

Ramie - A Green Resource for Fibre and Feed

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Owing to exponential increase in world population and depletion of natural resources poses a threat to environmental sustainability and widens the gap between the availability of resources and the capacity to meet human demands. Presently, identifying plant species capable of meeting the needs of both humans and animals while conserving natural resources represents a major challenge to scientific community. Therefore, researchers are interested in studying underutilized crops for their potential benefits. Ramie, a stiffest bast fibre known for its highest length, strength, good durability and excellent lustre. It has a multipurpose application in textiles, livestock feed, environment conservation and medicinal value. The present view of article provides discussion on multipurpose use and constrains of ramie.

Key words- Bast fibre, Degumming, Feed, livestock, Quality

Ramie (*Boehmeria nivea*), commonly referred to as China grass, white ramie, green ramie, or rhea. It is native to East Asia and predominantly grown in tropical and subtropical regions, such as China, India, Brazil, South Korea, Taiwan, Thailand, and the Philippines. Ramie is considering as oldest textile crop, with historical evidence of its use in making mummy cloth in Egypt dating back to 5000-7000 BC. Taxonomically, it belongs to the family Urticaceae, comprising about 100 species under the *Boehmeria* genus, and recognized as the second most important fibre in global trade. Unlike other bast fibres, ramie exhibits several unique characteristics. It is the longest natural plant fibre well known for its white, shiny, and silky appearance. Ramie is a long-lived perennial crop, with a lifespan of 6-20 years, and can be harvest up to six times per year. The bark phloem contains high levels of colloidal substances, such as gums and pectin, which require chemical treatment for effective fibre extraction. Ramie fibre is also noted for its anti-decay and antibacterial properties, making it valuable for healthcare and hygiene-related applications. Owing to its remarkable physical and chemical characteristics, ramie is often referred to as the “King of Natural Fibres”. In India, ramie cultivation is concentrated mainly in the north-eastern states, with limited production in Maharashtra, Goa, and Tamil Nadu.

Ramie is traditionally grown as a fibre crop; however, it is also recognized as a valuable source of nutritious green fodder. The leaves and tender tops are low in crude fibre content and rich in protein, essential minerals, lysine, carotenoids, riboflavin, and calcium. Its nutritional value is comparable to that of alfalfa (*Medicago sativa*). Furthermore, it serves as an effective phytoremediation of heavy metals in degraded lands. Despite its multiple benefits, the cultivation of ramie remains limited compared to that of other fibre crops. Major constraints include underdeveloped ramie-based industries, difficulties in crop establishment, labour and technology intensive processes such as fibre decortication and degumming, and the lack of well-defined market opportunities for its products.



Figure 1: Ramie crop in the field

Botanical description of ramie

Ramie is a hardy perennial, monoecious species belonging to the family urticaceae. The genus *Boehmeria* (x=14) comprises more than 100 species, of which the cultivated species are *Boehmeria nivea* (white ramie) and *B. nivea* var. *tenacissima* (green ramie). The differences between these two cultivated forms are presented in Table 1. The root system is deep and extensive up to one meter in depth. The stem is unbranched, green, and pubescent with short and long serial stems, it grows to a height of 2-3 m and a diameter of 12-20 mm; these are individually called canes. A collection of several canes is known as a culm. The canes turn brown and woody upon reaching maturity. Crop is grown from rhizome, seed and stem cuttings however for commercial production propagated vegetatively through rhizomes and stem cuttings. The plant is monoecious, with male flowers borne on the lower portions of the stalk and female flowers on the upper portions in axillary panicles. Each leaf axil bears two panicles with small greenish-white flowers. The seeds are small, oval, coffee-coloured, and fertile.

Table 1: Difference between white and green ramie species

Character	White ramie	Green ramie
Scientific name	<i>Boehmeria nivea</i>	<i>B. nivea</i> var. <i>tenacissima</i>
Chromosome no.	2n=28	2n=24
Commonly name	True ramie, China grass	Rhea
Origin	China	Malay Peninsular
Region	Temperate and subtropical	Temperate
Leaves	Large heart shaped, crenate leaves covered on the underside with white hairs that give it a silvery appearance	Smaller leaves which are green on the underside
Fibre quality	Finer, longer, and naturally whiter fibre. Highly prized for premium textiles	Stronger fibre, but it is typically coarser and less white (often greenish-yellow)

Crop husbandry of ramie

Ramie grows well under warm and humid conditions with an optimum temperature of 25-31°C, annual rainfall of 1500-2500 mm, and relative humidity around 80%. It prefers well-drain loamy to sandy loam soils with a pH of 5.5-6.5 and is sensitive to waterlogging, frost, and strong winds. Planting usually carried out from the onset of the monsoon to October, while in North-Eastern India it planted during February-March and September-October. The crop is propagated vegetatively through rhizomes, plantlets (60,000 plantlets/ha), stem cuttings, or waste stalks planted at an angle of 45° with furrow spacing of 60 × 30 cm. Under acidic conditions, lime @ 3-4 t/ha and FYM @ 10-15 t ha⁻¹ are recommended. Fertilizers are applied at 20:10:10 kg/ha N:P₂O₅: K₂O after planting, followed by 30:15:15 kg/ha per cut during the first two years and 60:30:30 kg/ha per cut from the third year onwards. Application of quizalofopethyl 10% EC @ 40 g/ha or quizalofopethyl 5% EC @ 60 g/ha at 20 days after each cutting followed by one hand weeding effectively control all grassy weeds in ramie and is recommended for entire ramie growing regions. Ramie has significant potential in diversified cropping systems, proving remunerative as an intercrop with wheat, mustard, and pea and multi-tier agroforestry. Successful regional models include combinations with rubber and cinnamon, coconut and black pepper, mango and black pepper, and arecanut. Raw fibre yields up to 16-22 q/ha. The average fibre content in ramie is about 3 to 4% of green biomass of the crop. Ramie cultivation generates a net profit of approximately Rs. 25,000-40,000 per hectare annually from the second year onward through the sale of degummed fibre @ Rs. 60/kg. In addition, farmers can earn a net profit of about Rs. 2,50,000-3,00,000 per hectare from the sale of rhizomes @ Rs. 30/kg in the fifth year (Mitra et al., 2021).

Ramie as a fibre crop and its characteristics

Ramie recognized as the strongest natural bast fibre having notable physical and chemical properties (Table 2). Ramie fibres are multicellular, relatively short in length, and are arranged in bundles. Anatomically, they are prosenchymatous in origin, consisting of elongated cells with tapering ends commonly found in supporting tissues such as collenchyma or sclerenchyma. As these fibres not derived from the secondary activity of the cambium, they are considered primary in origin, which differentiate from jute and kenaf (Mesta) fibres.

Table 2: Physical and chemical properties of ramie fibre

Properties	Values
Fibre length (mm)	20-250
Fibre diameter (mm)	40-60
Length: breath ratio	3500
Cellulose (%)	68.5-91
Hemicellulose (%)	5-16.7
Lignin (%)	0.6-0.7
Fibre strength (g tex ⁻¹)	65
Fibre fineness (tex)	0.8
Moisture regaining capacity (%)	12

(Dittenber and Gangrao, 2012).

Fibre extraction and degumming

Harvesting is done manually by cutting stalks near ground level. Cortex or bark removed, either by hand or machine, in a process called decortication. Decorticated ramie fibre contains about 19-30% gummy substances, primarily composed of a heterogeneous mixture of carbohydrates, mainly pectin's and other polysaccharides. The process of removing these materials called as degumming. Currently, degumming can be performed using physical, chemical, biological, 1, or biochemical methods.

Physical method: Ramie fibre is treat with physical means, such as mechanical rolling, ultrasound, supercritical CO₂ and stem blasting to break H-bonds between cellulose molecules and to weaken binding between fibres.

Chemical method: According to the National Institute of Research on Jute and Allied Fibre Technology, chemical degumming is perform at 96-98°C for 2 hours using a 1% NaOH solution containing a wetting agent, followed by treatment with 0.5% Na₂SO₄ to improve fibre tenacity. The degummed ramie fibres are yellowish in colour. Subsequently bleached with ClO₂ or H₂O₂ at elevated temperatures to obtain cleaner and brighter fibres (Mitra et al., 2013).

Biological degumming: During degumming, ramie gums are treat either with non-cellulolytic microorganisms in situ or with extracellular enzymes that utilize gum hydrolysates as a carbon source for metabolic activity. Several effective pectin-degrading microbial strains lacking cellulolytic activity have been identify, including *Paenibacillus campinasensis* BL11, *Bacillus pumilus* DKS1, *Bacillus clausii*, *Bacillus cereus*, *Bacillus tequilensis*, and *Actinomyces* sp. However, microbial degumming often results in process instability and incomplete gum removal, however enzymatic degumming relies on the synergistic action of pectin-degrading and hemicellulose-degrading enzymes, such as pectinase, mannanase, and xylanase (Cheng et al., 2020). This process is most effective at moderate temperatures ranging from 40°C to 70°C under alkaline pH 8-11, where gum-like substances become more soluble. These conditions not only enhance degumming efficiency but also help maintain fibre quality.

Biochemical method: A combination of biological and chemical method to reduce the chemical usage and maximize degumming process. Liu et al. (2012) applied the synergistic degradation of different enzyme components (enzyme complexes of pectinase and hemicellulase) to degum ramie at pH 7-10, followed by treating with $2\text{Na}_2\text{CO}_3 \cdot 3\text{H}_2\text{O}_2$ to inactivate enzymatic catalysis. Biodegradation of pectin is done by neutral pectinolytic bacteria (Stains-DKS, AK1, S1) and alkalophilic pectinolytic bacteria (Stains-SM21 and SM22) under anaerobic condition for 6-7 days followed by boiling in open vat at 90°C for 30 min with 1% alkali (Mitra et al., 2013). Degummed fibres are silky and light.

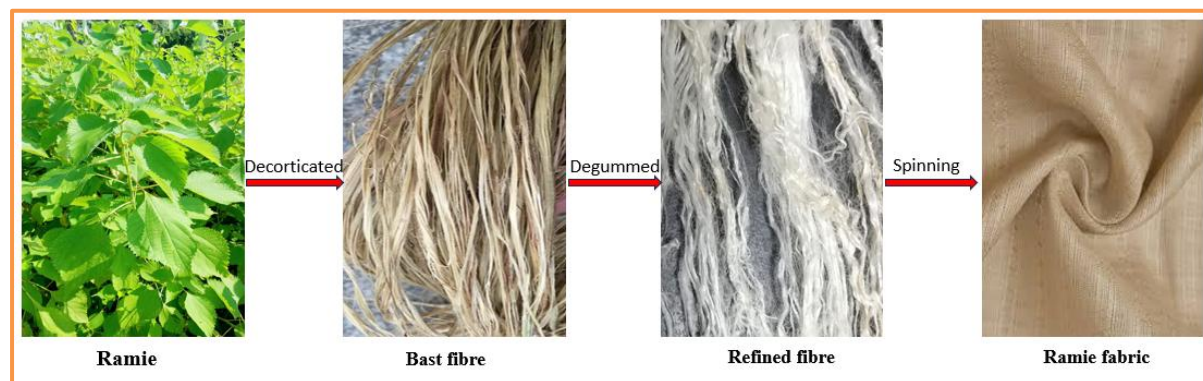


Figure 2: Main processing of ramie fibre

Ramie as a feed crop

In India, feed expenses constitute nearly 70% of the total operational cost in dairy animal production. The rising cost of conventional livestock feed, coupled with the increasing demand for high-protein feed, has reinforced the need for exploring alternative crop sources. Ramie is a fast-growing perennial plant used as a source of bast fibre and green nutritious feed. The whole plant provides a valuable feed for cattle, pigs and poultry, containing high digestible fibre and protein. Ramie can be ensiled with molasses, dried artificially to create leaf meal, or fed as green fodder. It is a desirable source of animal feed with higher crude protein content than other balanced feedstuffs on the market.



Figure 3: Overview of Ramie as a Feed Resource for Livestock (Rehman et al., 2019)

Constrains

Despite its potential uses as fibre and feed to livestock, ramie fibre holds secondary importance compared to other plant fibres in global trade. The major limitation in production and utilization is lack of efficient large-scale fibre extraction machinery, the high cost associated with degumming, spinning, and weaving, inefficiency in degumming process due to requirement of high temperature, lack of availability of efficient microbial stains and the high price of ramie-based products. Nevertheless, these constraints can be addressed by focusing on advancement in developing appropriate technologies and machinery.

Conclusion

Ramie serves as an alternative plant species that can be utilized for both bast fibre production and livestock feed. Its major advantages lie in its versatility, as it can be cultivated in different agroclimatic zones where the cultivation of most other field crops is challenging. The high nutritional value of ramie has increased interest in its use beyond fibre production. In addition to being a fibre crop, ramie can serve as a valuable fodder source for livestock. The increasing demand for plant-based protein feeds has further enhanced its potential, providing new opportunities to support the growth and sustainability of the ramie industry.