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The Potency of Indonesian Ramie to Support Textile Industry

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Abstract : Studies on the characters of ramie fiber and its potency to substitute synthetic fibers and other natural fibers, such as cotton, in both textile and non-textile industries have been intensively carried out, both in the form of reviews and research articles. In these studies, the results showed that ramie fiber with all its characteristics is very potential both as a substitute and as composite material in textile and non-textile industries. However, until now the development of ramie fiber in Indonesia has not in good trend. Moreover, the trend continues to decline, based on the number of the area of ramie plantation. The limited use of superior rami variety is one of other factors that caused the low and various fiber quality produced by farmers. Balittas has released one superior ramie variety, i.e., Ramindo 1 in 2007. This variety has potential productivity of 2-2.7 tons of fiber/ha/year, fiber length 2139.75 mm, fiber diameter 17.56 µm, felting power 114.29, flexibility ratio 0.63, coefficient of rigidity 0.37 and is classified in class III quality. Ramindo 1 also have the advantage of being able to adapt well to the lowlands (50 m asl) to highlands (1,500 m asl). Balittas also manages 88 ramie clones as genetic resources for the development of new superior varieties of ramie in Indonesia. This paper discusses the potency of Ramindo 1 and several potential ramie clones fibers as textile raw materials.

Keyword: Textile industry, Ramie, Ramindo 1, Natural fiber, Genetic resources.
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1. Introduction

TPT (textile industry and textile products) is a major component in Indonesia's manufacturing industry and is a significant source of employment [1]; [2] and the largest foreign exchange earner for non-oil and gas groups [1]. In 2005, TPT was able to absorb 1.18 million workers [1]. The TPT industry also accounts for about 7 percent of Indonesia's manufacturing gross value (NTB) in 2016, according to interim estimates, which is equivalent to 1.4 percent of total GDP [2], [3]. The Indonesian Ministry of Trade states that the growth of the non-oil and gas industry in the first quarter of 2018 was relatively high compared to the same quarter in 2016 and 2017 at 0.32% and 6.39%. This growth was supported by the growth of the Textile and Garment Industry group by 7.53% (yoy). While the export value of the textile and apparel industry for the January-March 2017 period each increased by 0.07 USD billion and

0.18 USD in the first quarter of 2018 (January-March 2017). The improvement in the economy of the USA and other export destination countries is the main cause of the increase in the growth of the textile industry.

In addition, according to [4], the textile industry and Indonesian textile products (TPT) also open an opportunity to increase Indonesia's participation in the Global Value Chain (GVC) by focusing on upstream research and development activities as well as downstream marketing businesses so that they will obtain the biggest added value while increasing its position in the GVC. Participation in the Global Value Chain (GVC) is important for the economic development of a country because it can create growth opportunities. This sector is also not a stand-alone industry, but consists of a series of interrelated activities from upstream to downstream. The textile industry subsector consists of the industries of fiber making, spinning, weaving and knitting and garments which are classified into upstream, midstream and downstream industries [5]

Ramie fiber is one of the most powerful textile natural fibers derived from bark (bark) of the Boehmeria nivea L. Gaud plant and is also known as Grass linen or China Grass or China line. Ramie fiber can be blended with cotton, silk, wool and synthetic fibers to make various kinds of products such as textiles, towels, clothes, curtains, upholstery and so on [6]; [7]. Ramie fiber mixed with cotton produces exclusive linen [8]. The carding waste of ramie, called noils mixed with cotton or dish towels into a second grade cloth like denim [6].

According to Timmel (1957), the level of polymerization of ramie sub-unit cellulose was very high (5800) compared to cotton (4700) and jute (4700). The level of polymerization is an indicator of fiber viscosity and resistance to microbial degradation [7]. Based on this (pure cellulose content and polymerization content), ramie fiber is more resistant to fungal and microbial degradation than other bark fibers. Ramie fiber has resistance to bacterial, fungal and insecticidal attacks. Ramie fiber also gets stronger during wet conditions [9]. Ramie fiber with all its characteristics can be used as an option to reduce the use of cotton fiber, ramie fiber also has twice as many as the tensile strength of cotton fiber and the ability to absorb water [8].

In addition to the fiber, other parts of the ramie plant and waste from the processing of ramie fiber can be utilized which is an additional advantage for farmers. Ramie leaves can be used as highly nutritious animal feed ingredients and fertilizers, and ramie leaf tops can be used as raw material for food and beverages. Moreover, the decortication waste can be processed into organic fertilizer, and the remaining decortication containing a lot of wood and fiber can be used for pulp/paper raw material. In addition, ramie planting on critical land can increase the volume of groundwater and be able to store water reserves for the dry season and convert critical land into productive land in only 5-6 months [8].

Based on the information provided by The Discover Natural Fiber Initiative (DNFI), world ramie production in 2008-2016 (estimated) declined from 254,871 tons of tons to 120,347 tons with contributions to the economy as a source of livelihood, labor and production value in the year 2016 was estimated at 0.12 million households, 1 million workers and $ 0.2 [10]. However, in line with the strengthening of the world economy which triggered an increase in purchases of apparel and home

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furnishings, 5% annual growth in paper production was recorded, increased use of natural fibers in composite materials and rising pollution of linked to chemical fiber products so expected to have an impact on expanded use of natural fibers [11].

The occurrence of the cellulose gap (global demand for fiber consumption along with

population growth, growth in prosperity and climate change and limited supply of cotton fiber) and especially in Indonesia was the regulation of the Minister of Trade of the Republic of Indonesia No. 85 / MDAG / PER / 10/2015 which gives permission to import raw materials for TPT manufacturing industries for importers who have APIP (Importer Identity Numbers) to be an alternative opportunity to develop non-cotton cellulose fibers as textile raw materials, textile products and technical textiles [8]; [12]. This opportunity must be utilized with the development of ramie as a whole through increased cultivation, mastery of processing technology and diversification of final products [8]. Ramie fiber has a character similar to cotton fiber and is included in long fibers, strong, high water

absorption, shiny like silk and has a much higher productivity than cotton [12].

But the development of ramie always experienced ups and downs and obstacles. One

obstacle in developing ramie was the use of varieties and seeds that are not pure [13]. The use of superior varieties and quality seeds in accordance with SNI standards is expected to increase the average productivity at the farm level from 0.95 tons / ha / year to 2- 2.5 tons / ha / year [13].

This paper tries to discuss the potential of Ramindo 1 varieties of ramie fiber and several

potential clones as textile raw materials

2. Rami (*Boehmeria ni6ea* (L.) Gaud.)

Ramie originated from China, Japan and the Malay Paninsula which was a tropical region,

but could be grown in a temperete environment and could be harvested three times a year [9]; [7]. Ramie plants were also one of the oldest natural fiber producing plants domesticated by humans, in India ramie fiber had been used since 600 BC [7]. Japan was a country of the origin of ramie varieties that was currently being developed because Japan had begun researching and assembling ramie varieties since 1912. Miyazaki 110. Miyazaki 112, Murakami and Saikeiseishin were some of the ramie

varieties that have been produced by Japan [6].

Ramie in Indonesia had been known since prehistoric times but commercially was only

developed in 1750 by the Dutch Government and in 1934 it was planted and developed in Pujon, Malang, East Java. At that time, ramie grown well and the plant height reaches 2 m, but now it is no longer developed [14]. In 1957 installed spinning mill Pematang Siantar I North Sumatra with a capacity of 6,000 spinning units and was able to produce 18 tons of ramie yarn every month, but the installation was only able to operate for 13 years and in 1970 the factory was closed due to lack of supply of raw ramie fiber. In 1998 and 2002, the Ministry of Industry and Trade and the Ministry of KUMKM again tried to develop ramie with areas of development in Central Java, West Java, Lampung, South Sumatra, Jambi, Bengkulu and North Sumatra, but could not develop due to a shortage of raw material for ramie fiber and market uncertainty [15].

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Ramie could adapt well in a wide range of altitude and climate zones ranging from the lowlands to the highlands and the tropical climate, subtropics and temperature, but ramie has better growth and yields in temperate regions than in the tropics and subtropics. although the harvest duration is only less [6]; [16]; [17]. In normal conditions, fresh ramie stems are 45-60 tons/ha/year which can produce 1,000-1,600 kg of dry fiber and 500-1,200 kg of degumed fiber with different harvest duration for each climate zone, ie 2-3 harvests for the region temperate climate, 4-5 harvest times for subtropical climates and can reach 7 times in the tropics in one year [16]. Whereas according to [6] yields in temperate regions were 15-20 mt/ha green plants with harvest times 2-3 times and 8-10 mt/ha for tropical and subtropical regions with a harvest duration of 5-6 times .

Ramie plants could be harvested if they give a characteristic: the lower part of the stem was brownish, the lower part of the leaf was yellowish and begins to wither, the apical part begins to curl, young shoots begin to appear on the ground and the bark was easily exfoliated [7]. [6] stated that the first harvest of ramie was carried out when the plants had not yet entered the flowering period, while the second harvest was carried out when the plants entered the initial phase of flowering and the third harvest was carried out when the plants entered the peak flowering phase. If the harvest is done too early, the fiber has not entered the immature phase and has a low yield. Conversely, if the harvest is done too late, the stem will begin to wood and the process will be difficult, the fiber will be lost and rough [9]. The first harvest of ramie is not done in the first year but is done in the second year. In the first year the plant height is not uniform, usually branching and not suitable for bonding. Harvesting in the second and third years is a harvest with maximum fiber yield and continuously decreases in the fourth year and so on by 5-10% [6].

In the 45 mt green ramie plant based on three harvests per year consisting of 60% green stem and 10% green leaves, 12.4% dry stems would be produced, 3.5% decorticator dry fibers and 7.2% dry leaves [6]. The yield of ramie fiber in every season is approximately 10000 g / m. In each wet weight, ramie consists of 30% fresh leaves and 70% fresh stems, while dry fiber renders from fresh stems are 3% or equivalent to 200 g / m [9]. Determination of harvest time is very important for ramie because it will affect the quality of the fiber produced [6]; [16]; [17]. The production of ramie fiber is also more influenced by climatic conditions than the age of plants [9].

As an annual plant, ramie has a life cycle of up to 20 years. Ramie also had good competition with weeds because of the rapid closing of ramie growth. Herbaceous plants, grow upright, usually not branched, fast growth type, high (1-2 m), stem diameter 8-16 mm at the base depends on the climate conditions where it grows [6]; [9]. Along with plant growth, the percentage of plant fiber content in general has increased by 2-4% [7]. Fiber originates from the bark of the stem and was classified as a soft fiber without lignin (non lignified soft fiber) [6]. Ramie requires growing requirements, which have 1500-2500 mm rainfall with temperatures between 25^0C-31^0C (max. 35^0C) and optimum relative humidity of 80% (may not be <21%); Soil pH 6-7 [7].

Ramie fibers both stranded manually and with decorticators were called rami fiber rows and still contain 19-35% gums consisting of a mixture of various carbohydrates, especially pectin and polysaccharides (manosa, galactose, rhamnosa, arabinosa, xylans and others), small quantities of parenchyma cells and phelloderm tissue that must be removed before the fibers are woven and spun

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into fine threads [6]; [7]. The composition of gums in ramie fiber is arabans and xylans (hemicelluloses) which were insoluble in water but soluble in alkaline solutions [6]. The content of ramie fiber consists of 69-91% α-cellulose, 5-13% hemicellulose, 1% lignin, 2% pectin, and 2-4% ash. The main composition of ramie gum is hemicellulose and pectin which are insoluble in water but soluble in alkaline solutions. The gum content in ramie fiber would affect the quality of the fiber produced so that a degumming process is needed to eliminate it [7]. Ramie fiber which had been carried out by the degumming process contains 96-98% α-cellulose [16] with little hemicellulose (<3%)

and lignin (<0.5%) [7].

Ramie fiber is a collection of filaments that are joined together and are called bundles. In

each filament (elementary fiber) wrapped by gums and pectin, it had thick secondary walls as an indication of the high content of cellulose in ramie fiber. Ramie fiber also had a form that was irregular and flat (flat) with rounded or oblong fiber ends [9]. Ramie fiber had a modulus of elasticity (65 +/- 18 GPa) which was higher than E-glass fiber (~ 21.3 +/- 5 GPa) so it was very prospective in mechanical use. Besides that, ramie fiber also had high strength (800-1000 MPa), not much different from the strength value of E-glass fibers. Based on the value of rigidity and high fiber strength, and its impact on the environment, ramie fiber and also natural fiber others could replace the use of synthetic fibers

[9].

Degumming is one of the processes in ramie shoving. This process aimed to remove gum

contained in ramie fiber to obtain the highest quality ramie fiber. There were two kinds of degumming processes, namely conventional (chemically) and bio-chemical treatments. Chemically using alkaline solutions (such as NaOH) with different reducing agents with yellowish fiber results and added H2O2 (sodium hypochlorite) solution for the bleaching process. Addition of alkaline solution with polyvinyl alcohol (anti-deposition agent) and sodium triphosphate (penetration agent) significantly increases gum washing. Bio-chemical used pectinolytic microorganisms that produce pectinolytic enzymes. These microorganisms were capable of producing enzin pectin lyase, pectin methyl esterase and polygalactonase. Molds, yeast and bacteria were microorganisms that could produce pectinolytic enzymes [7].

The results of a study conducted by [18] which reviews the use of ramie fiber and its effect

on the environment using the Life Cycle Assessment (LCA) method stated that degumming and spinning of ramie fiber was the main contribution as pollutants to the environment. In the same study, [18] also stated that ramie fiber was not more competitive in its impact on the environment especially if the spinning process was included in the assessment categories so further studies were needed given that the processing of ramie fiber is still done simply when compared with glass fiber processing which had been done professionally by companies.

3. Indonesian Ramie Varieties

Indonesia currently had one superior ramie variety which was released in 2007 based on Decree of the Minister of Agriculture No. 105 / Kpts / SR.120 / 2/2007 under the name Ramindo 1 (Figure 1). Based on the description of the variety in the attachment to the decree, Ramindo 1 had the weight of dry fiber / plants 4-5 grams with fiber productivity / ha / year 2-2.7 tons (depending altitude) and fiber

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yield of 3-4% with good fiber quality. Ramindo 1 also had extensive adaptability so that it could be planted and cultivated in the low to highlands and peatlands. Ramindo 1 could be harvested every 2 months so that in one year it could be harvested 5-6 harvests.



Fig. 1. Ramindo 1

Source: Balittas

The results of the research conducted by [17] showed that although had the lowest average fiber growth (297.5 μm) compared to the other four clones in the first week but at the end of the observation, the eighth week, Ramindo 1 had a mean fiber length growth higher (5512.75 μm) than all the clones tested except Padang 3 (7040 μm) clones. The study was carried out in the lowlands with an altitude of 265-350 m above sea level. These results indicate that Ramindo 1 had better adaptation to the lowlands than other clones. The clones used in the study were Lembang, Indochina, Ramindo 1, Padang 3 and Bandung A.

Based on fiber derivative values (fiber length, fiber wall thickness, fiber diameter, luminous diameter, runkel ratio, felting power, flexibility ratio, rigidity coefficient and muhlepheph ratio), Ramindo 1 were included in the fiber quality classification in class III and will be produced sheets with tear, crack and medium pull together with Indochina, Padang 3 and Bandung A. Lembang was clones with the best value and was classified into fiber quality classifications in class II and will be produced sheets with high crack strength and tensile strength [17].

A slightly different result was showed by the results of a study conducted by [19] that Ramindo 1 had a lower plant height and stem diameter than Bandung A and Lembang A, but had the number of tillers per clump, fresh weight of plants and stems (kg), fiber weight per plot or per hectare higher than Bandung A and Lembang A so Ramindo 1 has the highest fiber yield among the other two clones. Ramindo 1 had cellulose, hemicellulose and lignin content of 72,076%, 10,775% and 10,883, lower than Lembang A clones but higher than Bandung A. In addition, the results of the study also showed that all the clones were included in the fiber quality classification in class II.

Genetic resources provide an important basic role and are a major component in the selection and improvement process of one or several important properties in plant improvement varieties through breeding activities [20]. Genetic diversity must be well conserved and used effectively to anticipate new pests and diseases, to produce new plant varieties that adapt better to environmental changes [20]; [21]. Plans with genetically different in specific traits were the main requirement for plant breeders [20]. Characterization in the context of germplasm according to [22] is a description of genetic material including all information related to a collection, while evaluation is recording activities which

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are limited to only a few important agronomic traits [20]. Characterization is carried out on agronomic and morphological characteristics, while evaluation is carried out of biotic

stress and abiotic screening for germplasm collection so that it can be maximally utilized [20].

Balittas has 88 clones originating from exploration and introduction and 58 of them had been

gradually carried out characterization and evaluation starting from 1998. The ramie germplasm collection owned by Balittas was entirely white ramie. Conservation activities was carried out which include rejuvenation (plant age >7 years), characterization (shape, size, coloration and appearance of leaves, stems, male and female flowers and leaf tops; flower type; growth type; plant height; stem diameter; potential results), evaluation (shading conditions, peatlands, lowlands, medium land, highlands) and documentation [14]; [23]; [24]; [25]; [12].

The results showed that there was a diversity of production characters which varied from 11.80 to 30.57% from the 20 accessions of ramie germplasm owned by Balittas which were planted at the Cobanrondo Experimental Garden. The highest diversity with a coefficient variability value (CV) of 30.57% was the number of plants with a height >1m (productive stem), while the trunk diameter is the lowest diversity with CV value of 11.80% [12]. From the results of research carried out by Balittas that there were five clones that could be growed and produced on peatland with specificity: three clones (Pujon 10, Pujon 10 A and Lembang) growed and produced the highest yields during the rainy season and two other clones (Bogor 7 and Kotaraja) could be growed well during the rainy season and dry season but possess low production based on the parameters of plant height, stem diameter, number of stems/clumps, weight of plant and fresh stem weight. Peatlands were chosen because the high of organic matter content and one of the growing conditions for ramie is the land must have high organic matter content [24].

Research conducted by [23] on 58 numbers of ramie germplasm collections that there were 12 clones that had potential with a plant height of 200 cm and yields of 5-7.8 g/grass China namely Pujon D, Pujon 9, Pujon 902, East Java 3-0, Indochina, Medan I, Bandung A, Hakuki, Lembang, Lembang A, Pujon 601, Pujon G. In addition, from the evaluation results, there were three potential clones on low, medium and high land, namely Pujon 10, Pujon 13 and Indochina. Pujon 10 and Pujon 13 clones, besides the potential for lowland, medium and high land areas, also had the potency to be

planted and developed on peatlands

High variability was also found among the clones of ramie germplasm collection in the

lowland on the character of fresh plant weight, fresh stem weight and dry fiber weight based on variability coefficient values (CV) > 20%. While stem diameter was the character with the lowest coefficient of diversity among all observed properties, namely 8.9%. In addition to the medium region, the results also showed that there were 16 clones that had high potential production both in the lowlands, medium and high region, two shade tolerant clones (under coconut tree stands) and three peat-tolerant clones [25].

Plant height and stem diameter were two component properties that had a close relationship

with the yield of fibers in fiber-producing plants from bark. The results of research conducted by [26] showed that the nature of plant height, number of stems per clump, weight of stover and fresh stem

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weight correlated closely with the results of China grass with the correlation values of 0.85, 0.75, 0.83 and 0.9; however, based on the path analysis only fresh stem weights properties had a positive and real direct effect on the results of China grass so that it can be used as a selection criterion to obtain

high yield ramie clones.

Ramie fiber with all its characteristics had the potential to be developed both as a substitute

for synthetic fibers and other natural fibers, especially in the textile and textile products industries. The study conducted by [13] stated that the potential for ramie development to substitute 40-45% of 500,000 tons per year of demand was 200,000 - 225,000 tons per year of ramie fiber ready for spinning. If china grass production was between 2,250-3,000 kg per ha or equivalent to spinning fiber around 1,500-2,000 kg per ha, then the area of ramie development will be approximately 134,000 ha. Not much different was conveyed by [8] which stated that with the estimation of the amount of production and the area of ramie planting assuming, the need for ramie ready to spin was 200,000 MT / year, the China grass yield was 4% of the wet stem, 50 % fiber yield of wet China grass / ha / harvest and yields of 2 MT China grass/ha/year or equivalent to 50 MT of wet stems/ha/year then Indonesia needs an

additional ramie plantation area of 199,500 ha with an area of Indonesian ramie plantations of 528 ha.

4. Conclusion

Ramie fiber is very potential as a substitute for synthetic fibers and other natural fibers,

especially in supporting the textile industry and textile products. One effort that can support this is the provision and development of superior ramie varieties. The use of superior varieties is one of the requirements to produce high yields and high ramie fibers quality that expected to provide a large economic impact for the farmers.

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