennial shrub (Medina-Cano et al. 2023). This plant is rustic and tolerant of a wide range of environments. The best soils should have adequate natural drainage, a medium texture, and good porosity (Navacerrada et al. 2014).

The plant can be propagated in three ways. One option is sexual propagation by seeds, although this is quite uncommon. The others are asexual through “hijuelos” or “bulbillos”. “Hijuelos” are little seedlings sprouting at the base of the main stem that contain three or four true leaves. Structures known as “bulbillos” form from meristematic sprouts in the inflorescence of plants (Guzman et al. 2023).

The plant leaves are processed mechanically to remove the fique fibres. It is utilised in the packaging uses in the coffee and cocoa export sectors, the production of textile products, and handicrafts. We are currently facing a global shortage of sisal and jute fibre. They have similar characteristics to fibres like fique. This is a chance for this plant to expand in the fibre industry (Rendón-Castrillón et al. 2023).

4.4.2. Family Malvaceae

The Malvaceae family has about 243 genera, with a minimum of 4,225 species. Herbs, shrubs, and trees that are widespread worldwide but mainly in the tropics belong here. The primary purposes of the plants' cultivation are as food crops, ornamental plants, and sources of fibre (Britannica 2023). There are lot of plants for producing fibre that belong to this family, such as the cotton, jute and kapok (Gómez-Maqueo & Gamboa-deBuen 2022).

4.4.2.1. Genus *Ceiba*

The *Ceiba* genus includes eighteen species that are native to America and Africa. We are extracting the fibre mostly from the fruits and seeds of the plants. This high-cellulose fibre is used in textile manufacture, for filling, and for industrial purposes. The qualities of kapok's fibre have drawn scientific attention in recent times. It was discovered that they are anti-bacterial and anti-mite, as well as environment-friendly and biodegradable. Plants in this genus also have a lot of importance for local people in several parts of South America. For example, in Mexico, *Ceiba pentandra* is taken as a sacred tree symbolising the bond between the human world and God. In Guatemala, it is their national tree (Gómez-Maqueo & Gamboa-deBuen 2022).

Ceiba pentandra is a pantropical plant tolerant of a wide range of environmental factors (Bocanegra-González et al. 2018). The distribution is from Mexico to Argentina, from seasonally dry tropical forests to tropical forests (Tareau et al. 2022). This species has a lot of potential for reforestation and improving degraded regions (Bocanegra-González et al. 2018). The use is mainly for fibre production; the fruit is not edible and might be occasionally used in medicine. We are removing the fibre from the fruit, a capsule containing a seed wrapped by hairs, named kapok (Tareau et al. 2022).

4.4.2.2. Genus *Corchorus*

The distribution of this genus is mainly in tropical areas around the world. In this genus, there are around fifty species that are growing as annual herbs. It is most recognised for its production of phloem fibre, jute, which is highly valued. Another use for these plants is for traditional medicine; studies have been done on them to treat degenerative illnesses, pain, fever, and sexual dysfunction (Kumari et al. 2019).

Corchorus aestuans originated in Latin America and can now be found in tropical regions. Although it is not very strong, the fibre that this plant yields from its stem is of high quality. The fibres are being transformed into threads or strings, from which come coarse but not so resistive products. In Africa, the leaves are often consumed or used in traditional medicine for headaches, stomach-aches, or pneumonia (Plant Resources of Tropical Africa 2013).

4.4.3. Genus *Herissantia*

This genus has its name after a botanist, Louis Herissant, from French. About five species belong here, but they are often misplaced in the genus *Abutilon* (Western Australian Herbarium 1998).

Herissantia crispa Brizicky is a pantropical herb that originated in America (Brink & Escobin 2003). Although the habitat has a significant impact on the plant´s growth, flowering and fruiting occur in the wet season. The species is valuable for its fibre and for the production of substances like flavonoids, sterols, and so on (Ramana et al. 2022). The fibre obtained from the bark has a really high quality (Brink & Escobin 2003).

4.4.4. Genus *Malachra*

This genus is found in several countries in Africa and in tropical and subtropical America. For instance, the majority of species, including many endemic ones, are located in Brazil and Colombia. The number of species is seventeen, but only nine are accepted. Communities use them in traditional medicine to treat a variety of health issues or as a forage for their livestock (Cervantes-Ceballos et al. 2022).

Malachra capitata, an erect or underground shrub, is mostly grown to produce really good-quality fibre (Deodhar 2016). The fibre is taken out of the stem's secondary phloem. Compared to jute fibre, which it is frequently mixed with, it is whiter, softer, and longer. It may be used for the production of strong ropes but also for some coarser fabrics, such as bags. In the Philippines, bathing with decoctions of roots and leaves is common, and using leaves alone can help prevent rheumatism and diarrhoea (Brink & Escobin 2003).

4.4.5. Genus *Malvastrum*

Genus *Malvastrum* is overall a small genus, including twenty-four species, that are distributed globally and have a large history of ethnobotanical use. The species is distinguished by its yellow axillary flowers (Zafar et al. 2023).

Malvastrum coromandelianum is a small herb, frequently seen as a weed, because of its quick colonization (Zafar et al. 2023). We are obtaining strong white fibres from the bast of the plant. Usually, the fibre needs to be retted for one week before processing. We have two options: either we can twist the fibre into ropes or we can take the entire stems and turn them into brooms (Plant Resources of Tropical Africa 2013). It is also widely used medicinally in Mexico; leaves mixed together with alcohol treat infections, or leaf infusions medicate diabetes (Sanghai et al. 2013).

4.4.6. Genus *Sida*

Genus *Sida* is pretty big, including about two hundred species of herbs, undershrubs, or shrubs that can be both perennial as well as annual. Species of this genus are distributed in both hemispheres of the Earth, primarily as weeds in tropical and subtropical regions. For thousands of years, the local population has used them in traditional medicine to treat a wide range of illnesses (Dinda et al. 2015).

Sida glabra has its origins in Mexico, was later distributed to tropical America, and was even introduced to Florida. The greatest growing conditions for this annual plant are found in the seasonally dry tropical biome. It can be consumed or used in medicine (The Board of Trustees of the Royal Botanic Gardens, Kew 1768). Regretfully, research on this plant as a potential source of fibre was stopped and never resumed (Brink & Escobin 2003).

4.4.7. Genus *Wisssadula*

There are 32 species of the genus *Wissadula* that are found in the Neotropics, with 19 of those species spread in Brazil. They are growing mostly in regions with a lot of sunlight, not so much in the forests. Nowadays, the genus is divided into two sections named *Wissada* and *Wissadula*, based on the number of ovules in each (de Mello et al. 2024).

Wissadula contracta is a perennial erect undershrub that originated in tropical America, where it grows along the roadsides. It was cultivated around the world, primarily in gardens. In Indonesia, there were experiments for the extraction of bast fibres that were retted and then sun-dried, resulting in high-quality fibre (Brink & Escobin 2003).

Table 1 – List of fibre plants originated in South America

Botanical name	Vernacular names	Used part	Remarks	Other uses
		Originated in South America		
Asparagaceae				
Agave cantala	cantala Bombay hemp maguey	leaf	The perennial herb originated in Mexico, but now it is hard to find it there. The fibre is known as "hard fibre," and it is used to make carpets, bags, and baskets.	ornamental use auxiliary use forage use
Agave sisalana Perrine	sisal sisal hemp sisal agave	leaf	It is a perennial herb that originated in southern Mexico, but its wild forms are not known. It produces very long fibres used in cordage production.	ornamental use medicinal use forage use
Agave vivipara L.	dwarf sisal dwarf aloe	leaf	Originated in Mexico, specifically in Yucatán. These days, this perennial herb is mostly used as a hedge plant beside railways, primarily in India.	ornamental use

Table 1. (Continued)

Botanical name	Vernacular names	Used part	Remarks	Other uses
Furcraea cabuya	cabuya	leaf	It originated in Costa Rica and Ecuador. Its fibres are used to make ropes and sacks.	auxiliary use fuel use
Furcraea foetida Haw.	Mauritius hemp pita green aloe	leaf	It is native to tropical America. Its natural distribution spans from southern Mexico to the northern and eastern coasts of South America. Use as fibre is becoming less common.	ornamental use auxiliary use
Arecaceae				
Attalea funifera	bahia piassaba palm piassava palm coquille nut	leaf sheath	This plant is native to eastern Brazil, where we can find it mainly in dry forests. The broom industry uses its fibres, primarily for hard brooms.	fruit use medicinal use

Table 1. (Continued)

Botanical name	Vernacular names	Used part	Remarks	Other uses
Raphia taedigera	pinecone palm yolillo palm	leaf	It is the only species from the genus Raphia to be found in tropical America. The fibre that is extracted has a lot of uses and is both soft and strong.	construction use fruit use
Bromeliaceae				
Neoglaziovia variegate Mez	caroá makimbeira	leaf	Used in Brazil's Northeast Region for the extraction of fibre. For coarse cloths and mats.	medicinal use
Cyclanthaceae				
Carludovica palmata	Panama hat palm toquilla palma de sombrero jipijapa	leaf	The natural distribution is probably from Guatemala. The well-known Panama hats are made from the young leaves. Mats, baskets, cigar boxes, and so on are created from elder leaves.	ornamental use fruit use

Table 1. (Continued)

Botanical name	Vernacular names	Used part	Remarks	Other uses
Malvaceae				
Ceiba pentandra L. *(Bombax pentadrum L)*	kapok silk-cotton tree	fruits	The fibres are used for stuffing and thermal and acoustic isolation. The shells of the fruit are also used as fuel or to make baking soda.	medicinal use
Ceiba trischistandra	floss silk tree palo borracho	fruit	It is a tall tropical tree native to Peru and Brazil. The white fibre that we harvest from the fruit is mostly used to fill pillows and mattresses.	medicinal use spiritual use
Corchorus aestuans L.	West African mallow East Indian mallow	bast	It is a pantropical weed native to tropical Latin America. It is used as a vegetable in addition to fibre production.	forage use vegetables medicinal use
Herissantia crispa (L.) Brizicky	cemplak lantern vine	bark	This herb is native to the tropical Americas but has been introduced in many other parts of the world. Its bark yields fibre, and this fibre is of very high quality.	medicinal use ornamental use forage use

Table 1. (Continued)

Botanical name	Vernacular names	Used part	Remarks	Other uses
Malachra capitata	wild okra malva	bast	There are around 10 species of Malachra, and they are all native to tropical America. Because of their relative strength, the fibres are used to make ropes and coarse fabrics. Usually, it is an annual herb.	medicinal use
Malvastrum coromandelianum (L.) Garcke	salsaluyut broomweed	bast	The pantropical herb has its origins in tropical America. Either the whole stems can be used to manufacture brooms, or the white, very lustrous bast fibre can be extracted.	medicinal use auxiliary use ornamental use
Sida glabra Mill.	smooth fanpetals sticky sida	bast	Native to Mexico and introduced into Java. It was thought to be a promising plant for fibre, but the study was interrupted.	medicinal use forage use ornamental use

Table 1. (Continued)

Botanical name	Vernacular names	Used part	Remarks	Other uses
Wissadula contracta (Link)	bagori pungpurutan	bast	Its origin is in tropical America. From the plant's bast, we are extracting a fibre of high quality.	medicinal use ornamental use

(Brink & Escobin 2003; Plant Resources of Tropical Africa 2013; Espig & Rehm 1991; Plantnet 2023; Fern 2022)

Table 2 – List of fibre plants cultivated in South America

Botanical name	Vernacular names of plants	Used part	Remarks	Other uses
		Cultivated in South America		
Araliaceae				
Tetrapanax papyrifer	ricepaper tree Chinese ricepaper plant	pith	This shrub, or small tree, is native to Taiwan and southern China. Rice paper is made from the plant's pith. Nowadays, it is mostly grown as an ornamental crop.	ornamental use medicinal use
Asphodelaceae				
Phormium tenax	New Zealand flax phormium harakeke	leaf	It originated in New Zealand, but it is grown commercially as a fibre plant in many other countries. Fibres were used for many things, but mostly for cordage. The fibre's hardness is somewhere in the middle between hard and soft.	ornamental use medicinal use

Table 2. (Continued)

Botanical name	Vernacular names of plants	Used part	Remarks	Other uses
Cucurbitaceae				
Luffa cylindrica	luffa loofah sponge gourd	fruit	It is cultivated worldwide. Fibrous plant with fruits containing black seeds. It is used for bath sponges or shoe padding	medicinal use vegetables
Cyperaceae				
Cyperus digitatus	digitate cyperus rumput dekeng	bast	This species is pantropical. Mats and baskets are made from its stems.	medicinal use
Eleocharis acutangular	purun	bast	The origin of this pantropical species is unknown. Stems are used for making bags, cigarette boxes, and in Brazil, even for weaving.	medicinal use
Hypoxidaceae				
Curculigo capitulata	palm grass	leaf	Curculigo species are typically found in tropical regions. The fibres are used for fishing nets or in cordage production.	ornamental use fruit use

Table 2. (Continued)

Botanical name	Vernacular names of plants	Used part	Remarks	Other uses
Leguminosae				
Crotalaria juncea L.	sun hemp Indian hemp	bast	Cultivated in Brazil. One of the tropical regions' most popular crops for green manure. Mainly used for cordage, twine, fishing nets.	auxiliary use medicinal use fuel use
Linaceae				
Linum usitatissimum L.	flax lin	bast	It is grown for its oil-rich seeds and bast fibre. These days, flax is a common component in health meals like multigrain breads and cereals for breakfast in Europe and North America.	vegetable oil use medicinal use timber use
Malvaceae				
Abelmoschus manihot (L.) Medik.	aibika sunset hibiscus	bast	A tropical perennial plant native to West Africa with strong and durable fibres. Mainly used in cordage production.	ornamental use medicinal use food security

Table 2. (Continued)

Botanical name	Vernacular names of plants	Used part	Remarks	Other uses
Abutilon theophrasti Medik.	China jute Indian mallow	bast	Today it is distributed in the temperate and sub meridional regions. It is grown for its rough fibres, which are used to make hammocks, nets, carpets and rope.	medicinal use cereals
Gossypium hirsutum L.	cotton	seed hairs	It is the most important cotton species, accounting for over 90 percent of the total cotton production. Although its fibre is mostly used in the textile industry, it may also be found in a wide range of other products.	vegetable oil use forage use fuel use
Hibiscus cannabinus L.	kenaf guinea hemp	bast	Originating in Africa, this annual herb is also found there in its wild form. Fibres are similar to jute and are used mainly in cordage production.	ornamental use forage use dye and tannins use vegetable oil use medicinal use

Table 2. (Continued)

Botanical name	Vernacular names of plants	Used part	Remarks	Other uses
Hibiscus sabdariffa L.	roselle siam jute	bast	Given how recently it has been used for fibre, this plant most likely made its way to America for use as a vegetable. In Indonesia, it was extensively used for bags for sugar packing.	vegetables dye and tannins use ornamental use fruit use
Urena lobata L.	Congo jute paka malva aramina	bast	Although its exact origin is unknown, it most likely originated in Africa or Asia. Traditionally, bast fibre is used to make cordage and coarse textiles. It is also widely utilised in industry to replace jute.	vegetables feed use medicinal use

Table 2. (Continued)

Botanical name	Vernacular names of plants	Used part	Remarks	Other uses
Musaceae				
Musa textilis	Manila hemp abacá	leaf sheath	It is native to the Philippines and northern Indonesia. Fibre is mostly used for specialty papers and cordage. The fibre production process calls for a lot of manual effort.	medicinal use
Poaceae				
Sporobolus indicus (L.)	smutgrass West Indian dropseed	bast	It is distributed throughout the tropics. Making brooms is the main use. Additionally, it may be used to create fans or hats.	forage use medicinal use ornamental use
Urticaceae				
Boehmeria nivea (L.) Gaudich.	ramie rhea China grass	bast	The origins of this perennial plant are most likely in China. It is one of the oldest fibres in textile production. These days, it is mainly used for ropes, nets, or fabrics.	forage use medicinal use

(Brink & Escobin 2003; Plant Resources of Tropical Africa 2013; Espig & Rehm 1991; Plantnet 2023; Fern 2022)

5. Conclusions

My main goal was to gather as much information and data as possible and provide an overview of both the main fibre crops and the neglected ones. The thesis explained what fibre plants actually are and what their main uses are. The main focus was the region of tropical South America and the ethnobotanical use of the local people living there.

The main uses for natural fibres were divided into three groups: apparel, household, and industrial use. It was found that cotton was the main source of fibre used in the production of clothing. However, the crop needs a lot of water for its growth, which is why *Linum usitatissimum*—an alternative—is now being raised. Furthermore, there are many other of additional underutilised crops that might perhaps partially replace the primary crops. But not a lot of experiments and studies were made.

The thesis analysed some of the underutilised genes and species. Two structured tables were created, which show the specific plants as well as their potential for fibre use. However, the majority are medical plants, and research into these plants for potential use in medicine is far more vital than that into plants for fibre production.

I believe that further studies and surveys of potential sources of fibre may be conducted in the future. There are numerous species, and we have only a limited amount of knowledge about them.

To conclude, I believe the thesis achieved its objective. The data gathered from books and internet databases was summarised, and an overview and analysis were completed.

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Appendices

List of the Appendices:

Appendix 1: Underutilised plants originated in South America from the families Asparagaceae and Malvaceae – Figures

Appendix 1: Underutilised plants originated in South America from the families Asparagaceae and Malvaceae - Figures

Fig. 1. *Agave sisalana Perrine* (Krogsgaard 2020)

Fig. 2. *Agave vivipara L.* (Plantnet 2022)

Fig. 3. *Furcraea foetida* (Rajatewa 2021)

Fig. 4. *Ceiba pentandra* (Milliken 2023)

Fig. 5. *Corchorus aestuans L.* (Schmitz 2016)

Fig. 6. *Herissantia crispa L.* (Whaley)

Fig. 7. *Malvastrum coromandelianum*
(Schmitz 2017)

Fig. 8. *Malachra capitata*
(Rajatewa)

Fig. 9. *Sida glabra Mill.*
(Hernández 2014)