Evaluation of commercial cultivars of banana (*Musa* spp.) for their suitability for the fibre industry

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Summary
Evaluation of commercial cultivars of banana (*Musa* spp.) for their suitability for the fibre industry
Banana (*Musa* spp.) fibre has many and varied applications in the pulp and paper industry, as well as acting as a natural water purifier, and having uses in bioremediation and recycling, for printing currency, and also in the textile industry. Fibre is extracted from the plant pseudostem either manually or mechanically. Six commercial banana cultivars of different genomic groups (AAA, AAB and ABB) were tested to evaluate their suitability for use in the fibre industry. Various yield and quality components such as biomass production, fibre yield, total soluble solids, pH, total acidity, moisture content, total carbohydrates and total cellulose were analyzed. The fibre yield was found to be higher in AAB genomes, represented by 'Pachanadan' and 'Poovan', than the others. However, all the commercial varieties yielded good-quality fibre, as indicated by their cellulose content.

Key words: banana, biomass, cellulose, fibre, leaf sheath, pseudostem

Résumé
Évaluation de cultivars commerciaux de banane (*Musa* spp.) comme source de fibre industrielle
La fibre de banane (*Musa* spp.) se prête à des applications nombreuses et variées : dans l'industrie de la pâte et du papier, comme système naturel de purification d'eau, dans la bioremédiation et le recyclage, l'impression du papier-monnaie, ainsi que dans l'industrie textile. La fibre est extraite du pseudo-tronc de la plante par un procédé manuel ou mécanique. Six cultivars commerciaux de banane de différents groupes génomiques (AAA, AAB et ABB) ont été testés pour évaluer la possibilité de les utiliser comme fibre industrielle. Différents critères de rendement et de qualité tels que production de biomasse, rendement en fibres industrielles, solides solubles totaux, pH, acidité totale, teneur en eau, glucides totaux et cellulose totale ont été analysés. Un rendement en fibres plus élevé a été observé dans le cas des génomes AAB, représentés par « Pachanadan » et « Poovan ». Cependant, toutes les variétés commerciales produisent des fibres de bonne qualité, comme l'indique leur teneur en cellulose.

Resumen
Evaluación de cultivares comerciales de banana (*Musa* spp.) en cuanto a su adecuación para la industria de la fibra
La fibra de banana (*Musa* spp.) tiene numerosas y variadas aplicaciones en la industria de la pasta y el papel; actúa como un purificador natural del agua y es usada en biomedicación y reciclado, la impresión de dinero y también en la industria textil. La fibra se extrae del seudotallo de la planta, tanto a mano como de manera mecánica. Se probaron seis cultivares comerciales de banana de diferentes grupos genómicos (AAA, AAB y ABB) para estimar si resultaban adecuados para la industria de la fibra. Se analizaron varios componentes de calidad y rendimiento, como la producción de biomasa, rendimiento de fibra, total de sólidos solubles, pH, acidez total, contenido de humedad, total de hidratos de carbono y total de celulosa. Se halló que el rendimiento de fibra era mayor en los genomas AAB representados por 'Pachanadan' y 'Poovan' que en los otros. Sin embargo todas las variedades comerciales produjeron fibra de buena calidad, como lo indicaba su contenido de celulosa.

Introduction
Bananas and plantains (*Musa* spp.) are important crops within the global fruit industry. They are cultivated in over 120 countries, over an area of 10 million hectares, with an annual production of 88 million metric tonnes (Sharrock and Frison 1998).

In India, banana is appropriately referred as '*Kalpatharu*', a plant of all virtues. Each and every part of the plant is used for specific purposes. Apart from its use as a dessert fruit and for culinary purposes, the banana plant has multifaceted uses: the leaf is commonly used as a hygienic dining plate; the male flower is a favourite vegetable; the inner core of the pseudostem is a popular vegetable, with many therapeutic uses; the sap is used as an indelible ink in industry and the underground rhizome is exploited as animal feed in a composite mixture with other feedstuffs (Singh and Uma 1996).

The various uses of banana fibre have been collated by Uma et al. (2002). The use of the spent banana plant (after harvesting the bunch) for fibre extraction has slowly gained recognition worldwide because of the multifarious uses of banana fibre in the paper and pulp industry, as a natural water purifier, for bioremediation and recycling, for printing money, in the textile industry as a base material, in small-scale art and handicraft industries, and in the production of a wide range of goods, including rope cordage, yarns, abrasive backing paper, tea bags and shoes. Because banana fibre is biodegradable, carrier bags made from it are an ideal alternative to polythene bags, which are fast becoming an environmental pollutant.

Fibre is extracted from the leaf sheath or pseudostem of the banana plant by decortication of the sheath. The pseudostem is the aerial stem seen above the ground and is formed by closely packed leaf sheaths embedded in the growing tip. Each leaf has a basal leaf sheath forming a part of pseudostem, petiole and lamina. The fresh banana plant yields about 0.6–1.0% of fibre, depending on the variety and method of extraction used (Uma et al. 2002).

Banana fibre characteristics and uses and value-added products
Banana fibre as a natural sorbent
Banana fibres in their natural state produce a highly sorbent material. The key factor is the high porosity and natural capillary action of the fibre, allowing it to absorb oil. Banana

fibre is a super-sorbent, in that less fibre product is needed to remediate any spillage. Banana fibres can be used in sorbent socks, pillows and booms, or as loose fibre to clean up land-based spills.

Banana fibre as a base material for bioremediation and recycling

Organic contamination is frequently treated through 'bioremediation', a method that employs bacteria to 'eat' the contamination. In order for these bacteria to survive within the contaminated environment, they must be provided with a natural substrate material on which they will thrive. Banana fibre provides this medium and could be used in the remediation industry as a natural bioremediation agent.

Banana fibre as a natural water purifier

Banana fibres have already been tested for use as a filtration agent in the treatment of wastewater, which is often contaminated with oils and other organic materials. The natural affinity of banana fibre to oils and organics, and its tendency to repel water, makes it a good natural alternative filtration agent for industrial and municipal waste treatment.

Banana fibre as a base material for the paper and pulp industry

The use of banana pseudostem has been investigated for the production of craft cellulose, to be whitened for use in the manufacture of special paper used in the restoration of documents. The raw material used, at nearly 94% humidity, is obtained from commercial banana plantations.

Wild varieties, which are grown in abundance in the north-eastern Indian forests, can be efficiently used in the pulp industry. After harvesting the bunches, all the spent plants of commercial cultivars can also be used. Paper made out of banana fibre is reported to be of high strength and is used to make tea bags and currency notes.

Banana fibre in the mushroom industry

A study conducted at the Instructional Farm, Vellayani, India, regarding the suitability of banana pseudostem for mushroom cultivation, indicated that banana pseudostem alone and in combination with paddy straw produced comparatively higher mushroom yields than paddy straw alone.

Banana fibre in handicrafts and textiles

A variety of products have been made from banana fibres in the Philippines. The banana fibres were reported to be elegant and highly versatile. As they do not crumple easily, these fibres have been used in the manufacture of dress materials. The fineness of texture depends on the quality of the fibre used. The material has a beautiful sheen and is used for making wedding gowns and barongs.

Hand-extracted fibres have been used to produce handbags, wall hangings, table mats and other fancy articles. The fibre can be powdered and different colours of fibre obtained using natural dyes, which can be made into beautiful pictures. Portraits drawn and filled with colourful banana fibre chips have become popular in the handicraft industry in Mizoram, India, and have good potential in the export market.

Banana fibre: a licence to print money?

Few paper products undergo more continuous handling and folding than currency notes and it is a significant expense for national banks to replace worn banknotes. New Agriculturist (99/4), the online journal also reports that Japanese yen notes printed on paper based on the banana fibre, abaca (*Musa textilis*), exhibited superior tear resistance and tensile strength.

Other uses

A wide range of goods is available, including rope cordage, yarns, abrasive backing paper, tea bags, attractively patterned cloth, handbags/purses and shoes. Exports of abaca products are an important earner of foreign exchange, with the USA taking around two-thirds of exports. Singapore, Australia, Malaysia, Thailand and Europe are also important markets (Uma et al., 2003).

The inherent drawback of banana fibre is its poor quality and higher irregularity, owing to the multi-cellular nature of the fibres. The individual cells are cemented with lignin and hemi-cellulose and thus form a composite fibre. Banana fibre is classified as medium quality fibre and performs very well in combination with other fibres for making fine articles like handicrafts, currency, etc.

The banana fibre industry as a cottage industry: a source of employment

There is great scope for effectively utilizing banana pseudostem waste for the preparation of a whole range of products, as described above. With dwindling traditional resources, the paper industry is also facing an acute shortage of raw materials. There is an urgent need to look for biorenewable and biodegradable raw materials. Banana, satisfying both these primary requirements, represents an excellent alternative for the pulp industry. Although its use is already being exploited, more efficient technology is needed in order to accelerate this industry.

India has about 600 000 ha under banana cultivation, which yields approximately 37 million tonnes (t) of pseudostem waste per year. This could be profitably used for extracting approximately 2.8 million t of fibre, with a wide range of applications. Banana fibre is classified as a hard fibre, based on the fact that it includes strands of whole vascular bundles, including xylem, phloem and true fibres. They have more lignified and rougher surface fibres than cotton and kapok and soft fibres such as flax, ramie, jute and hemp.

The principal constituents of banana fibre are α cellulose (also called cellulose-1) intermingled with hemi-cellulose (polysaccharides) and lignin (Kirby 1963).

There is an enormous potential in India to develop an industry based on banana fibre. The raw-material necessary is freely available and an industry based on banana fibre would increase rural employment opportunities and help to alleviate poverty. Products made from banana fibre would have a good export market, particularly in view of its biodegradable nature.

Genomic status and fibre yield

Though fibre can be extracted from all banana and plantain cultivars, the fibre yield shows great variability according to genomic status (AA, AAA, AB, AAB, ABB, AAABB, AAAB, ABBB, BB), ploidy level (2x, 3x, 4x) and the variety. The relative combinations of the A and B genomes contribute greatly to plant biomass production. In general, the B genome tends to produce strong, bulky plants with greater biomass. Therefore, plants with a greater proportion of the B genome, for instance ABB, produce more biomass than their other triploid counterparts, such as AAA or AAB. Although it has been stated that fibre is extracted from the pseudostem, only the top 8–10 layers of the leaf sheath yield fibre. The fibre-extractable pseudostem and fibre yield percentages were found to be 46.4% of the total plant weight and 0.53% of the extractable pseudostem in dessert cultivars and 55.2% and 0.78%, respectively, in culinary types (Uma et al. 2003). The present study therefore used six major commercial clones of banana, including culinary and dessert cultivars, which were conventionally grown, to study the characteristics of these varieties with respect to fibre yield and quality.

Materials and methods

Test clones

Five indigenous cultivars and one popular exotic introduction, all with commercial importance, were tested. The details of the clones in terms of their taxonomic status and other traits in the Indian banana industry are shown in Table 1.

Crop production

Thirty plants of each test clone were planted in a completely randomized block at the NRCB Research Farm, Trichy, India, in February 2002 - 03 under the prevailing wet-land production system. Plants were given a routine application of nutrients (250:50:300 g NPK per plant along with 20 kg of vermi-compost and 20 g of furadon twice during February–April depending on their duration). The bunch was harvested separately and the plant, minus bunch, was taken for biomass production.

Biomass estimation

The whole plant was uprooted after bunch harvesting and was separated into individual plant parts such as leaves + pedicle, corm + roots, and pseudostem. They were weighed separately to calculate the biomass.

Table 1. Details of the commercial test clones used in this study

Cultivar	Genomic status & sub group	Area under cultivation ('000 ha)	Other traits
Robusta	AAA (Cavendish)	248.5	-Mainstay of the banana market -Grown under high input conditions, largely by progressive growers -Highly susceptible to pests and diseases -High-priced variety -Dessert variety
Poovan	AAB (Mysore)	24.3	-Poor-man's variety, suited to marginal conditions -Traditional cultivar of southern and north-eastern states of India -Partially resistant to many biotic and abiotic stresses -Dessert variety
Pachanadan	AAB (Pome)	16.1	-Popular cultivar in higher altitudes -Preferred variety of southern States -Dessert cultivar
Karpuravalli	ABB (Pisang Awak)	12.5	-Poor-man's crop suited to all types of soil and weather conditions -Highly tolerant to pests and diseases -Suitable for processing into value-added products -Dual-purpose variety
Peyan	ABB (Unique)	0.1	-Cultivar with therapeutic value -Potential backyard cultivar of traditional banana-growing zones -Dessert cultivar
Saba	ABB (Bluggoe)	12.8	-Exotic introduction from the Philippines (through ITC, Belgium) -Promising substitute for Bluggoe group of cooking bananas -Highly suited to marginal soils -Dual-purpose variety

Fibre extraction and fibre yield

The pseudostem was further divided into fibre-extractable pseudostem and fibre-non-extractable pseudostem. Starting from the outermost layers, up to 10 layers were taken as fibre-extractable pseudostem, and each layer was weighed separately for fibre yield. Fibre was extracted manually. The weighed fibre-extractable pseudostem was cut into 1 m pieces and placed on a wooden board. Using a sharp, flat steel scraper with a wooden handle, the epidermal layer was first removed and the sheaths were scraped until the fibre was free from soft pithy material, epidermis and other extraneous matter.

Biochemical parameters

Preparation of sample

Samples were randomly collected from each layer of the fibre-extractable pseudostem of each banana plant, cut into small pieces, and ground in an electric mixer to achieve maximum uniformity. This paste was used for the biochemical analysis. The paste was squeezed through a muslin cloth and the juice was collected for measuring total soluble solids (TSS) and pH.

Total soluble solids (TSS) and pH

The juice of the pseudostem was analyzed using an Erma hand refractometer (0–32°Brix) for estimating the amount of TSS, and the results obtained were expressed in °Brix.

The pH of the pseudostem was estimated using an Elico India (Model L1-127) pH-meter.

Total acidity percentage

The total acidity was determined by the method recommended by Ranganna (1979) and expressed as a percentage using the principle that the acidity in the sample is estimated by titration with a standard alkali, using phenophthalein as an indicator.

Moisture content

An infrared moisture balance was used for determining the moisture percentage in the pseudostem by quickly drying the sample under exposure to infrared radiation without changing its chemical structure.

Total carbohydrates

Total carbohydrates were estimated by the method of Hedge and Hofreiter (1962). Carbohydrates were first hydrolyzed into simple sugars using dilute 2.5 N hydrochloric acid, which was kept in a boiling water bath for 3 h. In a hot acidic medium, glucose becomes dehydrated to hydroxymethyl furfural. This compound, with anthrone (200 mg/100 ml of ice-cold 95% sulphuric acid), forms a green-coloured product. The absorption maximum was read at 630 nm.

Total cellulose

Percentage total cellulose was estimated adopting the procedure of Updegraff (1969). Cellulose undergoes acetolysis with acetic/nitric reagent (4:1 ratio) forming acetylated cellodextrins, which are dissolved and hydrolyzed to form glucose molecules after treatment with 67% sulphuric acid. This glucose molecule was dehydrated to form hydroxymethyl furfural, which forms a green-coloured product with anthrone, and the colour intensity was measured at 630 nm.

Statistical analysis

The experiments were conducted using a completely randomized design with four replications. The results were analyzed using simple statistical packages (GW-Basic version 3.20).

Results and discussion

Biomass production

The details of biomass produced from various plant parts, contributing to the total biomass, are presented in Table 2.

The proportions of biomass contributed by leaves + peduncle, corms + roots, and pseudostem did not differ significantly with the varieties. However, the overall plant weight exhibited significant differences. Cultivars 'Saba', 'Karpuravalli' and 'Peyan' demonstrated a significantly heavier biomass, ranging from 36.78 to 37.63 kg/plant excluding the bunch weight. The finding that the B genome received from *M. balbisiana* increases the biomass of the plant was supported by these results, as all the cultivars with the B genome (ABB) had a higher biomass owing to precocity and general robustness. Surprisingly, the factors contributing to whole-plant biomass (i.e. leaf + peduncle, corms + roots, pseudostem) exhibited non-significant differences among the varieties.

Fibre-extractable pseudostem also differed between varieties, with 'Robusta' (AAA), a 'Cavendish' clone, exhibiting the least (29.22%), followed by 'Saba', 'Poovan' and 'Karpuravalli'. The genomic constitution had less influence on the fibre-extractable pseudostem. The highest value (62.29%) was obtained from 'Peyan' (ABB), a popular backyard cultivar. This suggests that, irrespective of the genomic constitution, the bispecific clones AAB and ABB are most suited for fibre extraction. These are also the common cultivars of the traditional and commercial banana-growing areas of India, i.e. the north-eastern states and southern peninsular India, which could be commercially exploited for fibre after bunch harvesting.

Fibre yield varied significantly with all the cultivars tested. The lowest value (0.26%) was recorded from 'Karpuravalli' and the highest (0.88%) was from the cultivar 'Pachanadan'. Irrespective of genomic status, cultivars exhibited good fibre yield, as in the case of fibre-extractable pseudostem. This is a positive trend, which could be exploited commercially where India enjoys the polyclonal system of cultivation. The most widely grown 'Cavendish' clones (as represented by cv.

Table 2. Biomass production and its contributory parameters in different cultivars of banana

Cultivar	Plant parts					Fibre yield
	Whole plant weight	Leaves + peduncle	Corm + roots	Pseudostem	Fibre-extractable pseudostem	
	(kg)	(%)	(%)	(%)	(%)	(%)
Poovan	21.83[a]	16.79	27.39	55.82	40.14[b]	0.72[d]
Karpuravalli	36.78[b]	18.92	26.52	54.56	29.22[a]	0.26[a]
Pachanadan	25.73[a]	16.73	31.59	51.68	34.29[a,b]	0.88[e]
Saba	37.63[b]	21.16	36.69	42.16	37.25[b]	0.40[b]
Peyan	37.13[b]	21.98	31.90	49.46	62.29[c]	0.53[c]
Robusta	19.00[c]	10.50	5.00	52.66	46.23	0.52
CD at 1%	9.3246	NS	NS	NS	10.9030	0.1110

Note: Values with the same superscript letter are not significantly different from each other.

'Robusta'), region-specific bispecific clones (AAB and ABB) such as 'Poovan' ('Mysore'), 'Silk', 'Pome', 'Pisang awak' ('Karpuravalli') and cooking bananas (as represented by cv. 'Saba') can all be successfully utilized for fibre extraction.

Biochemical characteristics

Total soluble solids (TSS)

The TSS present in the pseudostem ranged between 1.47 and 1.93 °Brix in 'Peyan' and 'Pachanadan', respectively. The cultivars 'Karpuravalli', 'Saba' and 'Peyan' were similar to each other, whereas 'Poovan' and 'Pachanadan' were similar to each other. The results presented in Table 3 suggest that TSS of the fibre, unlike pH, does not have any effect on the quality and longevity of the fibre. The varietal differences with respect to TSS do not matter much when considering their suitability for fibre production.

pH

There were no significant differences observed among the cultivars; pH varied from 6.39 to 6.66 (Table 3) among the cultivars. Neutral to slightly alkaline pH is supposed to be the best for quality fibre in terms of longevity and durability. Sikdar et al. (1993) have reported that the dilute alkaline pH of the plant sap assists in dissolving non-cellulosic matter, giving rise to better fibre fineness in jute, leading to a higher quality ratio. In the present study, banana fibre exhibited pH values slightly lower than normal, requiring an after-wash with a weak alkali to achieve better quality. This treatment has been found useful to reduce yarn breaking and has been successfully demonstrated in jute (*Corchorus olittorius*).

Total acidity

The total acidity percentage varied significantly among the cultivars. The maximum acidity was found in cv. 'Saba' (0.03%) and the minimum was found in 'Pachanadan' (0.02%). In 'Poovan', 'Karpuravalli' and 'Peyan' the acidity was found to be 0.025%, 0.023% and 0.034%, respectively (Table 3).

Lower acidity and pH slightly above normal (pH = 7) is optimum and, when this is not the case, the fibre needs to be treated with alkali to dissolve non-cellullosic material, resulting in better quality fibre suitable for making diversified products. The present study shows that the varieties tested had relatively high acidity, which was not suitable for direct use. A chemical treatment with a weak alkali such as sodium hydroxide and sodium carbonate was found to increase the surface of the fibre (Padmavathy

Table 3. Biochemical parameters of banana fibre as affected by varietal differences

Parameter	Cultivar						CD at 5%
	Poovan	Karpuravalli	Pachanadan	Saba	Peyan	Robusta	
TSS (°Brix)	1.87[b]	1.53[a]	1.93[b]	1.53[a]	1.47[a]	1.27	0.1945
pH	6.650	6.390	6.663	6.447	6.397	0.641	NS
Total acidity (%)	0.025[c]	0.023[b]	0.020[a]	0.031[d]	0.034[e]	0.029	0.0004
Moisture (%)	95.47[d]	89.13[a]	94.53[c]	93.60[b]	94.80[c]	90.64	0.4618
Total carbohydrate (%)	1.977	2.147	1.910	2.137	2.153	1.089	NS
Total cellulose (%)	3.103[c]	2.770[a,b]	3.193[c]	2.817[b]	2.697[a]	2.690	0.0946
Cellulose content in pure fibre (%)	56.49	55.84	57.89	56.33	56.07	56.34	NS

Note: Values with the same superscript letter are not significantly different from each other.

and Venkata Naidu 1998). Kirby (1963) has mentioned that the strength of commercial abaca (*Musa textilis*) is affected by its acidity: the higher the acidity, the lower the fibre strength. Loss of strength of stored Abaca fibre is also attributed to the acid content of the pseudostem prior to fibre extraction.

Moisture content

The moisture content of the pseudostem has a direct effect on the ease of fibre extraction and its quality. Our other experiments on the relationship of fibre yield to duration after harvest revealed that freshly extracted samples gave better fibre yield and quality was better, with less fibre breakage (Uma et al., 2002).

Moisture content in different layers also affects the quality of the fibre. Fibre extracted from sheaths that were shade-dried for 1–2 days resulted in fibre that was reddish-black in colour, which is not marketable (Kirby 1963).

In our present study, all the varieties except 'Karpuravalli' showed a moisture content of more than 90%, extending up to 95.47% (Table 2). Shantha and Siddappa (1970) demonstrated that fresh pseudostem of cultivars 'Maduranga' (ABB) and 'Rasabale' (AAB) had 85.6% and 90.7% moisture, respectively. This had a direct relationship with starch content and fibre yield.

Total carbohydrate

The carbohydrate content in different cultivars did not vary significantly. It ranged from 1.91% to 2.15% in 'Pachanadan' and 'Peyan', respectively. In 'Poovan', 'Karpuravalli' and 'Saba', the total carbohydrate percentage was found to be 1.98%, 2.15% and 2.14%, respectively (Table 3). Mature fruit, in general, exhibits the highest starch and total carbohydrate content and pseudostem is the second richest plant part, followed by the rhizome. Shantha and Siddappa (1970) reported that the pseudostem of the cultivars 'Maduranga' and 'Rasabale' had 50% of the starch content found in mature fruit. However, the quality of fibre as affected by its carbohydrate content is yet to be ascertained.

In one of the applications of fibre where the waste obtained during fibre extraction is used for starch extraction, the carbohydrate content makes a lot of difference. Banana pseudostem is experimentally proven to be an excellent source of edible starch, which could be extracted mechanically (Subrahmanyan et al. 1957). However, in the present study the test varieties chosen did not differ significantly with respect to the carbohydrate content, suggesting that all these clones could be commercially exploited for starch extraction.

Total cellulose in fresh pseudostem

The percentage of cellulose in banana pseudostem varied significantly among cultivars. The cellulose content in 'Poovan', 'Karpuravalli', 'Pachanadan', 'Saba' and 'Peyan' was found to be 3.10%, 2.77%, 3.19%, 2.19% and 2.70% respectively (Table 3).

Total cellulose in pure fibre

The cellulose content in banana fibre was similar to other vegetable fibres including jute (*Corchorus olittorius* L., 60.7%) and mesta (*Hibiscus cannabinus* L., 61.6%). The highest cellulose content is found in cotton - 82.7%, ramie - 68.6%, hemp - 67.0% and sisal - 65.8%. In our investigation, 'Pachanadan' yielded the highest cellulose content of 57.89%, followed by 'Poovan' (56.49%). The lowest was recorded for 'Karpuravalli', with only 55.84%. All of them significantly differed from each other with respect to cellulose content (Table 3).

Conclusion

All commercial cultivars of banana industry are triploids, with various genomic constitutions such as AAA, AAB and ABB. Cultivars belonging to AAB exhibited a higher percentage of fibre-extractable pseudostem and fibre yield. The highest was recorded in 'Pachanadan', followed by 'Poovan'. However, the cellulose content, the index of fibre quality, was similar in all commercial cultivars. The cellulose content of banana fibre was also comparable to other fibres such as jute and mesta. The results suggest that all these commercial cultivars of banana, namely 'Robusta', 'Poovan', 'Pachanadan', 'Saba' (cooking bananas), 'Peyan' and 'Karpuravalli', representing 82% of total banana industry in India, could be successfully exploited for the fibre industry after fruit harvest.

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