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Research Article

Characterization of Agronomical Traits and Quality from Three Clones of Ramie Plant (*Boehmeria nivea* [L.] Gaud.) in Ultisol Limau Manis

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Abstract

Background and Objective: The quality improvement of ramie, including inner and outer aspects are required to be developed to optimize its production. Unlike horticulture and food crops, ramie cultivation is not constrained by the soil type. This study was aimed to evaluate the agronomical characteristics of three ramie clones in ultisol land. **Materials and Methods:** This study was performed using descriptive analysis method with purposive sampling by collecting 10 clumps per clone. Clones of fiber ramie used were Ramindo 1, Bandung A and Lembang A. All clones were planted in ultisol soil located in 350 m above sea level from September 2015 until March 2016. **Results:** The highest fiber production was achieved from Ramindo 1 followed by Bandung A and Lembang A. The resulted fiber from all clones was considered as quality class II fiber marked by the nominal value ranging from 400-450. Bandung A exhibited the best quality of fiber with nominal value of 450. In terms of its chemical composition, fiber produced by Lembang A contained the highest cellulose (74.7 %) with the lowest lignin content (3.6 %).

Key words: Agronomical characteristic, clones, fiber quality, ramie, ultisol.

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Introduction

Ramie are widely known as a producer of exclusively classified fiber, especially the one cultivated in tropical regions, such as Indonesia (Sumantri, 1984). Its fiber is generally shining white colored, hygroscopic, resistant to sunlight, color resistant and easy to dry. In addition, ramie fiber is commonly used as a material for curtain, towel, wool mix, and tent cloth. Buxton and Greenhalgh (1989) stated that ramie fiber can also be used for tarpaulins, tattoo lamps, banknotes, and cigarette paper.

According to the General Directorate of Plantation of Indonesia (2012), ramie fibers has more superior quality and quantity compared to cotton fibers. Ramie fibers could size 120-150 mm in length and 30-40 μm in diameter. Its absorption is 12 % higher than cotton, however its fiber smoothness is lower compared to cotton. Chemically, fibers are generally composed of cellulose, hemicellulose and lignin. Bruhlman *et al.* (1994) explained that the best natural ramie fibers was supposed to contain 80-85 % cellulose, 3-4 % hemicellulose, 0-5 % lignin, and 5-6 % moisture content. According to the ramie fiber assessment conducted in Japan, Indonesia's ramie had been proven to be highly qualified and promising for global market in terms of fiber's fineness and tensile strength. The fineness level of Indonesia's ramie fiber reached 3.8 and its tensile strength exceeded the international standard about 6.7.

The quality of the ramie fiber depends on the quality of its raw fiber material, including the inner and outer aspects. The inner quality of fiber is associated with smoothness, fiber amount, strength and pectin level. Outside quality is mainly related to the visible appearance that can be seen and touched. Different jute clones would produce different fiber quality. Generally, the improvement of agronomical characteristics as well as development process during post processing and postharvest was highly recommended to enhance the quality of ramie fiber (Mayerni, 2006).

The experimental field station managed by Faculty of Agriculture of Andalas University had cultivated five different clones of ramie, namely Ramindo 1, Bandung A, Indochina, Lembang A, and Padang 3. Of all these clones, three clones (Ramindo 1, Bandung A and Lembang A) were further studied in this present study. Ramindo 1 has been considered as a superior clone recommended by the Indonesian Plantation Office. Syafri *et al.* (2015) reported that the quality of Ramindo 1 fiber was composed of 78.3 % cellulose, 4.92 % hemicellulose and 5.31 % lignin with tensile strength reached 871.137 MPa. Unlike Ramindo 1, Bandung A clone was known for its high production, while Lembang A exhibited the lowest production compared to other clones (Damayanti, 2014). However, the characteristic and quality of fiber produced by both clones remained questionable.

As ramie is categorized as plantation crop, infertile soil is not a significant obstacle limiting its cultivation and growth. One of low fertility soil type, ultisol, are known for its low pH, highly saturated Al, limited phosphate availability, low aggression, poor organic matter and unstable aggregate. Soil in Limau Manis region is dominated by this soil type. This kind of soil would highly restrict the growth of food and horticultural crops as it required high amount of nutrients. However, the utilization of this type of soil on ramie cultivation was still less documented. Therefore, this present study was carried out to evaluate the effect of ramie cultivation in ultisol on the quality of the resulting fiber from three different clones.

Materials and Methods

Preparation and Maintenance of Ramie

Three clones of ramie used in this study were Ramindo 1, Bandung A and Lembang A. All clones were planted in the experimental field station of Agriculture Faculty of Andalas University located in 350 m asl from September 2015 to March 2016. Plants were maintained through second pruning (after previous harvest), regular fertilization, watering, weeding, as well as pest and disease control.

Determination of Yield-Related Parameters

Several parameters related to ramie yields were measured, including age of harvesting, plant height, stem diameter, number of tillers, plant fresh weight, stem fresh weight, weight of crude fiber per plot and yield per hectare.

Characterization of Fiber Quality

Class of ramie fiber quality was assessed using standard protocols of TAPPI (*Technical Association For Pulp and Paper Industry*). Fiber quality measurement was conducted by determining fiber dimension of individual fiber firstly separated by maceration. The fiber dimension was observed under microscope with 400x magnification scale to determine the fiber length, diameter, wall thickness and lumen diameter. Derivative value of fiber dimension was then calculated based on its runkle ratio, felting power, flexibility ratio, rigidity coefficient and muhlsteph ratio to evaluate the class of the fiber quality. Not only fiber dimension, the chemical composition of ramie fiber was also determined through the measurement of water, ash, hemicellulose, cellulose and lignin contents.

Results

Agronomical Characteristics of Ultisol-grown Ramie

The growth of each ramie clone grown in ultisol showed various agronomical characteristics. Regarding the age of harvesting, Bandung A and Ramindo 1 took 68 days (Table 1), but Lembang A required longer duration to reach its harvesting age. The height of these ramie plants ranged from 78 to 92 cm where the highest height was obtained from Bandung A (Table 1). From the aspect of stem diameter, Bandung A and Lembang A exhibited similar size of stem diameter, while Ramindo 1 had the smallest stem diameter (Table 1). Ramindo 1 produced the most tiller number while Lembang A only produced nine tillers (Table 1). Unlike the morphological aspect, the assessment on yield-related parameters showed that Ramindo 1 produced the heaviest plant, stem, raw fiber per bed and hectare (Table 2).

Table 1. Agronomical characteristics of ultisol-grown ramie clones.

Clones	Parameter of agronomical characters			
	Age of harvesting (days)	Plant height (cm)	Diameter of stem (mm)	Number of tillers (stem)
Bandung A	68	91.670	6.507	15
Ramindo 1	68	78.139	5.302	20
Lembang A	75	86.138	6.746	9

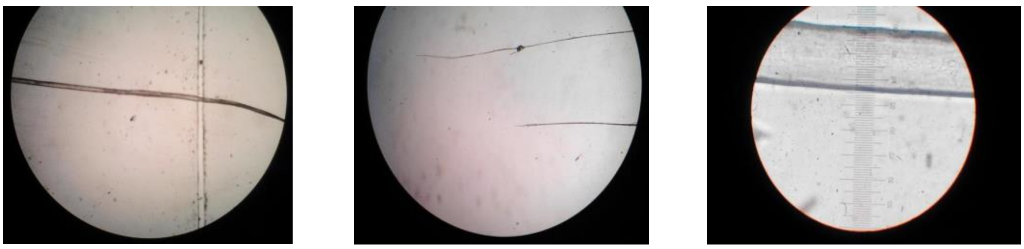
Fiber Quality of Ultisol-grown Ramie

According to its fiber dimension derivative values (Table 3), fiber produced by all three clones in this study was categorized as class II fiber. Based on its runkel ratio, muhlsteph ratio and rigidity coefficient, the highest value was shown by Lembang A fiber (Table 3). This clone also exhibited the thickest fiber wall about 4.8 µm (Table 3). However, the longest yet the thickest fiber was resulted from Bandung A. In addition, the felting power and flexibility ratio of this clone fiber was also superior compared to other clones. Unlike Bandung A and Lembang A, fiber of Ramindo 1 revealed the shortest size and the smallest diameter (Table 3). Visually, the anatomy of ramie single fiber showed common shape as seen in Figure 1.

Table 2. Performance of yield-related characters of ultisol-grown ramie clones.

Clones	Parameter of yield-related characters			
	Fresh weight (kg)		Fresh weight of raw fiber	
	Plant	Stem	Per bed	Per hectare
Bandung A	24.1	12.1	0.680	0.272
Ramindo 1	27	14.2	0.755	0.302
Lembang A	18	9	0.530	0.212

Fiber resulted from Lembang A showed the characteristic of class III cell wall and medium lumen with quite heavy or medium wood. The fiber in the pulp sheet was flattened showing a fine fiber bond. Differed from Lembang A, Bandung A and Ramindo 1 produced fiber with runkle quality classified as class II. Fiber of Ramindo 1 had thin cell wall and rather wide lumen. The wood itself was categorized as a lightweight where the fiber found in the spherical pulp sheet. Fiber of Bandung A had the same type of cell wall and lumen, but this clone was considered as mild wood species. Its fiber was formed in split pulp sheets with a fine fiber bonds.



a **b** **c**

Figure 1. Microscopic visualization of single fiber. (a) fiber length; (b) both end of a tapered single fiber; (c) fiber diameter. The observation was performed using Olympus microscope with 400x magnification.

Felting power is one of important properties that determines fiber quality. As seen in Table 3, fibers of all clones showed values of felting power grouped as class II grade. This felting power indicated the fibers flexibility and the tear strength of resulted paper. Muhlsteph ratio defined the pulp quality and those three clones were classified as class

III grade indicating plastic fibers with a smooth sheet. Regarding the formation of pulp sheets, fiber was quite indistinguishable from the non-woven bond resulting in low tear and low tension of sheet.

The fibers of these three clones also displayed class II quality in the aspect of flexibility ratio. Referred to criteria of Indonesian wood fiber assessment for pulp and paper raw materials, the resulted fibers had a thin fiber wall enabling the pulp sheets to produce sufficient strength of the sheet. Basically the strength of the paper is influenced by the strength of the fiber, which is the bond between the fiber and the fiber distribution in the sheet of paper. Unlike its flexibility, the fibers showed class III grade on rigidity coefficient indicating a not-too-thick fiber wall with medium lumen in the formation of pulp sheets. This kind of fiber structure was easy to be coupled with a bond between fiber and woven leading to the production of a tear strength sheet with moderate pull.

Table 3. Quality assessment of fibers produced by the three clones

Parameters of fiber quality	Ramindo 1		Bandung A		Lembang A	
	Measured value	Nominal value	Measured value	Nominal value	Measured value	Nominal value
Fiber length (μm)	43.92	100	59.12	100	49.25	100
Fiber diameter (μm)	21	-	30	-	27.5	-
Fiber wall thickness (μm)	3.75	-	3.7	-	4.8	-
Runkle ratio	0.5	50	0.33	75	0.54	50
Felting power	0.67	50	0.75	75	0.65	50
Muhlsteph ratio	0.56	75	0.43	75	0.58	75
Flexibility ratio	0.67	75	0.75	75	0.65	75
Rigidity coefficient	0.17	50	0.16	50	0.18	50
Number of values		**400**		**450**		**400**
Quality Class	**II**		**II**		**II**	

Fibers Chemical Composition

Chemical composition of fiber was evaluated based on five parameters, such as water, ash, cellulose, hemicellulose and lignin. As seen in Table 4, fibers of all three clones were mainly composed of cellulose where the high cellulose content was obtained from fiber of Lembang A. Due to this condition, Lembang A produced fiber with the lowest water, ash, hemicellulose and lignin contents compared to the other two clones. It suggested that the fiber produced by Lembang A clone showed a fine quality of fiber. Differences in the fiber chemical characteristics of each clone were caused by the genetic factor and the response of each clone towards the given environmental condition during the study.

Chemically, good quality of fiber was indicated by its high cellulose content as it would result in more powerful fiber (Figure 2). Additionally, fine fiber tended to be very dry and contained very little amount of ash. Ash content in fiber was associated with silica content where the higher the silica level the worse the fiber quality. Hemicellulose content in fiber were ideally restricted in a lower level. High hemicellulose content would affect the fiber structure by inhibiting the formation of fiber bonds. As hemicellulose played a role as an adhesive in every single fiber, the fiber would loss its crystalline and fibrous structure resulting in less flexible and rigid fiber quality. Fiber containing high hemicellulose tended to be easy to inflate, water soluble, highly hydrophobic and easily soluble in alkaline solvent. Similar to hemicellulose, high level of lignin would also decrease the fiber quality. Therefore, a high quality of fiber was supposed to contain mostly cellulose and free from hemicelullose and lignin contents.

Figure 2. Characteristic differences of linseed fibers from the three clones.

Discussions

Haroen (1997) proposed that a fiber could be considered potential as textile raw material when its characteristics possessed appropriate length, diameter, fiber wall thickness and lumen size. In term of length, the longer the fiber, the better the quality. In contrast, a fine quality fiber was supposed to have thin fiber wall and small diameter and lumen size. Long fiber was known for its ability to produce a high tear strength paper. For pulp and paper manufacture, tear strength was the most influential parameter used for the choosing of raw material (Heygren and Bowyer, 1989). Based on the results, all clones produced fibers categorized as class II fiber. This result was in accordanse with Preston (1963) stating that fiber of ramie was commonly belonged to class II grade. Fiber belonged to this quality grade was generally produced by light to heavy wood and had a thin to medium fiber walls with rather wide lumen size.

The differences in fiber water content of each clone were associated with the genetic properties. According to Mohanty *et al*. (2005), the water content of ramie fiber ranged from 7.5 to 17 %. Fiber with excessive water content was highly sensitive to pathogen infection, especially fungi (Astuti, 2007). According to Haroen (1997), ash content in plant fibers ranged from 2.0 to 4.0 %. This chemical component was correlated to silica content. The higher the ash content indicated the high level of silica of a fiber, thus the worse the fiber quality. Regarding the hemicellulose content, Mohanti *et al.* (2005) reported that ramie fibers generally contained 13.1 – 16.7 % hemicellulose. According to Syafri *et al.* (2015), natural ramie fiber of Ramindo 1 contained 5.31 % lignin content. High levels of lignin might occurred due to various factors, such as high intensity of rainfall, soil type and pH as well as genetic factor.

Table 4. Chemical composition of fibers produced by the three clones.

Chemical components (%)	Clones		
	Bandung A	Ramindo 1	Lembang A
Water	13.138	13.827	11.941
Ash	1.499	1.437	0.602
Cellulose	71.427	72.076	74.767
Hemicellulose	11.613	10.775	9.938
Lignin	11.099	10.883	3.587

Conclusions

Ramindo 1 showed the highest biomass and crude fiber production compared to Bandung A and Lembang A. The resulted fibers of those three ramie clones belonged to class II grade with nominal values ranging from 400-450 where the highest value was exhibited by Bandung A. Chemically, fiber of Lembang A displayed the best quality as it contained the highest cellulose about 74,8 %.

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