Journal of Scientific Research and Reports

Volume 30, Issue 12, Page 14-30, 2024; Article no.JSRR.127401
ISSN: 2320-0227

Indian Grasses and Their Potential for Sustainability

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Authors' contributions

This work was carried out in collaboration among all authors. Author AB conducted internet research and reviewed available publications. Author SC conceptualized the study, supervised the drafting process, and authored the entire manuscript. Author SJ evaluated and assessed the work, provided encouragement, and revised all drafts. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jsrr/2024/v30i122647

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/127401

Review Article

Received: 23/09/2024
Accepted: 26/11/2024
Published: 03/12/2024

ABSTRACT

Global researcher and consumer prioritize protecting the atmosphere and biodiversity by promoting eco-friendly products, favoring natural fibers over synthetic materials for their bio-renewable properties and sustainability benefits. The main aim of the review paper was to study the different grasses and their utilization. The author focused on Grass fibres, their sources, properties, and application and their scope for sustainable development ins textile industry. Grasses are somewhat unique in that they frequently succeed in displacing other plants from wide areas of land. Grass fibers are another group of monocotyledonous fibers, where the entire stem together with the leaves are pulped and used in papermaking. Such pulps are composed not only of fibers, but of other

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Cite as: *Chaudhary, Sonal, Anjali Bhardwaj, and Shalini Juneja. 2024. "Indian Grasses and Their Potential for Sustainability". Journal of Scientific Research and Reports 30 (12):14-30. https://doi.org/10.9734/jsrr/2024/v30i122647.*

cellular elements as well. However, very few individuals recognise the value of grasses. While several plant families provide for human needs, the grass family out performs all others in terms of the quantity and quality of its output. Not much of the work has been done on grass fibres. Hence the need of the hour was felt to explore the potential application of Golden grass (sabai grass fibre), Nettle grass, Vetvier grass, Nappier grass and Gajar grass so as to find sustainable solutions for textile sector.

Keywords: Eco –Fashion; grass fibre; green textiles; sustainability.

1. INTRODUCTION

Sustainability is the ability of natural systems to continue operating, to remain diverse, and to create all the materials required for them to maintain their ecological balance. The excessive manufacture and disposal of plastic is stressing the planet's ecosystems. Perhaps this is the right time to learn more about the accessibility of natural plant fibres for textiles. There is a renaissance of interest in natural fibres due to the advent of global warming and climate change, a rising level of environmental consciousness, and the relaxing of governmental laws. In order to create new fabrics that can cure the world, a number of plants, fruits, and seeds are currently being either rediscovered or newly processed (West, 2021).

Lignocellulosic fibres can be derived from wood, annual plants, agroforestry waste, or industrial operations such as papermaking or textile production. The potential to add value to waste that is typically burned in the field by employing agroforestry waste as reinforcement for polymer-based composites can lengthen the value chain of the product (Kamarudin et al., 2022).

Natural fibres are often collected from the plant's bark, stem, fruit, leaves, and roots. Natural fibre cellulose chemical composition varies depending on where it comes from and how old the plant parts (roots, fruits, stems, bark, and leaves) are. Several noncellulose components, including hemicellulose, lignin, and wax, cover the cellulose element in the fibre. Mendong grass, Napier grass, Elephant grass, Snake grass, Sansevieria ehrenbergii, Wild cane grass, Broom grass, Kusha grass, Sisal, Sansevieria cylindrica, Arundo donax L., Sansevieria trifasciata, and corn husk have all been considered as potential natural fibres for use as reinforcement in polymer composites (Lokantara et al., 2020).

Recent years have seen an enormous rise in research interest in the potential of natural fibres as reinforcing materials for the development of biocomposite materials due to their appealing qualities and benefits over composites reinforced with synthetic fibres. Even so, because of their limited qualities, high water absorption characteristics, poor fiber/polymer compatibility, and wide variations in fibre quality, natural fibres are still less competitive with synthetic fibres as reinforcement materials in the global composite market. In order to create composite materials for a variety of uses, including hard packaging, marine applications, building materials, and automobile interior elements, plant fibres have recently been employed as reinforcing fibres for polymers (Musa & Onwualu, 2024).

There are some benefits to using natural fibres rather than mineral fibres. Because natural fibres are less abrasive, they prevent equipment degradation. Natural fibres have greater specific qualities than mineral fibres since they are lighter and less dense in their composites. The automobile and aerospace sectors, which are always looking to lighten their vehicles, will find this interesting. Furthermore, natural fibres are non-toxic to humans and safe to work with, in contrast to mineral reinforcements like glass fibres (Kamarudin et al., 2022).

Using Natural fibres has many advantages, especially for developing countries, where the livelihood and food security of millions of small famers and processors depend on it. These fibres offer health benefits, provide natural ventilation and insulation again both cold and heat. The fibres of the coconut are naturally resistant to mould and pests. For hospital bed sheets, linen is the most hygienic fabric, while hemp fibre offers antibacterial properties. Moreover, these fibres present a high-tech option, offering affordability, lightness, and good mechanical strength, particularly when combined with thermoplastic panels for advanced applications. From a fashion perspective, natural fibres form the foundation of eco-fashion, ensuring sustainability throughout the entire lifecycle of clothing products (Sahu et al., 2016).

Both the chemical components and the structure of plant fibre are rather intricate. By nature, plant fibres are an intelligently constructed composite material. The fibres consist essentially of an amorphous lignin and/or hemicellulose matrix reinforced with hard, crystalline cellulose microfibrils. With the exception of cotton, the majority of plant fibres are made up mostly of cellulose, hemicelluloses, lignin, waxes, and other water-soluble substances (Djafari Petroudy, 2017).

With a large diversity of plants from forestry to agriculture resources, plants offer a wide range of opportunities to generate many new materials and products. The world is filled in plants, which provide resources that are renewable, sustainable, and biodegradable to develop eco-friendly materials and goods. The most prevalent polymer in the world is cellulose. Plants have a cellulose content of between 40 and 60 percent; the remainder is made up of hemicellulose, lignin, pectin, etc. For materials scientists, plants present fresh opportunities to uncover unanticipated features that may be precisely engineered to create innovative bioproducts. Different kinds of plants that are cultivated around the world provide nations new economic prospects (Bruun, 2020).

Although clothing and animal feed are two distinct concepts, we combine them here because grass is utilised both for fibre extraction and the production of clothing. Such grass-green textiles will be a sustainable alternative to cotton production (Bonefeld, 2020).

In this nation, grass is a significant crop, and grassland is a cheap source of feed. However, unless the produce is successfully used, it is an unprofitable way to use land, especially in areas where the climate is suitable for producing other crops. Of fact, the only way to use land that is unsuitable for other crops due to topography or rainfall is to grow grass on it (Holmes & Jones, 1964). Some of these grasses' seeds were eventually discovered to be edible. This reality, along with the understanding of the precariousness of a nomadic existence, probably made man realise the necessity of supporting himself on a scale that later evolved into intensive agriculture (Bennett, 1936).

Grasses cover large areas of land and are uniformly dispersed throughout the entire planet. They can be found on any type of soil, in a variety of settings, and in any type of climate. Grass dominates the floral composition in several areas (Rai et al., 2019).

Grass is very important to man because of its nearly ubiquitous distribution and high economic worth. However, very few individuals recognise the value of grasses. While several plant families provide for human needs, the grass family outperforms all others in terms of the quantity and quality of its output (Acharya & Pradhan, 2019). Grasses are somewhat unique in that they frequently succeed in displacing other plants from wide areas of land. Grass is spread across vast areas of land and is grown in all climatic conditions and environments. Numerous plants and grasses have a variety of applications, including providing food for animals, preventing soil erosion, and serving as lawns in domestic and commercial settings (Pradhan & Acharya, 2020) .The description of different grasses shown in Table 1, the scientific name, found places and also their uses in different field like utensils, Artistic work, Craft product, Textile Paper manufacturing, bag, Mats Forage crop, Bioenergy, Animal housing, Food, Cosmetics, Medicine, Textile Industry additive, biofuels, handicrafts, Perfumery, water conservation, Soil quality enhancement, Textile fibre, textile Finishing conservation, Soil quality enhancement, Textile Finishing malaria, diarrhoea, Bioremediation, Wound healing, Anti-cancer, Mulching, source of biogas, Composite, Removal of heavy metals and dyes etc.

Grasses are renewable resources that can be sustainably harvested without causing significant harm to the environment. Grass fibers are biodegradable and reducing environmental impact compared to synthetic fibers like polyester, which can persist in landfills for centuries. Grass fibers can be blended with other fibers or processed in various ways to achieve a range of textures and properties, making them versatile for different textile applications. Grass fibers can offer unique textures and appearances that appeal to consumers looking for natural and organic alternatives to conventional textiles. Grass fibers may require technological advancements in processing and refinement, they have the potential to offer desirable performance characteristics such as breathability, moisture-wicking, and durability. Grasses can often be cultivated in diverse geographical regions, potentially allowing for local production and reducing the carbon footprint associated with transportation in the

Table 1. Textile Grass Fibres

S. No.	Grass, Common name	Botanical Name	Found	Traditional Uses /Application	References
1.	Sabai Grass	*Eulaliopsis binata* (Retz.)	India, Pakistan, Thailand, Myanmar, Nepal, China, Malaysia Philippines	Ropes, Lamp shades, utensils, Artistic work, Craft product, Textile Paper manufacturing, bag, Mats	(Mohapatra & Saha, 2020; Satpathy & Sahu, 2010)
2.	Nettle Grass	*Urtica dioica*	India, China, japan, Thailand, Germany, UK, Russia, Ethiopia	Forage crop, Bioenergy, Animal housing, Food, Cosmetics, Medicine, Textile Industry	(Viotti et al., 2022; Samanta, 2021)
3.	Napier Grass	*Pennisetum purpureum*	Africa, Asia, North America India, Australia	Cattle feed, Bio fuel Production, improve soil fertility, Paper production, Reinforcement Cement based Tiles, Table mats, sleeping mats, decorative wall hangings, Baskets, Composites,	(Negawo et al., 2017)
4.	Vetiver Grass	*Chrysopogonzi zanioides*	India, Malaysia, China, Thailand, Ethiopia and Brazil	Animal feed, food additive, biofuels, handicrafts, Perfumery, water conservation, Soil quality enhancement, Textile fibre, textile Finishing	(Balasankar et al., 2013), (Gnansounou et al., 2017)
5.	Gajar Ghas	*Parthenium hysterophorus*	India, China, Pakistan, Nepal, Sri Lanka, Bangladesh, Vietnam, Pacific Islands, Ethiopia, South Africa, and several countries of South and Central America	medicine to treat several diseases like inflammation, fever, malaria, diarrhoea, urinary tract infections etc, Bioremediation, Wound healing, Anti-cancer, Mulching, source of biogas, Composite, Removal of heavy metals and dyes.	(Tafese Bezuneh, 2015; Singh & Kaushik, 2020b; Bagchi et al., 2016; Gnanavel, 2013)

textile supply chain. Additionally, investment in research and development is essential to unlock the full potential of grass fibers and overcome any technical limitations. Overall, while grass textile fiber shows promise as a sustainable option for the textile industry. Grass fiber production can provide economic opportunities for rural communities, particularly in regions where grasslands are abundant. This can help diversify local economies and provide livelihoods for farmers and artisans.

2. DIFFERENT TYPE OF GRASSES FIBRES

2.1 Sabai Grass Fibre

Sabai grass fibre also known as golden fibre is renewable and sustainable and has a great deal of potential to improve the economic standing of the farmers. It belongs to the perennial plant known as eulalipsisbinata (sabai grass) (Acharya & Pradhan, 2019; Pradhan & Acharya, 2020). This plant is most commonly found in eastern region of India, as well as certain Asian nations including China, Nepal, Pakistan, Myanmar, Thailand, the Philippines, and Malaysia. It covers the significant part of the forested land in some regions like Bihar, Orissa, Punjab, West Bengal, and the Central region of India (Hunsigi, 1989). The sabai grass plant as shows in Fig. 1. Sabai Grass is only second to bamboo in terms of importance as a raw material for the production of paper in India. Since 1870, it has been used to make paper. In addition to being used to make paper, it is also used to make rope for tying animals and building furniture for homes. It is mostly regarded as the lifeline of the tribal population in the Mayurbhanja district of Odisha. It has a yearly turnover of about 3 to 4 crores and is harvested every year in the months of November and December (Dwari & Khandual, 2018). All lignocellulosic materials are composed of Cellulose, hemicellulose and lignin which are closely associated with each other at plant level. Eulaliposisbinata is an excellent natural cellulose material, noted for its long fibres that have good strength and toughness.The chemical composition of sabai grass fibre include cellulose, hemicellulose and all lignocellulisic components. Sabai grass shares similarities in composition with lignocellulosic crops that are used to make fiber. The natural cellulose material eulaliposisbinata is known for its long fibres that have good strength and toughness (Sahu et al., 2016) .In the present scenario the sabai grass fibre has the potential to be able to use as textile fibre. So, considering the above characterisitics of grass the textile industry is involved in a variety of activities that include growing sabai grass for production of fibre and at the same time manufacturing and processing of products like ropes, mats, carpets, sofa sets, wall hangings, and fashionable items (Pradhan & Acharya, 2020). Water is used to hand-process the ropes, smoothing them out. To bring out its lustre, it is dried and polished after that. Every tribal family member works in making ropes. The ropes are further tightened with the use of a device called a "Gharadi" that local artisan created. For use in weaving Charpai (Cots), Sabai ropes are mostly sold outside of the state. Due to the fact that they are a natural product, ropes are frequently used over synthetic threads for tying and providing bamboo to paper mills. It is also used to make screens, Khatia, flower vases, bags, door mats, table mats, sofa sets, chairs, tea pots, and other items (Dhal et al., 2010). The Mayurbhanj district's Rural Development Centre is working with the locals to diversify the goods made from this grass, which has a high tensile strength. Sabai grass furniture is a work of art in itself (Chand and Rohatgi, 1992).

Fig. 1. Sabai Grass (Lahiry, 2023)

2.2 Nettle Grass Fibre

The cellulosic plant fibre nettle is widely distributed in tropical wastelands all over the world. There are around 500 species of nettles in the Urticaceace family. Although hard and inextensible, this fibre has a high strength (Phogat & Das, 2017). Nettle plant with its various parts is shown in. Fig. 2. Similar to flax (Linumusitatissimum L.) and hemp (Cannabis sativa L.) and used for textiles before the introduction of cotton, fibre nettle (*Urtica dioica* L.) has a long history as a fibre plant in Germany and Austria. It has recently been reintroduced in Germany and the Netherlands, reinforcing the evidence that the use of nettle for a local, sustainable economy that produces fibre with little impact on the environment might be profitable (Bacci et al., 2011). The family Urticaceae includes plants that range in height from 0.6 metres to over 2 metres and are common in our gardens and rural regions. These plants can be found in both temperate and tropical climates (Harwood & Edom, 2012). It is a perennial herb that tolerates shade and is tall, robust, and erect, reaching heights of up to 3 m (Srivastava & Rastogi, 2020). Unlike the annual flax and hemp plants, nettles have the capacity to survive in the field for five to ten years or longer. Due to the low lignin concentration of nettle plants, mechanical decortication to separate nettle fibers from plant stems uses less energy than flax and hemp fibers. In the past, low yields (fibre content between 10 and 15 percent) restricted industrial application to the textile sector (Fischer et al., 2012). The optimal time to collect Himalayan nettle for fiber-based products is between the months of November and December, as at this time the necessary fibers from the stem portion of the plant are ripe (UBFDB, 2007). Since the plant is only ready to be harvested once per year, it can only be harvested annually. The strength and quality of the generated fabric is adversely impacted if green plants are harvested from nettles when they are being used to make clothes (Debnath, 2015). The insulating qualities of nettle fabric come from the hollow fibres, and when the fibres are twisted, a finer, more breathable fabric is produced. The nettle fibre is collected and utilised to make sportswear, summer and winter clothing (Alexander, 2022). NGOs have run income-generating initiatives that included instruction on better techniques to process, spin, and weave Himalayan nettle. As a result, yarn made from Himalayan nettle and related crafts are sold in the UK. The textile industry has shown interest in Himalayan nettle among producers of both casual and sports clothing (Samanta, 2021). The Uttarakhand Bamboo and Fibre Development Board (UBFDB) has revealed that a significant amount of raw nettle is accessible, with strong potential as a handicrafts sector, adding value to the tourism economy, and high export potential.

Fig. 2 Nettle Grass

2.3 Napier Grass Fibre

Pennisetum purpureum, also known as Napier Grass, is a member of the Poaceae family. It also known as the name elephant grass and its plant shown in Fig. 3. It is a perennial grass that grows fast. Beginning in tropical sub-Saharan Africa and migrating to the Americas and the West Indies before being brought into Australia in the 1960s, the plant was first introduced as forage into most tropical and subtropical climates (Abu Bakar et al., 2019). It is a grass that grows quickly and produces a high yield (40 tons per hectare per year) with very little nutrient supplementation (Reddy et al., 2018). There have been planted several different varieties of Napier grass, including Taiwan Napier, dwarf Napier, king grass, red Napier, and Indian Napier. In Malaysia, Napier grass, sometimes known as Indian Napier, has the identifier IKN091 (Abu Bakar et al., 2019). It can grow in a wide range of environments, tolerating various land types, climates, and growing seasons, and only needs a small number of inputs to grow

(Kommula et al., 2016). This grass develops in tropical soils because it is productive, simple to grow, drought-tolerant, and adaptable to a wide range of environmental factors (Lee et al., 2022). Napier grass (*Pennisetum purpureum*), is morphologically robust, tall, and a perennial bunchgrass that is predominantly propagated by stem cutting (Reddy et al., 2018). It can take only three to four months to reach maturity after planting, and it can keep growing every six to eight weeks for up to 5 years (Ridzuan et al., 2015). The plants create 15–25 cm long, short, creeping rhizomes with fine roots at the nodes (Daud et al., 2014). Napier grass is a natural, quickly expanding plant that just needs a small nutrient supplement (Reddy et al., 2018) Its potential as an energy crop for the creation of commercially viable biomaterials is enhanced by the fact that it can be harvested up to four or five times annually. Napier grass fibre strands were obtained by combining the mechanical and water retting processes (Adeniyi et al., 2021). It is extremely sustainable. These fibres were obtained using a straightforward hand water retting procedure, and then they underwent an alkaline treatment (Haameem J.A. et al., 2016). Each plant of grass is 40% or so of each plant's production is fiber whether Napier grass fibers could be used as a green composite reinforcement (Reddy et al., 2012). The use of Napier grass fibres for the production of biofuels and biomaterials can be found in the literature (Adeniyi et al., 2021). To produce cellulose single fibres for use in large-scale applications, new biomass sources are being investigated. As a result, Napier grass has the potential to be an extremely appealing commercial biomass source for the manufacturing of single fibres (Reddy et al., 2018). The about 20-m napier grass fibre length, which is similar to the short fibre hardwoods, gives an idea of the potential utility of these naturally uncultivated crops in the production of pulp and paper (Lim et al., 2020). The composite that had optimum tensile and flexural characteristics contained 25% volume percentage of Napier fibre. Both the long and short Napier fiber-reinforced composites indicated decreased strength and modulus with an additional increase in the volume fraction of up to 30% (Haameem et al., 2016). In order to create a zero-waste environment, Napier grass, sugarcane stem, and other underutilised discarded grass-type biomass are pulped for improved biomass conversion. This work proposes an effective way for enhancing the conventional wood-pulping technology and provides a firm foundation for understanding the actual potential of grass-type biomass for paper manufacturing (Lee et al., 2022).

Fig. 3. Napier Grass

Fig. 4. Vetiver Grass

2.4 Vetiver Grass Fibre

VetiveriaZizanoides, a perrineally growing grass that is native to India, is a member of the grass family. In both north and south India, it is also referred to as khas. Vetiver Grass plant shows in Fig. 4. The grass has a large fine root system that can reach depths of 2 to 6 m in the first year of planting and can grow as high as 2 metres. A perennial grass with a deep root structure, vetiver grass produces a lot of bio-mass and has distinctive morphological traits (Kumar et al., 2019). Since vetiver is commonly grown throughout Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Rajasthan, and Uttar Pradesh, it can help Indian farmers make a living. Due to its role in traditional medicine, pest control, and aromatic materials, vetiver essential oil can also be utilised as a therapeutic aromatic plant (Rukhaya et al., 2022). By using photosynthesis, vetiver grass seeding in agricultural areas will add carbon to the soil. It preserves organic stuff in the soil. In order to maximise soil carbon storage, it is crucial to maintain the soil and plant properly while growing vetiver grass systems (Teshale & Legesse, 2022). The vetiver plant is a low-cost, environmentally friendly solution for bioremediation, wastewater treatment, and soil and water conservation. Pharmaceutical and cosmetic companies frequently use vetiver essential oil. Vetiver oil is recognised to help with mental illnesses like stress, anxiety, and depression. It has antitubercular, antioxidant, antibacterial, antifungal, and other qualities (Varaha et al., 2020). Vetiveria was first used for its aromatic and therapeutic purposes by the Indians, who went on to employ it for additional domestic and environmental purposes in India and other places (Lavania, 2008). Assess the impact of Vetiver on the elimination of methane produced in anaerobic treatment processes. Study the usage of Vetiver plant by-product as biomass utilised for biofuel generation (Darajeh et al., 2019). These two versatile crops could be co-cultivated and integrated to offer important advantages to a target community, foster rural economic growth, and contribute to food and energy security. Handicraft items like hats, bags, doormats, dolls and toys, crochet, beautiful jewellery, and coral sculpture are produced using local resources like vetiver, aloes, and coconut shells. For many households, handicraft is a source of income. Handicraft items like hats, bags, doormats, dolls and toys, crochet, beautiful jewellery, and coral sculpture are produced using local resources like vetiver, aloes, and coconut shells (Raman et al., 2018). The raw material vetiver can be used to make pulp and paper. Studies at the Forest Research Institute, Dehradun in India found that vetiver may be digested with lime to produce pulps appropriate for producing strawboards. Hemicellulose is abundant in vetiver, which has a cellulose concentration of 45.8%. (DW). Vetiver grass undergoes chemical processing to yield a pulp suitable for writing and printing sheets, but necessitates blending with long-fibered pulp due to its short fibers. Microscopic analysis reveals distinct polygonal grouping of vetiver fiber cross-sections and bundled structure of long fibers. Characterized by stiffness, glossiness, and moderate tenacity, vetiver fibers produce a thick and rough, hemp-like cloth with diverse applications such as women's gowns and table mats, offering a visually striking and versatile textile option (Keunun 2013).The vetiver grass fiber was stretched, braided, and combined with natural and synthetic fibers, which resulted in diverse qualities in terms of flexibility and pulling strength over time (Chandhasa et al., 2017). Producing baby bedding using vetiver root grains, cotton, and bamboo fibers in a ratio of 1:3:1, or 20% bamboo and 60% cotton fiber, 20% cut vetiver root pieces (Rachel and Kumar, 2017). This project work on a cushion bed for babies represents a successful attempt to create an eco-friendly nonwoven fabric bed cover cushion composed of cotton & bamboo fiber with grains of vetiver. Applications for relieving stress, back discomfort, skin rashes, and other anti-microbial clearance in the medical area. The roots' pleasant aroma makes them suitable for use in clever fabrics. Rather, there are various fresh textiles for the home, such as mattresses, pillows, and sofas. A new item for textiles used as bedding for babies (Rachel et al., 2018). The vetiver extract treated fabric has more thermal conductivity and less thermal resistance than the untreated fabric, resulting in more heat transmission in the vetiver extract treated fabric than in untreated cotton fabric, according to the comfort property test. The results of the air and water vapor permeability tests also indicated that there was a minimal difference between cotton fabrics coated with vetiver extract and cotton fabrics that had not been treated, and that the coated fabrics had better wicking properties than the untreated fabrics because molecules were deposited in the fabric's structure (Ampritha, 2019). Vetiver zizanoides is a rich source of numerous phyto and bio active constituents namely diethyl pathalate, Isopropyl dimethyl carboxylic acid etc. registered free radical scavenging, anti-inflammatory, UV protection, antimicrobial, antifungal and aromatic properties Better morphological and thermal qualities made the vetiver oil microcapsules ideal for finishing textiles. Even after many washings, the treated fabric maintained its antibacterial and fragrant qualities. They also keep the wearer more comfortable and healthier while emitting a calming, cooling, and pleasant fragrance. As a result, the eco-designed multifunctional knitted fabric is appropriate for a variety of health care textiles, including hosiery and clothes for hospitals and infants (Kudligi et al., 2020). Form, cotton fabric, sponge layers, and Vetiver root grain are used to create the handmade textile organic bag. This is an innovative textile artefact made by hand that the young people of the society can use to protect their mobile devices, tablets, and laptops from the heat. The acceptability of the bag was examined using a descriptive analytical method. The study's findings supported the viability of employing this organic, 3-in-1 vetiver pouch in handcrafted textile items. Vetiver root grains are needed and sough off by the IT employees in order for the novel textile artefact to evade heat for mobile, tab, and laptop devices (Rachel et al., 2018).

2.5 Parthenium Grass Fibre

The Asteraceae family includes the foreign annual herb *Parthenium hysterophorus*. *Parthenium hysterophorus* has recently been spreading around the globe from India, Africa, and pacific islands, especially to Australia (Singh and Kaushik, 2020). It has spread to every Indian state. In terms of density and infection intensity, the most heavily infested states are A.P., Bihar, Chhattisgarh, Delhi, Haryana, Karnataka, Maharashtra, M.P., Punjab, Tamil Nadu, and U.P. In Assam, Gujarat, H.P., Jharkhand, J.K., Uttarakhand, Orissa, W.B., and Rajasthan, the infestation level is moderate (Raj & Jha, 2017). In wastelands, public green spaces, orchards, forests, flood plains, agricultural regions, urban settings, overgrazed pastures, industrial areas, playgrounds, roadsides, railroad lines, and residential plots, parthenium (Kaur et al., 2014). Its popular names include Congress grass, Congress weed, Santa Maria feverfew, broom bush, Bitter weed, Carrot grass, False ragweed, Fever few, White top, and the "Scourge of India." It is a native of the American tropics (Kapoor, 2012; B.N. et al., 2017). An erect plant, P. hysterophorus grows to a mean height of 2 meters. It adjusts to different agroclimatic conditions and practically disperses itself to a variety of developing environmental circumstances (Tafese, 2015). In one lifespan, it generates between 10,000 and 14,000 seeds, which can be spread via a variety of methods. It might be found in a variety of environments, including abandoned lots, gardens, roadways, and around buildings, all of which have been advantageous for the growth of this plant because there is little interspecies competition there (Singh and Kaushik, 2020). In ideal soil, the plant can eventually grow to a height of 2 m as it matures and generates numerous branches in its top half (Gnanavel, 2013). The plant may mature and set seed at a height of just 10 cm under dry conditions. The leaves are 30-60 mm long, heavily lobed, and hairy. The stems are robust, rigid, and coated in tiny hairs (Paudel, 2010) as shown in Fig. 5. It is an upright, heavily branched annual herb that is notorious for being a health, agricultural, and environmental problem (B.N. et al., 2017). The plant is used to cure heart problems, fever, anaemia, wounds, and ulcerated sores. The root's decoction is used to cure diarrhoea, while extracts with lesser concentrations could be used as an antifungal. It is used topically for skin conditions, and a decoction of the plant is frequently ingested as a treatment for a wide range of illnesses (Bagchi et al., 2016). It is a good nitrogen source and aids in the preservation of soil qualities by forming aggregates. The "Parthenin" content controls growth, ensuring that the following crop grows successfully. By limiting photosynthesis, mulching has a suffocating impact on weeds. Additionally, it improves the soil's quality, lowers surface temperatures, fertilizes the soil, and protects it from the rainy season (Gnanavel, 2013). We can use parthenium constituents to achieve our goals. Information is available on the impact of Parthenium on crops and its potential use as compost, a biopesticide, and green leaf manure (Kishor et al., 2010)This undesired plant can be turned into a financially advantageous plant by taking into account its biological activity in the areas of antibacterial, antidiabetic, anti-inflammatory, and its other substantial medicinal and industrial applications (Girish et al., 2020).Parthenium can treatment for gynaecological issues, skin rashes, herpes, toothaches, diarrhoea, and headaches (Bristone et al., 2020). Researchers claim that they have discovered its beneficial properties, including anti-tumour, anti-hepatitis virus, and also against other viral and bacterial disorders. It can also be used to remove heavy metals from the soil, but in all of these cases, authorities must pay close attention lest we be unable to handle the impacts it will have on the ecology (Shah, 2020). The *Parthenium hysterophorus* can replace compost because it is a strong provider of micro and macronutrients. This weed has an excessive number of these macro and micro elements, thus because of this quality, it can be used to provide agricultural plants. The *parthenium hysterophorus*, Lantana camara, Solanum nigrum, Eupatorium adenophorum, Tridax procumbens leaves were collected, dried and then powdered it. The powdered dye was used to dye the wool and silk fabric. Different natural and synthetic mordants can be used to obtain varied range of hues and shades with acceptable fastness properties. Therefore, some weed plants can be used for textile dyeing which will provide a scope for management of weed plants as well as safety of other useful indigenous plants (Bhandari and Rani, 2018). The study defined that extraction of dye with matured leaves of *parthenium hysterophorus* and used for dye the taser silk fabric with selected metallic salts in acidic media. It has good colour fastness properties and produce various eye cooling shades (Sarkar & Deo, 2010). *Parthenium hysterophorus* fibres (PHF) were manually retted from the plant's stem. After that, the properties of the alkali-treated and untreated fibres were compared. PHF treated with alkali showed improved density and decreased diameter. PHF that has been alkali-treated has a higher crystallinity index than untreated PHF (40.68%), at 48.89%. With alkali-treated PHF, the ultimate tensile strength rose 1.32 times. In natural fibre composites, *Parthenium hysterophorus* fibres can be employed as reinforcement (Vijay et al., 2021).

Fig. 5. Parthenium Grass

3. COMPARTIVE ANALYSIS OF GRASS FIBRES

3.1 Chemical Composition of Fibre

Natural fibres are often composed of cellulose, hemicellulose, and lignin layers as shown in Table 2. The lignin layer, the hemicellulose layer, and the innermost cellulose layer often make up the outermost layer of fibre. Since cellulose has high adhesive characteristics with a matrix throughout the composite's manufacturing process, cellulose is the most significant component of natural fibre. High cellulose content fibres usually have excellent mechanical properties (Lokantara et al., 2020). Moreover, the mechanical characteristics of plant fibres are influenced by their morphological, chemical, and physical characteristics. While a single fiber's characteristics are influenced by its size, shape, orientation, crystalline content, and cell wall thickness (Thyavihalli Girijappa et al., 2019). Environmental factors including growth, location (such as altitude or place), nutrients, temperature and season, and local climate condition all have an impact on the size and quality of fibres (Dittenber & Ganga Rao, 2012) Cellulose fibres, which are composed of helically wound cellulose microfibrils bonded together by an amorphous lignin matrix, constitute natural plant fibres. Lignin functions as a stiffener to provide the stem its resistance against wind and gravity forces, maintains water in the fibres, and protects against biological attack. It is thought that hemicellulose, which is present in natural fibres, acts as a compatibilizer between lignin and cellulose (Hansen and Björkman, 1998).

The chemical composition of different grass fibres varied. It was found that the cellulose content of parthenium grass fibre had smallest value i.e., 34% and highest value was 52.3 % (Nettle grass fibre). The hemicellulose content varies from smallest of 9% (Nettle) to the highest value of 46.5% (Napier grass fibre). Lignin of each grass fibre varied from 7.9% (Vetiver grass fibre) to 22.25% (Napier grass fibre).

3.2 Properties of Grass Fibre

Several factors, including variety, climate, harvest, maturity, degree of retting, decortications, disintegration (mechanical, steam explosion treatment), fibre modification, textile, and technical processes (spinning and carding), influence the qualities of natural fibres (Van de Velde & Kiekens, 2001). Additionally, the tensile strength is influenced by the extraction technique, chemical treatment, and the presence of cellulose, hemicellulose, and lignin in natural fibres (Vijay et al., 2021).

The properties of various grass fibres are summarized in Table 3. Fibre length is crucial for yarn spinnability, with nettle grass fibres having the longest length (43-58 mm) and sabai grass fibres the shortest (20 mm), likely due to differences in environmental conditions and species.

Table 2. Chemical Composition of Grass fibres

S.No.	Plants	Scientific Name	Chemical Composition		
			Cellulose w/w%	**Hemicellulose w/w%**	**Lignin W/w%**
a)	**Sabai**	*Eulaliopsis binata*	45%	21%	18%
b)	**Nettle**	*Urtica dioica*	52.34%	9.4%	18%
c)	**Napier**	*Pennisetum purpureum*	34.14%	46.58%	22.25%
d)	**Vetiver**	Chrysopogonzizanioides	34.4%	39.4%	7.9%
e)	**Gajar Ghas**	*Parthenium hysterophorus*	28%	21%	13-17%
Citation	a) (Guna et al., 2019) b(Bacci et al., 2011) c) (Kamarullah et al., 2015) d) (Methacanon et al., 2003) e) (Saini et al., 2014)				

Table 3. Properties of Grass fibre

S.No.	Grasses / Properties	Sabai Grass	Nettle Grass	Napier Grass	Vetiver Grass	Gajar Grass
a)	Fibre Length (in cm)	20 mm	43 to 58 mm	10-30 mm	80 mm	12-50 mm
b)	Fibre Diameter (in µm)	103 µm	62-100 µm	198.4 µm	100-220 µm	381 µm
c)	Elongation (%)	3.4%	2.3-2.8 %	2.8% (2)	1.6-2.4	1.8%
d)	Modulus(g/den)	21 GPa	87GPa	39-47GPa	12.0-49.8	41 GPa
e)	Strength	493 MPa	1594 (±640) MPa	106 MPa	328.28	10.8 ± 0.15 MPa
Citation	(Guna et al., 2019; Dwari & Khandual, 2018; Haameem J.A. et al., 2016; S. Kumar et al., 2024; Nigam et al., 2021; Vijay et al., 2021; Ruksakulpiwat et al., 2007; Samanta, 2021) (Somnuk et al., 2006; Sujith and Musthafa, 2022; Suryawan et al., 2017)					

Regarding fibre diameter, gajar grass exhibited the largest diameter (318 µm), while sabai grass had the smallest (103 µm). Nettle grass fibres ranged from 62-100 µm, Napier grass fibres measured 198.4 µm, and Vetiver grass fibres ranged from 100-220 µm.

Natural fibres are less expensive, more energy-efficient, and lower in density than synthetic or glass fibres. They are recyclable, renewable, and their porous nature complicates precise density measurements. In terms of elongation, sabai grass fibres had the highest elongation percentage (3.4%), while gajar grass fibres had the lowest (1.8%). Nettle grass fibres ranged from 2.3-2.8%, Napier grass fibres were at 2.8%, and Vetiver grass fibres ranged from 1.6–2.4%. Young's modulus and tensile strength correlated positively with cellulose content, while lignin negatively affected these properties. Wax content also positively influenced Young's modulus, while lignin and pectin reduced it. Hemicellulose and lignin affected moisture absorption. Nettle grass fibres had the highest Young's modulus (87 GPa), followed by Vetiver grass fibers (12-49.5 GPa), Napier grass fibres (39-47 GPa), and sabai grass fibres (21 GPa). In tensile strength, sabai grass fibres showed the highest value (493 MPa), followed by Vetiver grass (382.2 MPa) and Napier grass (106 MPa). Nettle grass fibres demonstrated superior strength compared to other grass fibres**.** As the result, the properties of grass fibre is good and a better options as a textile fibre.

4. CONCLUSION

To achieve long-term sustainability, global industries must transition gradually towards greener practices. While expecting an overnight transformation is unrealistic, small steps can be taken to adopt more environmentally friendly approaches to production. Natural fibres are superior materials that can take the place of existing synthetic fibres. Plastics are being used more often, particularly in homes and businesses. The usage of plastic products puts the ecological system at threat by causing an accumulation of non-biodegradable waste. Therefore, the research has been carried out on grass and the grass fibre one of the emergent areas in textile science that makes awareness for use in various applications. It can be concluded that the chemical composition, fibre length, diameter, fineness, elongation, modulus, and tensile strength are main properties have been analysed by various researchers. Grass fibre can become an effective source and products for textile industries.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/127401