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Interaction Study of Staple Length and Fineness of Cotton with Ultimate Yarn Regularity and Hairiness

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Abstract: The best utilization of raw material for manufacturing the optimum quality of yarn has become inevitable for the spinning mills to face the global competition. Yarn evenness and hairiness are the most important parameters from quality point of view and largely depend upon the fibre length and micronaire value, which are considered the foremost quality parameters for the selection of raw material. It is the purpose of this study to investigate the effect of cottons differing in micronaire value and fibre length on yarn evenness and hairiness so as to contribute a part in improving the raw material utilization.

Key words: Staple length, micronaire value, yarn regularity, spinning performance, unevenness, hairiness

INTRODUCTION

The growing global competition forces the cotton spinning mills to produce yarns in ever–increasing quality at competitive prices. When comparing the cost structures in different locations it can be clearly seen under consideration of all regional dissimilarities. The raw material price now as before represents the dominating factor in yarn manufacturing costs. This means that the key to survival in the international market is to best possibly utilize the raw material, despite all influences of labor costs and capital costs. Two quality parameters viz. fibre length and micronaire of raw material play vital role to control the yarn evenness and hairiness. Some references relevant to the present study are given as under:

Pillay[1] concluded that the correlation coefficient for fibre length with yarn hairiness is negative, as could be expected, since longer cottons have relatively fewer ends in a unit length of yarn than shorter ones. Douglas[2] stated that there is a close correlation between fibre fineness and yarn evenness. The mass variation in yarn is dependent on the co-efficient of variation value of fibre-to-fibre variation, and the number of fibres in the cross-section of the yarn. The fibre length influences yarn hairiness in the sense that a longer fibre length results in lower yarn hairiness. Zhu and Ethridge[3] concluded that the fibre fineness and nep content have little effect on yarn hairiness. Haque[4] stated that the longer fibres give smoother yarns because there are fewer ends to protrude. Powar[5] stated that fineness, length and percentage of long fibres jointly affect yarn hairiness to a large extent. Amjad[6] found that better the fineness of cotton, more would be the number of fibres per cross-section resulting, in higher spinability, better yarn strength, yarn evenness and luster. The lower the value of uniformity ratio will result in higher yarn hairiness. Zurek *et al.*[7] noted that the short and medium length evenness in yarn is influenced by the fibre length distribution and mean values of length, fibre fineness and its distribution and fibre neppiness. Anonymous[8] mentioned that fibre length is the most important fibre character effecting yarn quality. Length and length uniformity have a direct influence on yarn strength, elongation, evenness, hand, structure, and hairiness, as well as on yarn twist performance.

MATERIALS AND METHODS

Cotton bales of different micronaire value having same staple length were sorted out from the mills godown stock and then various length groups having a gradual increase in micronaire value were selected. In this way 55 samples, with five lengths against eleven micronaire levels were selected as follows:

	M_1	M_2	M_3	M_4	M_5	
L_1	M_1L_1	M_2L_1	M_3L_1	M_4L_1	M_5L_1	
L_2	M_1L_2	M_2L_2	M_3L_2	M_4L_2	M_5L_2	
L_3	M_1L_3	M_2L_3	M_3L_3	M_4L_3	M_5L_3	
L_4	M_1L_4	M_2L_4	M_3L_4	M_4L_4	M_5L_4	
L_5	M_1L_5	M_2L_5	M_3L_5	M_4L_5	M_5L_5	
	M_6	M_7	M_8	M_9	M_{10}	M_{11}
L_1	M_6L_1	M_7L_1	M_8L_1	M_9L_1	$M_{10}L_1$	$M_{11}L_1$
L_2	M_6L_2	M_7L_2	M_8L_2	M_9L_2	$M_{10}L_2$	$M_{11}L_2$
L_3	M_6L_3	M_7L_3	M_8L_3	M_9L_3	$M_{10}L_3$	$M_{11}L_3$
L_4	M_6L_4	M_7L_4	M_8L_4	M_9L_4	$M_{10}L_4$	$M_{11}L_4$
L_5	M_6L_5	M_7L_5	M_8L_5	M_9L_5	$M_{10}L_5$	$M_{11}L_5$

Where,
L_1= 1.05 inch, L_2= 1.06 inch, L_3=1.07 inch, L_4=1.08 inch, L_5=1.09 inch,

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And

M_1= 3.8 µg inch^{-1} M_2= 4.0 µg inch^{-1} M_3= 4.1 µg inch^{-1}
M_4=4.2 µg inch^{-1} M_5= 4.3 µg inch^{-1} M_6= 4.4 µg inch^{-1}
M_7= 4.6 µg inch^{-1} M_8=4.8 µg inch^{-1} M_9= 5.0 µg inch^{-1}
M_{10}=5.1 µg inch^{-1} M_{11}=5.2 µg inch^{-1}

The cotton samples were evaluated for the following physical characteristics

Fibre characteristics: Physical characteristics of cotton samples (i.e. length and fineness) were determined mostly with the help of "High Volume Instrument " HVI-900A, according to the standards of committee ASTM[9].

Yarn preparation: After the evaluation of the physical characteristics of the raw material, each cotton sample was opened manually and processed in the blow room. Then each sample was processed in carding and drawing section without changing any mechanical set up. The samples of sliver were processed to form roving of the same hank, roving samples were then spun in to ultimate yarn of the 20^s count at the same ring spindles. The yarn samples thus prepared were tested according to the standard methods as recommended by ASTM committee[10].

Yarn evenness: Yarn evenness (U%) was determined by measuring the capacity occurring as the yarn pass through the condenser and record in term of linear irregularity (U%) and the co-efficient of variation in yarn mass (CV%). Equipment employed was Uster Unevenness Tester (UT-4).

The Hairiness module of UT-4 consists of an electronic optical sensor, which converts the scattered light reflections of the peripheral fibres into a corresponding electron signal while the solid yarn body is eclipsed. Yarn hairiness is expressed in the form of hairiness value H, which is an indirect measure for the number of cumulative length of all fibres protruding from the yarn surface. The procedure of testing was derived from ASTM Standard[9].

Statistical analysis: Completely Randomized Design was applied in the analysis of variance of data for testing the differences among various quality characters as suggested by Steel and Torrie[11]. Duncan's Multiple Range test was also applied for individual comparison of means among various quality characters. The data was subjected to statistical manipulation on computer employing M-Stat micro computer program devised by Freed[12].

RESULTS AND DISCUSSION

Yarn evenness: The differences in the mean values of yarn unevenness due to different levels of micronaire value and fibre length was highly significant, but the interaction of fibre length and micronaire value (M×L) was non-significant.

Table 1: Comparison of individual mean values for yarn evenness (%)

Micronaire value	Mean value	Micronaire value	Mean value	Fibre length	Mean value
M_1	11.09b	M_7	10.50e	L_1	10.92a
M_2	10.82c	M_8	10.70d	L_2	10.80b
M_3	10.49ef	M_9	10.89c	L_3	10.72c
M_4	10.41fg	M_{10}	11.08b	L_4	10.63d
M_5	10.39g	M_{11}	11.26a	L_5	10.50e
M_6	10.25h				

Table 2: Comparison of individual mean values for yarn hairiness

Micronaire value	Mean value	Micronaire value	Mean value	Fibre length	Mean value
M_1	5.98a	M_7	5.84de	L_1	5.96a
M_2	5.96ab	M_8	5.88c-e	L_2	5.92ab
M_3	5.92a-c	M_9	5.91b-d	L_3	5.89bc
M_4	5.86c-e	M_{10}	5.93a-c	L_4	5.87cd
M_5	5.82e	M_{11}	5.96ab	L_5	5.84d
M_6	5.81e				

◘ Any two means sharing a letter do not differ significantly at 5% level of probability

The best value of yarn evenness at M_6 as 10.25 followed by M_5, M_4, M_3, M_7, M_8, M_2, M_9, M_{10}, M_1 and M_{11} with their mean values as 10.39, 10.41, 10.49, 10.50, 10.70, 10.82, 10.89, 11.08, 11.09, 11.26 %, respectively (Table 1). It seems that the micronaire value has definite effect on yarn evenness. Present results are supported by the findings of Douglas[2], who stated that there is a close correlation between fibre fineness and yarn evenness. The mass variation in yarn is dependent on the co-efficient of variation value of fibre-to-fibre variation, and the number of fibres in the cross-section of the yarn. While studying the relationship of cotton fibre properties and yarn properties Amjad[6] found that better the fineness of cotton, more would be the number of fibres per cross-section resulting, in higher spinability, better yarn strength, yarn evenness and luster.

Further comparison of individual mean values of yarn evenness for fibre length levels given in (Table 2) exposes the best value of yarn evenness at L_5 as 10.50% followed by L_4, L_3, L_2 and L_1 with their mean values as 10.63, 10.72, 10.80 and 10.92%, respectively. The present results show the gradual decrease of yarn evenness with the increase of fibre length. These results agree with the recent study by Anonymous[8] who mentioned that fibre length is the most important fibre character effecting yarn quality. Length and length uniformity have a direct influence on yarn strength, elongation, evenness, hand, structure and hairiness, as well as on yarn twist performance.

Regarding the interaction of micronaire value and fibre length (M×L), the cotton samples with five fibre length levels having micronaire value M_{11} has the best value of yarn evenness as 10.13% at fibre length level L_5. While the remaining mean values are ranked as 10.18, 10.25, 10.31 and 10.36% for fibre length levels L_4, L_3, L_2 and L_1, respectively. The range of yarn evenness for over all cotton samples is noted from 10.13 to 11.46% with best value for yarn sample M_6L_5 (4.4 μg inch^{-1}, 1.09 inch) and worst for $M_{11}L_1$ (5.2 μg inch^{-1}, 1.05 inch). Present results are similar to the findings of Abbas[13] and Maqsood[14] they reported the range of yarn unevenness of 20^s ring spun carded cotton yarn from 9.05 to 11.61 and 10.99 to 11.40%, respectively. The best values of yarn evenness are obtained at micronaire levels (M_3 = 4.1, M_4 = 4.2, M_5 = 4.3, M_6 = 4.4 and M_7 = 4.6 μg inch^{-1}) against higher fibre length levels (L_4 = 1.08 and L_5 = 1.09 inch).

The yarn evenness is considerably influenced by properties from which it was spun as it is pointed out by Triplett[15] who stated that the short staple length and high micronaire may contribute to problems with processing, resulting in greater yarn unevenness. In the same line, Zurek *et al.*[7] noted that the short and medium length evenness in yarn is influenced by the fibre length distribution and mean values of length, fibre fineness and its distribution and fibre neppiness.

The regressional analysis of yarn evenness due to different levels of micronaire and fibre length is presented in graphical form in Fig. 1. It shows the fitted regressional lines of fibre length levels at all the levels of micronaire for yarn evenness. The lines indicate that the increase of fibre length level gives the better values of yarn evenness. This might be due to the reason that the fibre length determines the amount by which fibres can overlap with one another; the longer fibres exhibit greater overlapping and easily bound together resulting in greater yarn strength. Where as, the gradual increase of yarn evenness is observed at all the levels of fibre length with the increase of micronaire level up to (M_6= 4.4 μg inch^{-1}) and negative response is seen beyond this level. It might be a genetic behavior of cotton variety MNH-93. At low micronaire levels there is less cell wall thickness and strength of fibres, and at higher micronaire levels the cell wall thickness and bending rigidity of fibres increase; cause the decrease in yarn strength which in turn effects the yarn evenness.

Thus it can be concluded that lower and higher micronaire values deteriorated the yarn evenness and higher levels of fibre length gave best yarn evenness.

Yarn hairiness: The differences in the mean values due to different levels of micronaire values and fibre length was highly significant, but the interaction of fibre length and micronaire value (M×L) was non-significant.

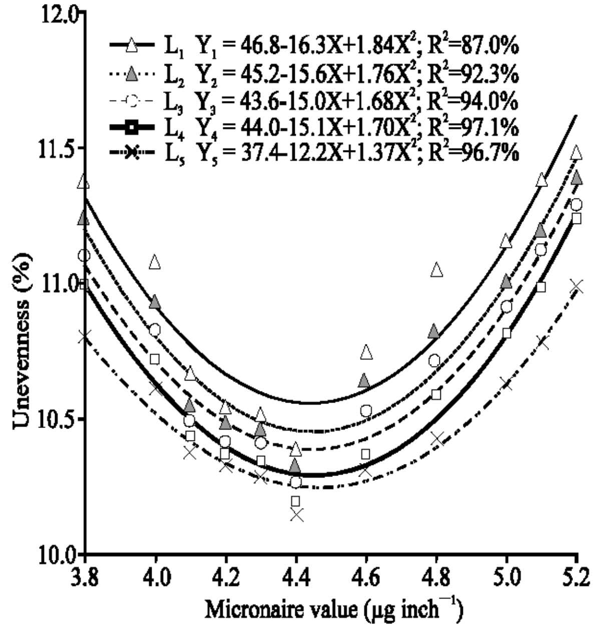

Fig. 1: Regression lines of staple lengths at different levels of micronaire value for unevennes

The best value of yarn hairiness at M_6 as 5.81 followed by M_5, M_7, M_4, M_8, M_9, M_3, M_{10}, M_{11}, M_2 and M_1 with their mean values as 5.82, 5.84, 5.86, 5.88, 5.91, 5.92, 5.93, 5.96, 5.96 and 5.98, respectively (Table 2). These results show that the cotton fibre fineness has a specific effect on yarn hairiness. Previously Ali[16] stated that fibre fineness is directly proportional to hairiness. Where as, Zhu and Ethridge[3] concluded that the fibre fineness and nep content have little effect on yarn hairiness.

The best value of yarn hairiness at L_5 as 5.84 followed by L_4, L_3, L_4 and L_1 with their mean values as 5.87, 5.89, 5.92 and 5.96, respectively. These results show that the longer the fibre less is the value of yarn hairiness (Table 2). The present result is broadly confirmed by Douglas[2] who concluded that fibre length influences yarn hairiness in the sense that a longer fibre length results in lower yarn hairiness. In another study, Haque[4] stated that the longer fibres give smoother yarns because there are fewer ends to protrude.

Regarding the interaction of micronaire value and fibre length (M×L), the cotton samples with five fibre length levels having micronaire value M_6 has the best value of yarn hairiness as 5.73 at fibre length level L_5. While the remaining mean values are ranked as 5.80, 5.81, 5.82 and 5.87 for fibre length levels L_4, L_3, L_2 and L_1, respectively. The range of yarn hairiness for over all cotton samples is noted from 5.73 to 6.06% with minimum value for yarn sample M_6L_5 (4.4 μg inch^{-1}, 1.09 inch) and

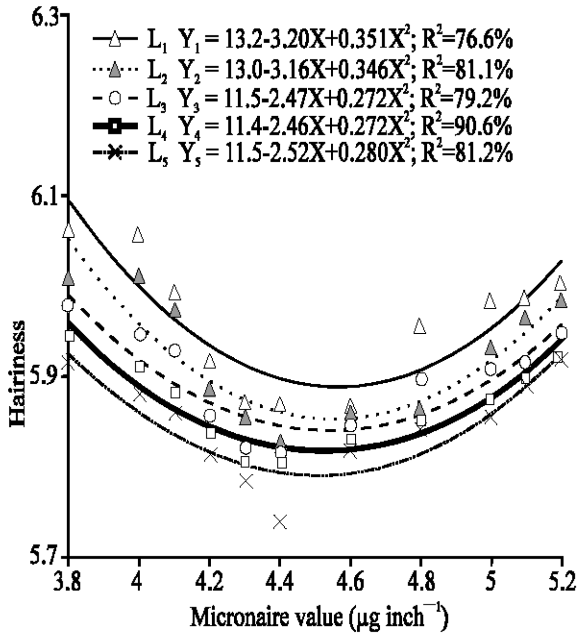

Fig. 2: Regression lines of staple lengths at different levels of micronaire value for hairiness

maximum for M_1L_1 (3.8 μg inch^{-1}, 1.05 inch). Present results are similar to the findings of Nabi[17] and Javaid[18], they reported that the range of yarn hairiness for 20^s ring spun carded cotton yarn from 5.48 to 6.78 and 4 to 6 respectively. The best values of yarn hairiness are obtained at micronaire levels M_4 = 4.2, M_5 = 4.3, M_6 = 4.4, M_7 = 4.6 and M_8 = 4.8 μg inch^{-1} against higher fibre length levels L_4 = 1.08 and L_5 = 1.09 inch.

The fibre length, length uniformity and fineness along with other fibre parameters significantly influence the yarn hairiness as it is mentioned by Powar[5], who stated that fineness, length and percentage of long fibres jointly affect yarn hairiness to a large extent. Likewise, Amjad[6] reported that lower the value of uniformity ratio will result in higher yarn hairiness. In the previous study, Pillay[1] concluded that the correlation coefficient for fibre length with yarn hairiness is negative, as could be expected, since longer cottons have relatively fewer ends in a unit length of yarn than shorter ones.

The regressional analysis of yarn hairiness due to different levels of micronaire and fibre length (Fig. 2), it shows the fitted regressional lines of fibre length levels at all the levels of micronaire for yarn hairiness. The lines indicate that with the increase of fibre length level there is gradual decrease in yarn hairiness. This might be due to the reason that the longer fibres have relatively fewer ends in unit length of yarn than shorter ones. Where as, the yarn hairiness decreases at all the levels of fibre length with the increase of micronaire level up to (M_6= 4.4 μg/inch) and negative response is seen beyond this level. It might be due to the reason that the cotton fibres with lower micronaire frequently cause the formation fibre hooks, cotton fibres with higher micronaire exhibits higher rigidity of fibres cause the breakage of fibres during processing; cause the increase of yarn hairiness.

The minimum yarn unevenness percentage (i.e. 10.13%) was noted at M_6L_5 (4.4 μg inch^{-1}, 1.09 inch). The hairiness was also minimum at these levels of cotton quality parameters. The lowers and higher micronaire values effect the yarn regularity negatively while the higher level of fibre length revealed a remarkable improvement in the yarn 20^s evenness well as reduction in hairiness

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