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Potential of Brown Cotton Fiber Development for Sustainable Textile Materials

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Abstract : The use of brown cotton fiber to meet fiber raw materials needs to be supported, because chemicals used for colouring in textile industry contributes to high pollution in the environment. The program for assembling brown cotton fiber varieties in Indonesia has begun in 2006. In 2018 three new superior varieties of brown cotton fiber were released, namely Bronesia 1, Bronesia 2 and Bronesia 3. This paper discusses the potential of brown cotton fiber as a textile raw material in Indonesia. The brown cotton fiber of Bronesia variety has the potential to produce 1011 kg/ha cotton fiber. Cotton fiber of Bronesia has fiber lengths ranging from 23-25 mm and has fiber strength between 21-23 g/tex. The uniformity fiber of brown cotton Bronesia is included in the high category, ranging from 83 - 84%. The brown cotton fiber of Bronesia has three color gradations, namely medium brown, light brown and dark brown. The brown cotton fiber of Bronesia has resistance to pest infestations, and can grow well on dry land. The brown cotton fiber of Bronesia has the potential to be used in the textile industry, especially the traditional weaving industry, therefore, it can support the sustainable textile industry. The purpose of this review is to discuss the opportunities for the use of brown cotton fibers from Bronesia varieties in supporting the Indonesian textile industry.

Keywords: Bronesia; Brown cotton; Textiles; Weaving

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1. Introduction

One of the natural fibers producing plant which is as the main raw material in the textile industry and textile products is cotton plants (*Gossypium hirsutum* L). The textile and textile products (TTP) industry is one of the strategic sectors which development is prioritized, because it contributes significantly to the national economy [1]. The national textile industry shows that trade was surplus with a value of not less than US $ 5 million, absorbing 1.34 million people and contributing to meet domestic needs of 46%. The value of textile industry investment in 2016 increased to IDR 7.54 trillion with significant foreign exchange earnings from the export value of US $ 11.87 million and capable of absorbing as much as 17% of the total workforce in the manufacturing industry [2].

The integrated textile industry in Indonesia involves the upstream to downstream sectors in producing final products, so that it requires and uses natural fibers. To be the largest TTP in Southeast Asia, it requires and uses a large amount of fiber raw material [3]. The need for cotton raw materials continues to increase along with the development of the population which drives the development of domestic TTP. The spinning industry, especially for cotton fiber, increased from 6.1 million spindles in 1997 to 7.8 million spindles in 2014, or in the last within 15 years there has been a growth of around 2% per year [4]. However, domestic supply of cotton fiber is very low. The of cotton imports volume every year tends to increase and varies from 450 to 760 thousand tons, equivalent to 99.5% of the national fiber needs, which are valued at approximately US $ 650 million [5].

Efforts to fulfill the demand for cotton fiber raw materials are carried out by increasing production of cotton fiber. In addition to white cotton, colored cotton fibers are also potentially utilized to meet the needs of the textile industry. There are four color groups of cotton fibers, namely white, brown, green and blue fibers [6]. The most widely cultivated is the brown and green fibers. In Indonesia, the development of colored-cotton began in 2006 in the program of assembling cotton varieties, especially brown-cotton fibers. Among colored-cotton fibers, brown fibers are more commonly cultivated and the brown colors are more stable than green fibers [7]. Brown, gray and reddish-brown colors are caused by tannin content and phenolic compounds in fiber lumen vacuoles [8].

The research result [9] reported that currently the demand for colored cotton for the textile industry would increase to reduce environmental pollution due to uncontrolled chemical coloring processes and become a very high contributor of pollutants throughout the fabric production process. Excessive use of water when coloring will also cause hazardous waste that has impacts not only on humans, but also threaten the surface water source [10]. [11] states that a minimum of 30 liters of water is needed in the production of 1 kg of fabric and 1-15% of the dye used in the textile industry is lost in textile industry waste water. Compared with white cotton fibers that are needed to treat with chemical dyes to make artificially colored cotton, the natural colored cotton fibers have a fairly high color resistance when washing repeatedly and not easily fade if exposed to ultra violet [12]. The development of colored cotton could be associated with the development of organic cotton.

In order to obtain new varieties of colored cotton, Indonesian Sweeteners and Fibers Crops the Research Institute (ISFCRI) conducted plant breeding activities that started with crosses involving three female parents (Kanesia 7, Kanesia 8, and Kanesia 9) with three male parents, namely KI 42 (73814, originally from Greece), KI 124 (Multiple Dominant), and KI 502 (RLBL, originally from Australia). The purpose of this breeding was to produce cotton that is tolerant/moderately tolerant to drought and possesses brown fiber. From the results of the crossing, progeny was obtained which were then selected

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individually and continued by lines selection. Selected lines were then tested for their production potential which was conducted in 2013. Subsequently, multilocation tests were carried out in 2014-2016 in 3 locations, namely: Asembagus, Pasirian and Sumberejo to test 6 selected lines and Kanesia 10 varieties used as a comparison. In 2018, Balittas released three new varieties of brown fiber cotton, namely Bronesia 1, Bronesia 2, and Bronesia 3.

The purpose of writing this review is to provide an overview and discussion about the assembly of brown-colored cotton and its opportunities in supporting the textile industry in Indonesia. The discussion that will be presented includes the process of the breeding of brown colored cotton, the production potency and fiber quality of the superior varieties produced, and their potential for development in supporting textile industry.

2. Breeding of Brown-Colored Cotton

Balittas has assembled brown-colored cotton varieties with a cross of six parents in 2006, conducted at Karangploso Research Station in Malang. The female parents consisted of three Kanesia varieties, namely Kanesia 7, Kanesia 8, and Kanesia 9; and male parents were three selected introduced accessions from Greece, United States and Australia, namely KI 42 (accession 73814), KI 124 (Multiple Dominant accession), and KI 502 (access to RLBL-Red Leaf Brown Lint).

Selection activities of plant breeding program were carried out at Karangploso Research Station, Malang starting from the population of F1 - F6 (conducted during 2007-2012), planted in conditions without pest control on rainfed land with a standard cotton cultivation package. Selection was carried out with selection criteria that included low levels of plant damage caused by cotton planthopper and cotton bollworm, number of fruit > 15 bolls/plant with a selection pressure of 15%. Test of preliminary potential production of F7 was carried out in 2013. These tests resulted 19 lines which were crossed in 1999 and 2003. The tests were carried out on experimental plots of these lines and compared with Kanesia 10. From this test we obtained 6 expected lines.

Multilocation tests were carried out in 2014-2016 in 3 locations of Balittas research stations, i.d., Asembagus, Pasirian and Sumberejo. The agroecological specifications of each location are presented in Table 2. During plant growth, the rainfall in Asembagus was 254-538 mm, in Pasirian varied at 260–1,263 mm and in Sumberejo varied at 276-428 mm. Six selected lines were used in this tests that carried out in 2013 and Kanesia 10 was involved as a comparison (Table 1).

Table 1. List of tested lines and comparison varieties

No	Lines	Crossing Combination	Fiber Color
1	06063/5	Kanesia 8 X KI. 42	Dark brown
2	06062/3	Kanesia 7 X KI. 502	Light brown
3	06066/2	Kanesia 8 X KI. 502	Light brown
4	06066	Kanesia 8 X KI. 502	Light brown
5	06067/3	Kanesia 9 X KI. 42	Dark brown
6	06063/3	Kanesia 8 X KI. 42	Dark brown
7	Kanesia 10	Comparison	White

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From those multilocation tests, 3 superior lines were proposed to be released as new superior varieties which are tolerant/moderately tolerant to drought and brown-colored fibers of lines 06062/3, 06066/2 and 06063/3. These lines are then proposed to be released as new superior varieties of brown-colored cotton, namely Bronesia 1 Bronesia 2, and Bronesia 3, respectively.

3. Potential Production of Brown-Colored Cotton

The multilocation test results of brown-colored cotton showed the average of plant height and yield components, consisting of the number of fruits/plants and the weight of 100 pieces (g). Table 2 shows that some of the tested lines showed variations of plant heights, and the average height of Bronesia 1, Bronesia 2, and Bronesia 3 varied between 114 - 121 cm. That no significant difference for plant height between brown-colored cotton with white fiber cotton, with a range of 90-120 cm [13]. The average number of boll/plant varies between 11-13 bolls/plants. The average weight of 100 bolls varies between 415 - 502 g. The number of formed cotton bolls per plant is directly proportional to the weight of seed-cotton produced. The more the number of bolls, the higher the weight of cotton produced. That the number of bolls per plant positively correlates both phenotypically and genotypically to yield per plant [14].

Table 2. The average plant height, number of bolls, and weight of 100 bolls of Bronesia varieties

Parameters	Cotton Variety		
	Bronesia 1	Bronesia 2	Bronesia 3
Plant height (cm)	115	114	121
Number of bolls/plant	11	11	13
Weight of 100 bolls (g)	502	456	415

The cotton productivity of Bronesia varieties in three locations showed that the productivity of Bronesia cotton was generally higher in Asembagus (Table 3). The three varieties showed different performances in all three locations. In Asembagus, Broneisa 3 shows the highest fiber productivity compared to the other two varieties. In Pasirian, however, Bronesia 1 showed the highest production potential, while in Sumberrejo Bronesia 2 showed the highest performance for production potential. This difference relates to the physiological process of cotton plants related to their ability to produce fiber, which is influenced by agro-climatic conditions at the study site.

Table 3. Fiber productivity of brown-colored cotton varieties

Location	**Fiber Productivity (kg/ha)**		
	Bronesia 1	Bronesia 2	Bronesia 3
Asembagus	910	854	1011
Pasirian	852	708	700
Sumberejo	728	759	669

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4. Fiber Quality and Color of Brown Colored Cotton

Fiber quality is determined by color, dirt, and post-harvest processing. A good fiber has bright colors and good luster, do not contain dirt and are free from nep. The fiber content and quality of cotton fiber are composed of fiber length, smoothness, strength, stretch and uniformity which are presented in Table 4. The strength of cotton fibers accepted by textile industry ranges from 28 to 32 g/tex for *G. hirsutum* and 42 to 46 g/tex for *G. Barbadense*; fiber length ranges from 27.4-31.5 mm for *G. hirsutum* and 34.5-36.3 mm for *G. Barbadense*; for fiber uniformity ranges from 80.0 - 82.5% for *G. hirsutum*, and 85.0 - 86.5% for *G. Barbadense*; fiber fineness is an indirect measurement of fiber smoothness and fiber maturity; which is needed from 3.9 - 4.9 mic for *G. hirsutum* and 3.7 - 4.2 for *G. Barbadense* [15]. The fiber length together with fiber strength will determine yarn strength and flatness, as well as the efficiency of the spinning process [16].

Table 4. Qualty of brown-colorred fiber of Bronesia

Variety	Fiber Quality					Fiber content (%)
	length (mm)	fineness (mic)	strength (g/tex)	elongation (%)	uniformity (%)	
Bronesia 1	23.96	5.70	22.4	6.9	84.7	33.6
Bronesia 2	25.74	4.00	23.7	5.9	84.9	34.5
Bronesia 3	23.20	4.10	21.2	8.8	83.6	33.1
Kanesia 10	28.28	4.60	27.0	8.1	88.7	40.9

The fiber length of Bronesia varieties showed the average of fiber length of 23.96 mm, 25.74 mm and 23.20 mm, respectively. The three varieties have a shorter fiber length than Kanesia 10 (28.23 mm). Fiber length is the average length of long fibers, fibers which are 12 mm long are classified as short fibers. Measurement of fiber length is expressed in 1/32 inches; the anatomical range is 0.79 - 1.36 inches. Longer cotton fiber tends to be finer, softer, and more twisty.

Data on fiber fineness measurements showed that Bronesia varieties reached 5.70, 4.00 and 4.10 mic, respectively. However, Bronesia 1 has a smoothness level that does not include the range of smoothness desired by the textile industry which ranges from 3.5-4.9 mic. Low fiber smoothness is caused by a lack of carbohydrates during fruit formation, lack of K elements, excess N, and excessive irrigation.

The strength of fiber is the energy needed to break a bundle of fiber in the size of one unit with a stelometer device which is expressed in the ratio between the strength at break and when stretching. The fiber strength of Bronesia varieties is 22.4 (low), 23.7 (low) and 21.2 (low) respectively. Higher fiber strength determines the strength of the yarn and is directly affected by changes in air humidity when testing fiber.

The elongation and uniformity of Bronesia varieties ranged from 6.9% and 84.7%, 5.9% and 84.9%, and 8.8% and 83.6%, respectively. The elongation percentage of the Bronesia 3 was better than that of other varieties and Kanesia 10. The percentage of uniformity of the three varieties is lower than Kanesia

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10. The measurement of fiber uniformity was carried out using a fibrograph which illustrates the uniformity of fiber length. If the percentage of UR <77 means that the uniformity of fiber is very low or the percentage of short fibers is high, the more short fibers will cause a break in the yarn in the spinning process so that the resulting yarn is of low quality. The uniformity index is expressed as a percentage which is very high (> 85%), high (83 - 85%), medium (80 - 82%), low (77 - 79%), and very low (<77%) [17]. Meanwhile, for indicators of fiber content, Bronesian varieties produced 33.6%, 34.5% and 33.1% fiber content respectively.

(a) (b) (c)

Figure 1. The color of colored cotton of Bronesia (a) Bronesia 1, (b) Bronesia 2, (c) Bronesia 3

The color observation of brown-colored cotton fiber was carried out on Bronesian varieties using two comparative tools of cotton fiber colors, namely the Munsell Color Charts for Plant Tissues and the Royal Horticultural Society (RHS) Color Charts (Figure 1). The results of the observations were that Bronesia 1 had a medium brown color with Munsell color charts value: group 7.5 YR and value 7/6 while the RHS value was included in Greyed Orange Group 165C. Broensia 2 variety have light brown color with Munsell color charts value: group 6.0 YR and value 7/6 while RHS values are included in Greyed Orange Group 165D. Bronesia 3 variety have dark brown color with Munsell color charts value: group 5.0 YR and value 6/10 while RHS values are included in Greyed Orange Group 164A.

5. Potential Development of Brown Cotton Fiber

The development of cotton commodities to support the textile industry on an ongoing basis can utilize brown fibers. Release of three new superior varieties of brown cotton, with potential production reaching 1011 kg/ha of fiber, the supply of raw materials for the textile industry can be achieved. In addition to the textile industry, brown cotton fibers can also be used as traditional weaving industry raw materials. The existence of weaving in Indonesia gives its own color to the wealth of the nation's culture (local content). Woven fabrics are not only assets, but also have potential as a source of foreign exchange. This potential arises, considering that woven fabric is now not just a symbol of tradition. Woven fabrics have become modern products, no longer being conventional materials [18].

Dissemination of technology results of research that has been carried out by Balittas in Kab. Sumba Barat Daya, East Nusa Tenggara has carried out a spinning demo of yarn made from brown cotton fiber. The craftsmen greatly appreciate the presence of brown cotton which is very much needed in the process

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of making woven fabrics. In addition to adding woven fabric motifs, the use of brown cotton fibers can also reduce the cost of weaving production, especially in terms of coloring cloth. The color of the fabric from brown fiber is not easy to fade and is not slippery like a woven fabric that uses synthetic threads.

The woven fabric from Sade Hamlet is generally very attractive, both in color and product because the materials used to produce woven fabrics come from nature, there is no mixture of chemicals such as the yarn they use comes from cotton, which then they spin themselves using traditional tools. While in terms of color, the famous Dusun Sade woven fabric will not fade even though it is often washed. Thus, the opportunity to use brown fiber is large enough to be used in making traditional woven fabrics [19].

The supply of cotton raw materials can be developed with a system of partnerships between cotton farmers and fabric managers or craftsmen. The development can be started by preparing superior seeds where the manager is obliged to provide quality seeds to cotton farmers. Thus, the manager also plays a role as a breeder of seeds. Some cotton development areas such as in South Sulawesi and East Nusa Tenggara have established a cotton partnership system, so that the development of cotton seed systems can realize an independent cotton seed community system to meet traditional textile and weaving industry raw materials can be achieved.

6. Conclusion

Bronesia 1, Bronesia 2 and Bronesia 3 are released as new varieties of Indonesian colored cotton. The potential production of the new varieties was 1011 kg/ha of cotton fiber. The quality of brown cotton fiber varies, even though its quality is still below the average quality of Kanesia fiber 10. The color of Bronesia varieties of brown cotton fiber has three color gradations, namely light brown, light brown and dark brown. The demand for colored cotton for the textile industry would increase to reduce environmental pollution due to uncontrolled chemical coloring processes and become a very high contributor of pollutants throughout the fabric production process.

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