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Investigation of Spinnability of Banana Fibers through Yarn Formation Along with Analysis of Yarn Properties

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ABSTRACT: *Banana is not only one of the important fruits in Bangladesh but also one of the anterior sources of the nutrition. But banana husbandry produces a huge amount of biomass which has been throwing to the environment and the above ground parts like pseudo stem is the major source of fiber. So the purpose of this research has been to investigate the prospect and spinnability of the banana fiber. For pursuing this thesis work "kobri" (AB genome) banana plant was used. In this study banana fiber was blend with cotton as the ratio of cotton: banana=50:50 and 30:70 and produce yarn by using ring and rotor spinning system and rotor spinning has been found comparatively more compatible than ring spinning system. But in case of both spinning system it has been found that thick places (+50%), thin Places (-50%), neps (+280%), U%, Cv% and hairiness of the yarn have been increased with the increasing of the portion of banana fiber and strength of the yarn has been increased with the increasing of banana part in the blend ratio. 100% banana fiber has been produced by using jute spinning system and the result found satisfactory especially the strength of the yarn but Cv% and hairiness was so high.*

I. INTRODUCTION

In the recent years, the synthetic products are dominating over the natural fibers due to the low cost and durability but the synthetic fiber is not biodegradable and most concerning fact is that it pollutes the environment [1]. But now everybody put emphasis on green technology and is seriously concerned about the environment. Natural fibers meet our clothing needs as well as they are eco-friendly. But some natural fibers had been remained unturned for a long time and for this reason proper utilization of natural resources become very important. Natural fibers are environmentally friendly as they provide some important properties like low density, appropriate stiffness, and mechanical properties and high disposability, moreover they are recyclable and degradable [2]. Banana fiber, a ligno-cellulosic fiber, obtained from the pseudo-stem of banana plant (*Musa sepientum*), is a bast fiber with relatively good mechanical properties [2]. Banana fiber at present is a waste product of banana cultivation and either not properly utilized or partially done so.

Banana is one of the most growing and important fruit crops cultivated by man in tropical parts of the world. Bangladesh is an agrarian country so it produces a huge amount of agricultural waste every year from its production process most of which are unutilized and thrown to the environment directly and results in pollution to soil, air, and water bodies. However many countries turn the waste into new sources of valuable resources for the country. But it is amatter of great unfortunate that in our country most of the agricultural waste is still kept unturned which pollute the environment. Banana stem is one of the major waste in Bangladesh but through proper management and utilization of this waste material able to create a new dimension in employment opportunities for rural people especially women and encourage the farmer to cultivate banana instead of malignant crops like tobacco. Banana is a common food of Bangladesh and is very familiar to everyone. This crop accounts for 45% of the total fruit production in the country with 25% share in the cultivable area.

The total production of banana is recorded to be one million MTs from an area of 56, 000 hectares of land. Banana fiber is strong, soft, and coarse and can be processed standard jute machinery and in some trials the fiber was blended with jute and Mesta but the yarn was hairy [3]. Actually, very limited work has been done on this fiber. The work was limited to estimate various character (physical and chemical) of this fiber and only jute spinning system was used to spun this fiber. But unfortunately, in our country, no significant research work is done on banana fiber inspite of huge prospect. So it is the demand of time to work on this fiber to enrich our textile field. The lack of research work on this fiber and previous works leave us much room to expand the significant project objectives. As the requirement of fibers is being increasing in the apparel industry from year to year, the supply of new or modified apparel fibers in the textile industry are demanding. From this concept, a

new approach has been adopted in this study to utilize banana fibers in the textile industry. The main objective of this study is to find out a suitable spinning system.

II. RAW MATERIALS

Banana fiber was extracted from Kobri (AB genome, *Musa paradisiaca*) [4] is also known as Kabri, Bangla, Shail, Thutae and Manua. Fiber was supplied by Fiber Research Center (FRC), Gazipur, Bangladesh.

III. EXPERIMENTAL DETAILS

3.1 Spinnability

Banana fiber is a plant bast fiber and it is long and coarse fiber. Spinnability depends on fiber length, strength and fineness. [5] Considering those factors banana fiber can be spun into both short staple spinning system (after cut into staple form) and long staple (jute) spinning system. But it was difficult to produce web in the carding machine. To overcome this problem banana fiber was blend with cotton fiber to form carding web. And by blending with cotton, both ring and rotor spinning system has been used to produce yarn. 100% banana fiber was used to produce yarn in long staple (jute) spinning system. And this experiment was done to check the spinnability of the banana fiber whether it can be spun or not. Two types of blend ratio were selected here

- Cotton: Banana=70:30
- Cotton: Banana=50:50

3.2 Yarn Formation

Raw banana fiber was cleaned and the lint was removed from the fiber after making the fiber staple form by using Shirley analyzer from PLATT BROS (SALE) LTD, Oldham England. The lint free fiber was blend with cotton in the carding process followed by producing sliver by using carding machine (Miniature Laboratory Type) from SDL, England. Drawn sliver was produced by using miniature laboratory type draw frame from SDL, England. The carding and drawing process was carried out at Bangladesh University of Textiles. Roving was produced by using simplex machine of Primeasia university yarn processing lab from MARATHE (1989), origin-India. Yarn was produced by using ring frame machine of Primeasia university yarn processing lab from O.M. LTD (1976), origin-Osaka, Japan.

Yarn was produced by open end spinning system by using rotor frame machine in BJRI (Bangladesh Jute Research Institute), Brand Name: Tongda, Model Number: HJF-1603, Origin: Shandong Tongda Textile Machinery Co., Ltd, China.

For long staple spinning Banana fiber was drawn by 1st draw frame, 2nd draw frame and 3rd draw frame from James Mackie and Sons, England. Yarn from drawn sliver in long (jute) spinning system was produced by using flyer frame from James Mackie and Sons, England.

3.3 Investigation of Yarn Properties

Tensile properties of yarn by the single- standard Method 1997 was analyzed by using Titan-Universal Strength Tester by James H. Heal & Co. Ltd. For investigating evenness, thick place, thin place, imperfection and hairiness of yarn, Premier Tester 7000 was used which origin is PremierPolytronics Ltd, India.

IV. RESULT AND DISCUSSION

4.1 Yarn Evenness, Imperfection Index and Hairiness

Yarn evenness varies with the variations in yarn fineness. This properties mainly measured, as the variation in mass per unit length. Yarn evenness variations are unpreventable as they come from the fundamental properties of textile fiber and from their resulting arrangement. Yarn quality parameters were tested by using Premier Tester 7000 and the result is shown in table 1

Table1. Evenness, Imperfection Index and Hairiness of different blend yarn

Sl No	Blend Ratio(C:B)	Count (Ne)	Spinning System	Um (%)	CVm (%)	Thn/Km (-50%)	Thk/Km (+50%)	Neps/Km (280%)	IPI	Hairiness
1	50:50	30	Ring	21.62	27.68	1360	3640	2400	7400	3.44
2	50:50	12	Rotor	12.49	16.24	40	240	440	720	2.06
3	30:70	30	Ring	32.81	44.95	6120	4480	5160	15760	3.56
4	30:70	7	Rotor	21.36	26.83	1080	3280	1320	5680	4.65

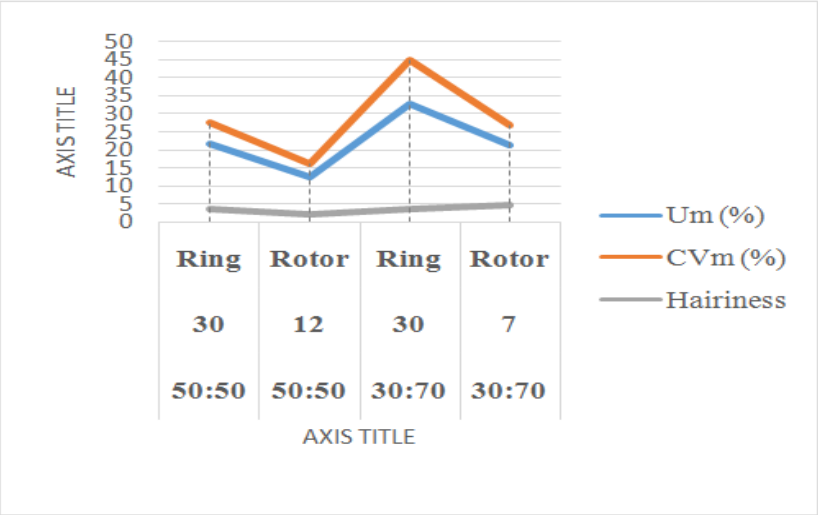


Figure 1. Um%, Cvm% and Hairiness of Different Blend Ratio (cotton-banana)

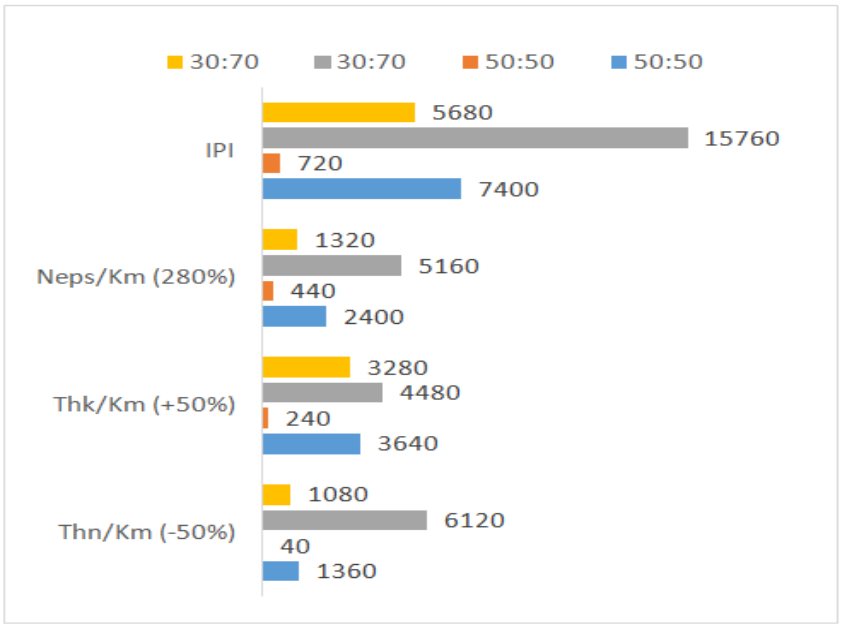


Figure 2. IPI, Neps, Thick and Thin Place of Different Blend Ratio (cotton-banana)

It is seen very clearly from above comparison shown in figure 1 and 2 that quality of rotor (cotton-banana blend)yarn is better than quality of ring (cotton-banana blend)yarn. It is also very ostensible from above chart that the unevenness of the fiber is increased with increasing of banana part in the blend ratio in case of both (ring and Rotor) spinning system. From the above analysis it can be inferred that rotor spinning is more suitable for banana fiber.

4.2 Yarn Strength and Extension

Yarn strength is very crucial factor for any kind of further process. Yarn strength can be measured by two ways, namely- lea strength and single yarn strength. To perform this test single yarn strength system has been used to analysis strength and extension of yarn. Strength and extension of different blend yarn is shown in table 2

Table 2. Yarn Strength and Extension of different blend yarn

Sl No	Blend Ratio(C:B)	Count (Ne)	Spinning System	Max Force(cN)	Extension (%)	Time to Break(s)
1	50:50	30	Ring	119	3.49	4.4
2	50:50	12	Rotor	327	6.09	8.1
3	30:70	30	Ring	174	5.49	6.3
4	30:70	7	Rotor	356	4.95	9.3

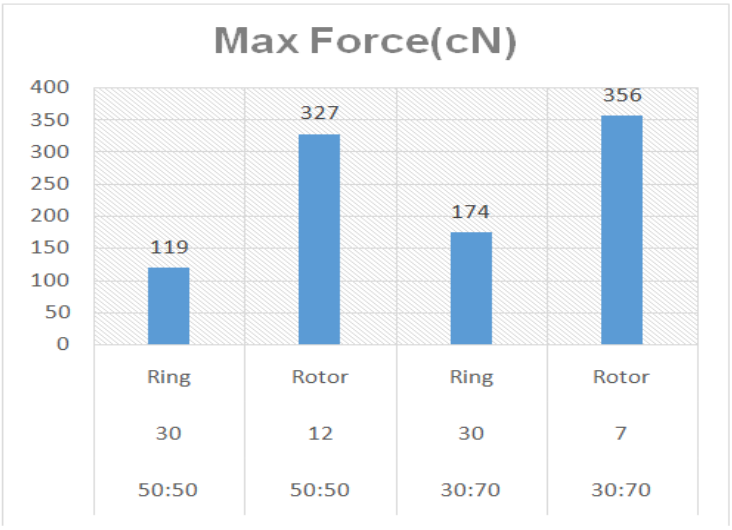
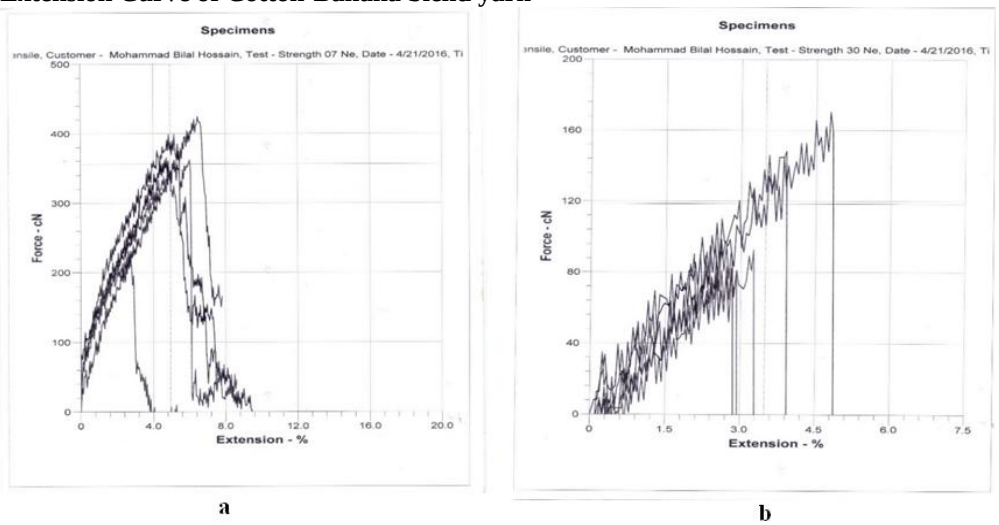


Figure 3. Yarn Strength of Different Blend Ratio (cotton-banana)

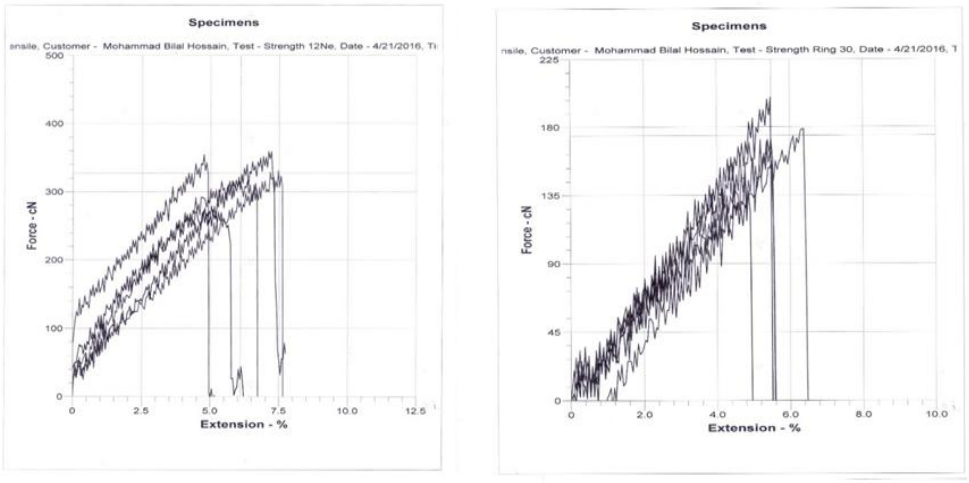
Figure 4. Yarn Extension and Time to Break of Different Blend Ratio (cotton-banana**)**

The results shown in figure 3 clearly indicate the strength of rotor yarn is more than ring yarn though the count of the yarn is different but it is very obvious from the above chart is that the strength of the yarn is increasing with the increasing of banana part in the blend ratio. Similarly extension rate and time to break also follow the same result shown in figure 4. So it can be deduced from above analysis that the strength of the yarn can be increased by mixing banana with cotton. It is also can be interpreted that for better result with banana fiber rotor spinning is more commodious.

4.3 Load-Extension Curve of Cotton-Banana blend yarn



a b



c d

Figure 5. Load-Extension Curve of Cotton-Banana Blend Yarn a) 30:70 Rotor b)50:50 Ring c)50:50 Rotor d)30:70 Ring

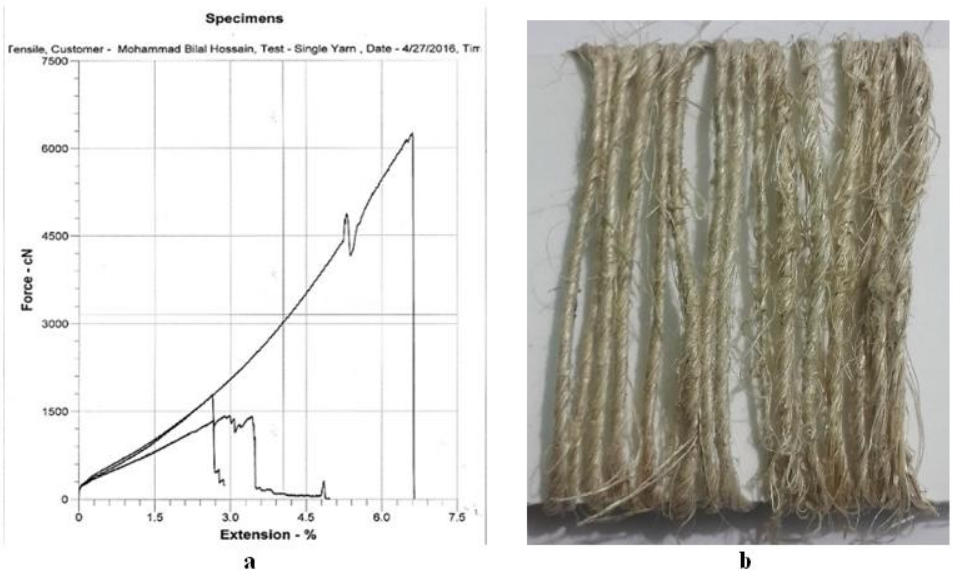
Figure 5 comprises the representative load-extension curves for cotton-banana blend yarn with different blend ratio by rotor and ring spinning system. The load-extension curve is generally known as stress-strain curve. It is very important for analyzing the yarn tensile properties. It is clearly visible that the load-extension curve of the above figure showing same result like evenness has already been described.

4.4 Strength and Extension of 100% Banana Yarn

100% banana tarn was produced by following jute spinning system and the yarn strength and extension was investigated by using single yarn strength method. The result is shown in table 3

Table 3. Yarn Strength and Extension of 100% Banana Yarn

Sl No	Count(lb./spindle)	Max Force(cN)	Cv (%)	Extension (%)	Time to Break(s)
1	43.54	3154	85.34	4.04	20



a b

Figure 6. a) Load-Extension Curve of 100% Banana yarn b) 100%Banana yarn

Table 6 shows the banana yarn strength, extension% and time to break and the figure 6a represents the load-extension curve of 100% banana yarn. It is seen from the above table that Cv% 85.34 which indicate the unevenness of the yarn is more. It was happened because during processing carding process was fully omitted due to shortage of fiber and instead of mechanical carding manual combing was done to individualize and parallel the fiber which was not perfectly done as carding process is also responsible for hairiness (figure 6b).

V. CONCLUSION

Yarn formation of banana fiber blending with cotton for short staple spinning and of 100% banana fiber for long staple spinning where the properties were found satisfactory through several testing of the yarn.

Rotor spinning system was found more convenient system to spun banana fiber blending with cotton fiber than ring spinning in case of short staple spinning and the blending with cotton was done due to inability of web formation of 100% banana fiber. On the other hand banana fiber is most suitable for jute spinning system as it is very similar with jute fiber though the yarn was found hairy but other properties are passable. Finally the investigation shows the prospect of banana fiber is resounding.

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