Blending Cotton with Regenerated Cellulosic Fiber (Bamboo) to Obtain a More Durable Yarn

Mohamed Neguib El-Banna[1], A.A.A.El-Banna[2], Mohamed A. M. El-Sayed Negm[3], Mahmoud Ismail El-Bagoury[4] and Dalia M. Nageeb[5]

1&2) Faculty Agriculture Saba Basha, Alexandria University, Egypt

3) Cotton Research Institute, Agriculture Research Center, Giza, Egypt

4&5) Cotton Arbitration & Testing General Organization, Egypt

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Abstract

This research was carried out at Cotton Research Institute of Agriculture Research Center, Giza, Egypt, to study the impact of different spinning systems and different bamboo + cotton blends of the properties on the blended yarn. A commercial cultivar, Giza 86 (a long- staple variety), and bamboo fiber were used in the experiment. Two spinning systems, i.e., ring and compact spinning were employed to produce 40'S carded yarns. The results obtained indicate that a compact spun bamboo + cotton yarn blended at a ratio of 67:33 yielded the highest mean values for the key yarn properties. The strongest fibers produced the best yarn quality.

***Key words*:** Bamboo, Cotton, spinning system, Blend ratios, Yarn Strength, Yarn properties

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Introduction

With the growing demand for more comfortable, healthier and environmentally friendly products, research and development efforts in the textile industry have focused on the use of renewable and biodegradable resources as well as environmentally sound textile manufacturing processes (Erdumlu and Ozipek, 2008). The most important factors in determining the properties of any given yarn are the type and ratio of the fibers that go into the blend. The properties of any yarn will vary according to the properties of the fibers used in their production. Thanks to the micro gaps in its structure; bamboo fiber has high air permeability and water absorption properties that allow it to keep the human body dry and free from unpleasant odors. Bamboo based fabrics are antibacterial and soft, and are only minimally subject to pilling and creasing. Bamboo fabrics also require lesser amounts of dyes for each dying level required. It is a natural product that is grown without the use of chemicals or pesticides and it is also quick to absorb moisture. One of the disadvantages of bamboo is that it has low fiber strength, so that the goal of blending it with cotton in the spinning process is to produce yarn with more acceptable qualities (Sekerden, 2011). Cotton, with its soft, luxurious feel and its hygienic properties has traditionally been one of the most human-friendly fibers in the world. The idea of blending cotton with bamboo was to produce yarn with qualities that could not be obtained by using any single type of fiber alone. Blending is also is done in order to lower production costs, circumvent shortages of natural fibers, improve spinning performance, increase yarn strength, achieve greater evenness, reduce the number of imperfections, among others (Ahmad *et al*., 2012). Bamboo and bamboo-cotton blended yarns play a key role in the natural product issue and are being endorsed for use in soft-look and soft-feel textiles (Prakash *et al*., 2012). The properties of cotton fiber and their spinning variables, such as yarn count and spinning system friendliness, are generally recognized as making an important contribution to the efficiency and performance of spinning process, aside from the quality of the yarn itself. There is a wide range of yarn counts and twists that will require, within the same spinning system, different fiber properties. Perhaps, the best way to emphasize this point is to briefly review the principles of different spinning systems centering on the fiber question, as such (El-Banna, 2013). Fiber processing and spinning can be affected by fiber properties (Price *et al*., 2009).

Ring Spinning

In Egypt, numerous breeding efforts have been directed towards enhancing cotton fiber length, strength and fineness in order to improve ring spinning performance. Ring spinning is the oldest type of spinning technique extant today. Thus it has benefited from being part of a continuous improvement process since its initial development in the 19th century. Furthermore, the introduction of more advanced spinning techniques in the 20th century spurred additional developments and innovative designs in ring spinning to keep pace with the high productivity of the emerging systems. Most of the technical advances in ring spinning were intended to improve the performance of the existing technology

Compact spinning

Compact spinning, which can best be described as a modification of the basic ring frame and friction spinning technique, has been generating increasing interest since its first commercial introduction at the International Textile Machinery Association (ITMA) exhibit in Paris in 1999. The system uses an air current to seize the fibers as they leave the front roller nipping line and to condense the fiber strand. The result is a dramatic reduction of the spinning "triangle" and better fiber alignment.The objective of this research was to investigate the effectiveness of blending two kinds of fibers, to compare the impact of two different spinning systems on the blended fibers, and to assess the combined interaction of different blending and spinning methods on a number of yarn properties.

Materials and Methods

This research was conducted at the Cotton Research Institute of the Agriculture Research Center, Giza, Egypt. About 100 Kg of lint of the Egyptian cotton variety Giza 86 was used to perform both fiber and spinning tests. A HVI system was used to determine fiber length and micronaire according to ASTM, D: 4605-1986. Cotton fiber testing was carried out at Egyyarn Spinning and Weaving Co., Industrial free zone, Badr city. The 100% bamboo fiber was supplied by CSA Textile Egypt, Borg El-Arab, Alexandria, Egypt. The bamboo fiber, i.e., regenerated cellulosic fiber, was processed using a conventional short-staple carded yarn spinning system. The properties of the Giza 86 cotton fiber and of the regenerated cellulosic fiber (bamboo) were determined and appear in Table 1. The study used ring and compact spinning systems with 40'S yarn count to make samples of 100% bamboo yarn, 100% cotton yarn and bamboo + cotton yarn blended at three different ratios. Standard spinning preparation and the modern machinery available in the experimental spinning mill of the Cotton Research Institute were used to produce conventional carded yarns under comparable technological conditions using RST1 Marzoli ring spinning equipment. After the spinning trials, the physical properties of each yarn sample were measured according to ASTM (1991) and the measurement results, i.e., yarn evenness (CV %) and imperfections, such as thin places, thick places as well as the number of neps, were measured on an Uster Tester 3 as recommended by Uster standards following the practice of ASTM (D-1425-84). The measurement length was 400 m/bobbin. Yarn tenacity (RKM) and elongation at break (%) were measured on a Statimat ME Tester as per ASTM (D-2256-84) with 120 breaks per sample.

Table 1: Fiber properties for the Egyptian Giza 86 cotton variety and for Regenerated Cellulosic Fibers (Bamboo)

Property	Bamboo	Cotton Giza 86
Titre, Dtex	1.5	1.3
Fiber length"mm"	38	32.5
Dry tenacity "cN/tex"	23	44
Dry elongation "%"	14	6
Tenacity, wet state "cN/tex"	15	54
Elongation, Wet state "%"	16	8
Moisture content "%"	13	8.5
Color	White	White

Yarn characteristics tested were as follows:

$B._1$. Single yarn strength (RKM)
$B._2$. Yarn elongation %
$B._3$. Yarn unevenness (CV %)
$B._4$. Thin places /400 m
$B._5$. Thick places /400 m
$B._6$. No. of neps /400 m

Characteristics Studied

The materials were tested for fiber properties, and yarn properties (Table 1).

Statistical Procedures

This investigation was conducted using a complete randomized design with three replicates and analyzed as a factorial experiment according to the procedure developed by **Snedecor and Cochran (1967)**. Data was procedure using the CoStat program. To test for differences among the means of treatment studied, the least significant difference (L.S.D.) was used at a 0.05 level of probability.

Results and Discussion

Yarn characteristics

Data presented in Table 2 show the mean values of the yarn properties, i.e. single yarn strength, yarn elongation (%), yarn evenness (C.V. %), yarn imperfections (thin places, thick places and neps /400 m) for 100% cotton yarn, 100% bamboo yarn as well as for the bamboo + cotton yarn blended at three different ratios and with the same yarn count: 40'S carded yarns.

B_1- Effect of the Spinning System on Yarn Properties:

Results indicated that the effect of the different spinning systems had a highly significant impact on single yarn strength, on the differences in the number of thin and thick places/400m and in the frequency of neps/400 m. Conversely, the differences in yarn elongation (%) and yarn evenness (C.V. %) were not significantly affected by the spinning system, as shown in Table 2. The highest mean value for single yarn strength (RKM) was [15.57 (RKM)] for compact spinning. Meanwhile, the lowest mean value [14.15 (RKM)] was recorded in ring-spun yarns. This may be attributed to the differences in yarn structure. In this connection, similar results were found by El-Banna *et al.,* (2013) who concluded that single yarn strength increased when using compact spinning.The highest mean values (131, 141 and 125.4 /400m) for yarn imperfections (thin places and thick places /400m) and neps/400m were found in the ring-spun samples, respectively. Conversely, the lowest mean values for those same traits (70.4, 83 and 89.8 /400m) were found in the samples processed by compact spinning. The differences may be attributable to the differences in the yarn structure. These results concur with the values recorded by Sevda and Kadoğlu (2012), who concluded that the tenacity values of carded compact yarns are significantly higher than carded conventional ring yarns and that conventional ring yarn had the greatest number of thin places and neps.

B_2 -Effect on Yarn Properties of Blending Bamboo with the Cotton Fiber

The data in Table 2 reveal that the blend ratios studied had a highly significant effect on yarn strength (RKM), yarn elongation (%), yarn evenness (C.V. %) and yarn imperfections (thin places, thick places and neps/400 m). The highest values [17.24 (RKM) and 11.20 %] for single yarn strength (RKM) and yarn elongation (%) were recorded for the B_5 control sample, 100% cotton fibers and for the B_1 control, 100% bamboo fiber, respectively. On the other hand, the lowest mean values for the same traits [12.41 (RKM) and 4.10 %] were recorded for the B_3 sample, 50/50 % bamboo-cotton and for the B_4 sample, 33/67 % blended bamboo-cotton yarn, respectively. The tenacity value was found to be higher (44 cN/tex) in cotton fiber than in bamboo fiber (23 cN/tex), as shown in Table 1. Thus it may be concluded that single yarn strength (RKM) gradually increased as a function of fiber tenacity and maintained that same trend. Yarn elongation gradually increased with fiber elongation.

Regarding yarn evenness (C.V.%) and the number of thin places and thick places, the highest mean values were recorded in the B_4 sample, 33/67 %, bamboo-cotton blended yarn (20.71 %, 165 and 142.5 /400m), respectively. The lowest values were recorded in the B_5 control sample -- 100% cotton fiber --, and the B_1 control sample -- 100% bamboo fibers --, (15.55 %, 50 and 70.5 /400m), respectively, as shown in Table 2. The results in Table 2 are in line with Sekerden (2011) who concluded that the ratio of bamboo fibers in the blend affected the evenness properties of the yarn. Sekerden (2011) also found that yarn unevenness decreased as the ratio of bamboo fibers in the blend increased.

As for the number of neps /400m, the highest mean value was found in the B_2 sample: 67/33 %, bamboo-cotton blended yarn (115.5 /400m). Meanwhile, a similar value was recorded for the B_5 control sample, -- 100% cotton fiber (95.5 / 400m), as shown in Table 2.

Table 2: Mean values of the single yarn properties as affected by the spinning system and blend ratio and their interaction during the processing of 40'S carded yarns.

Treatments \ Properties	Single Yarn					
	Strength (RKM)	**Elongation (%)**	**Evenness (C.V %)**	**Thin Places /400m**	**Thick Places /400m**	**No. of Neps /400m**
			Spinning system (S)			
Ring spinning	**14.15** b	5.85 a	18.20 a	**131.0** a	**141** a	**125.4** a
Compact spinning	**15.57** a	6.15 a	18.54 a	**70.4** b	**83** b	**89.8** b
			Bamboo / cotton % (B)			
100/00 (B_1)	14.42 c	**11.20** a	16.99 c	**50.0** e	95.5 b	105.0 c
67 / 33 (B_2)	14.92 bc	5.02 b	18.48 b	82.0 c	111.5 b	**115.5** a
50 / 50 (B_3)	**12.41** d	4.63 bc	20.12 a	145.5 b	140.0 a	111.5 b
33 / 67 (B_4)	15.32 b	**4.10** c	**20.71** a	**165** a	**142.5** a	110.5 b
00 / 100 (B_5)	**17.24** a	5.05 b	**15.55** d	61.0 d	**70.5** c	**95.5** d
			Interaction			
(S * B)	ns	ns	**	**	**	**

Means designated by the same letter within each column are not significantly different
***   : Significant at 0.05 level of probability.**
****: Significant at 0.01 level of probability.**
ns: Not significant.

It should be noted that the differences in yarn imperfections (thin places and thick places /400m) increased as the percentage of bamboo fiber decreased in the blended yarn. Conversely, the number of neps was inversely proportional to the percentage of cotton fiber in the yarn blended. These results concur with the results obtained by Tantawy (1977), who found that the tendency to form neps differed from one variety to another. It is well established that long staple cultivars usually have a higher tendency to form neps.

B_3 -Interaction Between Spinning Systems (S) and Among Different Percentage Blends of Bamboo & Cotton (S x B) on Yarn Properties

Table 2 shows that the first order interaction (S × B) of the two studied factors, spinning system (S) and blend ratios (B) were significant in most cases (4 out of 6 cases), which means that each factor behaved in different way when the other factors changed. Meanwhile, the remaining interactions (2 cases) were not significant, especially for single yarn strength (RKM) and yarn elongation (%), indicating that each trait may be acted upon as an independent factor.
Regarding yarn evenness (C.V.%), the highest mean value was (21.41%) for the compact spinning system in the B_4 sample: 33/67%, bamboo-cotton blended yarn, as shown in Table 3 . On the other hand, the lowest mean value for the same trait (14.3 %) was recorded for the compact spinning system as in the B_5 control sample, 100% cotton fibers. It may be concluded that yarn evenness increased as a function of the content of bamboo fiber going into the yarn blend as per a cross-section of the two studied spinning systems.

As for yarn imperfections (thin and thick places /400m), the highest mean values, i.e. 232 and 174 /400m, were recorded in the ring spinning system used on the B_4 sample of yarn blended at a ratio of 33% bamboo to 67 % cotton yarn. On the other hand, the lowest mean values for the same traits at 44 and 54 /400m were found in the yarn the B_1control sample processed by the compact spinning system at 100% bamboo fibers and with the compact spinning system used on the B_5 control sample at 100% cotton fibers, respectively, as shown in Table 3.

The ring spinning system used on the B_2 sample at a blend ratio of 67% bamboo to 33 % cotton yarn recorded the highest mean value of neps/400m 145/400m; the lowest mean value for the same trait, i.e. 67/400m, was obtained with the compact spinning system in the B_5 control sample at 100% cotton fibers.

Table 3: Interaction between spinning system (S) and the blend percentage of bamboo and cotton (S x B) for thin and thick places /400m and neps / 400m in 40'S carded yarns.

Parameters		Evenness (C.V. %)	Thin Places /400m	Thick Places /400m	No. of Neps /400m
Spinning system (S)	Bamboo-cotton Blend ratios (B)				
Ring spinning	**100/00 (B_1)**	16.45	56	135	114
	67 / 33 (B_2)	17.96	97	167	**145**
	50 / 50 (B_3)	19.81	204	142	126
	33 / 67 (B_4)	20.00	**232**	**174**	118
	00 / 100 (B_5)	16.80	66	87	124
Compact spinning	**100/00 (B_1)**	17.54	**44**	56	96
	67 / 33 (B_2)	19.00	67	56	86
	50 / 50 (B_3)	20.43	87	138	97
	33 / 67 (B_4)	**21.41**	98	111	103
	00 / 100 (B_5)	**14.30**	56	**54**	**67**
L.S.D$_{0.05}$		**0.428**	**0.729**	**4.343**	**0.449**

It should be noted that for the two spinning systems studied, the differences in yarn imperfections (thin places and thick places/400m) increased as the percentage of bamboo fiber in blended yarn decreased. It is well known that the number of neps is negatively correlated with the compact spinning system and bamboo fiber percentage of blended yarn. Similar results were emphasized by Uzair *et al.* (2015), who showed that, in general terms, an increase in bamboo fiber content tended to bring on increases in uniformity (U%) and imperfections, along with a decline in yarn tenacity. With each increase in the cotton fiber content of the blend there is a considerable increase in the number of imperfections.

Conclusion:

It may be concluded that the quality of the 40'S yarn count was affected most significantly by the spinning system and by the bamboo-cotton blend percentages. Fiber length and fiber tenacity were the greatest contributors to yarn strength. Fiber length and fiber elongation were the main contributors to yarn elongation and yarn evenness. However, the relative importance and contribution of fiber properties to yarn quality differed between fiber categories as well as between the two spinning systems. The results indicated that the ratio of bamboo fibers in the blend had a decisive effect on the properties of yarn.

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