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Full Length Research Paper

Spinning performance of ELS Egyptian cotton

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In the fall of 2005, the pilot spinning mill at cotton research institute "CRI", began making spinning investigations, researches and developments R and D beside the experimental spinning mill which conducts the spinning-test routine. It is possible to orient the textile industry in Egypt to make proper use of Egyptian ELS cotton lint for the production of fine yarns and high quality ready made garments. The cotton samples contained approximately 100 kg of ginned lint, in order to perform both fiber and spinning tests. Cottons from 5 different ELS varieties and promising crosses identified as 2 categories, were selected for this study, the first group represented the extra-long extra- fine category that is, Giza 45, Giza 87 and new promising cross G.77 X Pima. The second group represented the extra long staple category that is, Giza 88 and new promising cross G. 84(G.74XG.68). The fiber properties were tested in textile technology center, Trützschler GmbH and Co. KG, Mönchengladbach, Germany. The results showed that AFIS and HVI fiber properties can be used for the prediction of yarn properties successfully. Whilst the results were quite satisfactory, it was necessary to ascertain that the results were paralleled elsewhere, especially industrial scale. These checks, made by spinning duplicated samples at Pilot spinning mill, cotton research institute and in Misr Iran spinning and weaving company. The relative order of yarn characteristics were the same at the count level.

Key words: Egyptian cotton, fiber and yarn quality, fine yarn counts.

INTRODUCTION

One of the objectives of the pilot spinning mill was to test the potential spinning performance of the commercial varieties and new promising varieties which launched in the market. Change in fiber properties brought about by different varieties consequently, fiber properties, have further emphasized the need for up-to-date information to guide the cotton textile industry in obtaining maximum utilization of fiber properties and more reliable means of determining spinning organizations which will result in minimum end breakage and maximum yarn quality at maximum production rats.

The cotton breeding program in Egypt has developed over a long time. Strong emphasis has always been put on quality and good deal of improvement with yield potential and agronomic characters. In any work such as the development of new varieties of Egyptian cottons, 3 natural divisions can be recognized. These are, roughly the initial selection of types which give *prima facie* evidence of special merit, the accurate testing of these by whatever methods are judged most suitable and the final market judgment (Brown, 1955; Abdel-Salam, 1994). The

spinning limit usually refers to the production of the finest yarn count from a given fiber with acceptable quailties and an end breakage rate below a tolerable threshold. The commercial value of a fiber depends upon its spinning limit. It is important to know why a system fails to spin beyond a certain count on both the coarser and finer sides. A clear understanding of the mechanism of yarn formation and the way the fiber parameters interact with the spinning process can lead to further improve-ment in the machine design with a view to widening the count range. Many studies focused on spinning limits for ring spinning, Burley (1959), Graham and Taylor (1978), Sief (1994), Lawrence (2003), Krifa and Ethridge (2004) and Chattopadhyay and Sinha (2007) had the focus of their studies has been to determine the spinning limits and the influence of process and fiber parameters on spinning performances.

Regarding the end breakage in spinning, most work was performed on a small scale laboratory basis without verification by actual mill trial of the results obtained by spinning tests used in the laboratory. Due to rapid technological changes, the need for an accelerated and reliable spinning evaluation test is now greater than ever.

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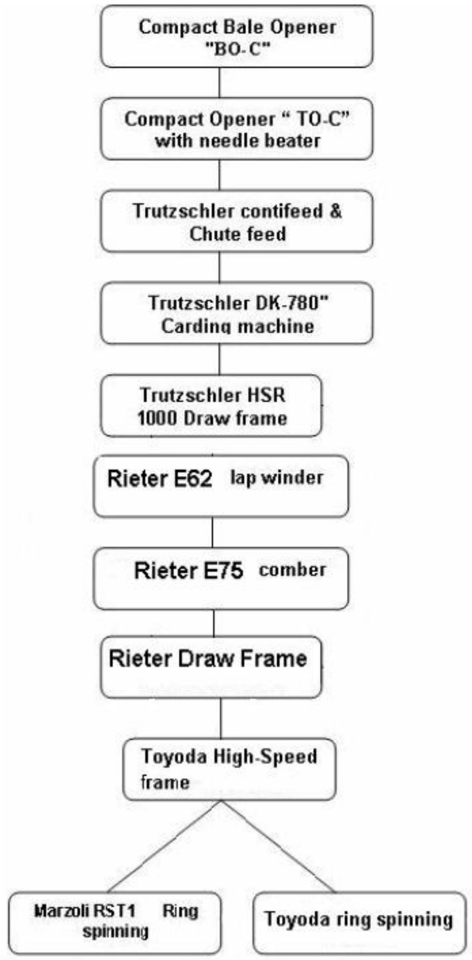

Figure 1. Outline of the mechanical process.

For the mill, the reliable accelerated spinning test method, which could be performed on a single frame, would be of considerable value in determining the merits of changes in cotton fiber properties and/or spinning variables.

The authors are aware that it is possible to orient the textile industry in Egypt to make proper use of Egyptian ELS cotton lint for the production of fine yarns and high quality ready made garments. In this respect, the government have implemented a series of new rules for accelerating privatization and encouraging foreign spinners to establish production facilities in Egypt. Improvements in the sector will enable Egypt to compete effectively within the framework of WTO regulations.

This paper presents a trial to, (i) predict the most important yarn parameters of ring spun cotton yarns by using AFIS and HVI fiber and yarn quality properties with linear multiple regression analysis. (ii) Discuss the performance of fiber and yarn data available to the ELS Egyptian cotton and carried out at pilot spinning mill, cotton research institute and, Misr Iran spinning and weaving company, as well as to verify pilot spinning mill findings with the industrial potential.

MATERIALS AND METHODS

Fiber properties

The cotton samples contained approximately 100 kg of ginned lint, in order to perform both fiber and spinning tests. Cottons from 5 different ELS varieties and promising crosses identified as 2 categories were selected for this study. The first group represents the extra-long extra- fine category that is, Giza 45, Giza 87 and new promising cross G.77 X Pima. The second group represented the extra long staple category that is, Giza 88 and new promising cross G. 84(G.74XG.68). The fiber properties were tested in textile technology center, Trützschler GmbH and Co. KG, Mönchengladbach, Germany in the fall of 2007, using the following instruments: HVI (High volume instrument), for fiber bundle measurement and AFIS (Advanced fiber information system) for single fibers measurement.

Spinning technique

Since the cotton was ELS, combed sliver was used for ring and compact spinning systems. The combed cotton was spun into Ne140, Ne 160 and Ne 170 yarns spun with 4.0 twist multiplier. The processing steps and machinery used are shown in Figure 1, including the branching to combing and to the compact and ring spinning frames. Regarding to combing process, all the cotton varieties and new promising crosses were combed at 18% noil to extract the short fiber, except the Giza 77xPima s6, the percentage of comber noil is 12%. This is the maximum percentage we have, meaning that the short fiber is very low and is more fiber uniform.

Yarn evaluation

Tensile properties

Single-yarn strength and breaking extension were measured on a Statimat ME instrument using a 500 mm gauge length and a 150 mm/min extension rate. The tests were performed in the standard atmosphere of 65 ± 2% R.H. and at 22 ± 1°C temperature. A minimum of 120 observations were made for each sample in order to obtain a 5% error of estimation. The single yarn strength, coefficient of variation of strength (%) and breaking extension values were recorded and then the average value was calculated. The results were also tested for significance.

Unevenness

The yarn unevenness was determined on an evenness tester using a test speed of 400 m/min for 1 min. 10 readings were taken for each sample and the average values of coefficient of variation %, hairiness and number of faults were calculated.

Statistical analysis

Regression analysis is the most common statistical method for estimation of the relationship between a dependent variable and one or more independent variables. This method has the advantage of simplicity in describing the quantitative relationship between textile material properties. Therefore, the multiple regression analysis method was selected for establishing the relationships between fiber and yarn properties. At the beginning, the types of relationship between selected properties (independent variables)

Table 1. HVI and AFIS measurements fiber data of selected varieties (of raw cotton).

Instruments	fiber property	Extra-long extra fine			Extra long staple	
		G.45	**G.87**	**G.77 X Pima S_6**	**G.88**	**G. 84(G. 74 X G. 68)**
HVI	Upper half mean length (UHM. Mm)	35.6	35.8	36.2	35.5	34.1
	Length uniformity index (U.I. %)	88.8	88.0	89.2	87.7	87.5
	Strength (g/tex)	43.5	45.5	46.5	46.5	49.0
	Elongation (%)	5.8	5.9	6.5	6.2	6.3
	Micronaire	3.1	3.2	3.0	3.8	3.6
Uster AFIS-L (w)	Medium fiber length (mm)	30.7	29.2	29.7	29.1	29.5
	Coefficient of variation (%)	32.4	32.9	34.7	33.5	31.8
	Short fiber content<12.5mm (%)	4.0	4.1	3.3	5.2	4.4
	UQL (mm)	36.6	36.7	36.6	35.5	34.4
(N)	Medium fiber length (mm)	25.1	23.5	26.5	23.5	24.7
	Coefficient of variation (%)	47.6	49.4	51.7	48.9	44.2
	Short fiber content<12.5mm (%)	16.6	19.8	15.7	18.4	14.9
	Fiber fineness (mtex)	118	125	120	142	144
	Maturity ratio	0.91	0.94	0.89	0.93	0.95
	Immature Fiber Content IFC (%)	6.3	5.8	7.0	5.7	4.8
Uster AFIS-T	Total (1/g)	3377	2379	2182	2652	2309
	Mean size (µm)	214	226	224	217	238
	Dust <500µm (1/g)	1145	1107	1017	1127	1113
	Trash (1/g)	90	72	65	87	69
	Visible Fiber matter V.F.M. (%)	2.4	2.7	2.7	2.7	2.03
Uster AFIS-N	Neps (1/g)	201	175	222	130	89
	Coefficient of variation (%)	14.41	23.80	19.0	16.0	14.10
	Mean size (mm)	0.68	0.70	0.69	0.68	0.70
	Seed trash (1/g)	10	9	9	7	7
	Mean size (mm)	1.04	1.06	0.98	0.98	1.03

and yarn properties (dependent variables) were checked individually by using curve estimation and correlation analysis. Statistical analysis indicated that there was a nearly linear relation-ship between fiber properties and yarn properties. Hence, the linear multiple regression analysis method was chosen for this study and the forward stepwise method was selected for linear regression analysis. Statistical analyses were performed using SPSS 9.0 software.

RESULTS AND DISCUSSION

Fiber properties

HVI an AFIS data obtained on the 3 cotton varieties and 2 promising crosses represented extra-long staple cotton category fiber samples is represented in Table 1. The following observations can be made.

Regarding to HVI fiber data, fiber length (UHM) averaged 35.44 mm and ranged from 34.1 mm G.74(G.84 x G.68) to 36.2 mm (G.77 x Pima S6) and according to the world quality charts, all 5 genotypes show staple lengths that fall in the premium range (ELS).

Length uniformity levels were average to excellent for all the genotypes under study (ranging between 87.5 and 89.2%). The uniformity values that are in the premium range (83.5 and higher).

Fiber bundle strength averaged 46.2 g/tex and ranged from 43.5 g/tex (Giza 45) and 49.0 g/tex (G.74(G.84 x G.68) have strength values over the premium range.

Micronaire values ranged from 3.0 (Giza 77 x Pima S6) to 3.8 Giza 88. The extra-long extra fine Egyptian cottons are only unique in low micronaire with high maturity. Regarding to AFIS data, fiber length (UQL) averaged 35.9 mm and ranged from 34.4 mm (G.74(G.84 x G.68) to 36.7 mm (Giza 87).

Yarn quality

Continuous predictors were selected based on relevant fiber properties that are significantly related to the yarn property being examined.

Table 2. Regression coefficients, t-values and significance level of variables of the linear regression model for single yarn strength.

Statistical parameter	Constant	UQL(w) Mm	Fineness millitex	Maturity%	Strength g/tex	Micronaire	Yarn count (tex)
B*	1.668	0.964	-0.900	0.732	0.800	0.819	0.736
Std Error	0.218	0.109	0.142	0.01	0.250	0.033	0.023
T	18.74	8.89	-5.062	2.63	3.268	3.49	2.66
Significant	0.029	0.000	0.002	0.009	0.007	0.013	0.036

* Partial regression coefficient.

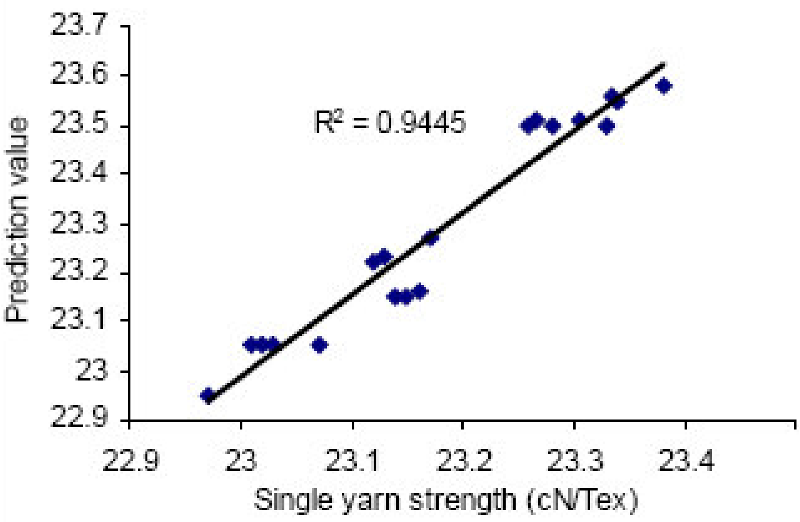

Figure 2. Prediction value versus observe single yarn strength (cN/Tex).

Predicting yarn tenacity

The tensile properties of any spun yarn depend upon the properties of its constituent fibers, the arrangements of these fibers within the yarn (that is, on the yarn structure) and the mass distribution of yarn along its length. The structure is primarily decided by the yarn formation mechanism and the process parameters. It is therefore, important to establish which fiber and yarn parameters influence yarn tensile properties and if possible, to derive the functional relationship between them. So far, numerous mathematical and empirical models have been established for the estimation of single yarn tenacity using fiber properties and some yarn parameters, Table 2.

Upper quartile length and micronaire value are other important fiber parameters for yarn tenacity. In addition increase in yarn count reduced yarn tenacity. As expected increased upper quartile length increased tenacity. Figure 2 shows the scatter plot of predicted values versus experimental values and regression line of our model.

Obviously, fiber strength is the most important factor for yarn tenacity. Instead of strength, fiber fineness becomes the foremost property among those of HVI fiber data, in addition we found very high negative correlation coefficient between fiber fineness and yarn tenacity (R = -0.900) as shown in Figure 2. This negative correlation means that the lower the diameter of fiber (that is, higher number of fibers in the yarn cross-section), the higher the yarn tenacity.

Our regression analysis expresses this relationship clearly. Table 3 shows regression coefficients of variables, t-values and significance level of each variable.

Arrangement of variables in the table indicates their relative importance for the model. Signs (+ or -) of regression coefficients of variables indicate the direction of influence.

Predicting yarn elongation

Table 3 shows the multiple linear regression analysis results. The breaking elongation is mostly influenced by yarn count. Upper quartile length and fineness are the most important fiber properties for the yarn breaking elongation. Other important parameters are yarn twist, roving count and roving unevenness. All parameters have positive effect except roving unevenness and fiber diameter. Several researchers concluded that yarn elonga-

Table 3. Regression coefficients, t-values and significance level of variables of the linear regression model for yarn elongation.

Statistical parameter	Constant	Elongation %	UQL (mm)	Fineness millitex	IFC	Strength g/tex	Yarn count (tex)
B*	0.292	3.2	3.7	0.355	-0.0731	0.136	-0.926
Std Error	3.59	1.8	2.3	0.15	1.53	0.0767	0.071
T	1.87	0.023	2.34	0.154	-1.55	0.078	-.676
Significant	0.648	0.000	0.007	0.021	0.025	0.014	0.046

* Partial regression coefficient.

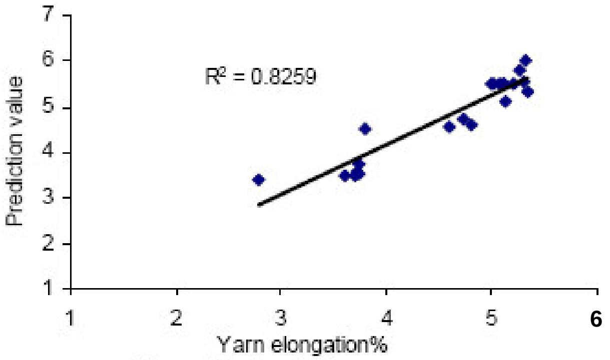

Figure 3. Prediction versus observed yarn elongation (%).

tion is chiefly influenced by fiber elongation and fiber strength.

We can not measure fiber elongation and strength on an AFIS instrument. Therefore the R^2 value and predicttive power of the model is relatively low. Figure 3 shows the wide spread of values around the regression line.

Predicting yarn unevenness

Cross sectional fiber variation is the main reason for yarn unevenness. The spinning method, yarn count and some fiber parameters have a decisive influence on the unevenness of yarn in addition to machine parameters. In Table 4 and Figure 4 linear regression analysis results are presented. The analyses showed that yarn unevenness was mainly affected by fiber fineness, immature fiber content and nep count. The direction of impact for, immature fiber content and nep count are positive. That is, increased parameters increased the yarn evenness. Fiber fineness designates the number of fiber in yarn cross section. Decreased fiber diameter increased the number of fiber in cross section and thus increased regularity.

Predicting yarn hairiness

Hairiness, another measurable yarn characteristic, is usually an undesirable property. Regression coefficients, t-values and significance level of the variables of the model are given in Table 5. The data illustrates that the most important fiber property influencing yarn hairiness is fiber fineness (millitex). Finer cottons create less yarn hairiness, increase yarn count (tex) and increase yarn hairiness. Upper quartile length reduced yarn hairiness. Long fibers have less chance to protrude from the yarn body and become a hair. Figure 5 shows the scatter plot of predicted values versus experimental values and regression line.

Spinning performance

Raw fiber quality (as measured by HVI and AFIS) is often an excellent indication of the industrial potential of the cotton. However, the decisive factor in a yarn spinner's choice of one cotton over another is the fiber quality resulting in the sliver destined to produce the yarn, which is a function of both the initial fiber quality (raw fiber) and the alterations that occur in the course of the different processing stages (fiber-machine interactions).

The range of yarn counts which were successfully produced under identical process conditions from 5 different fibers are shown in Table 6. A strict comparison between 5 cotton fibers is not possible as they are not exactly identical in their physical parameters, that is, length and fineness. Cotton has the widest possible count range up to 170 Ne without end breakages. The majesty of ELS Egyptian cotton is produce extra fine yarn counts with also, extra quality as shown in Table 6.

Comparisons between results obtained at Pilot Spinning Mill (CRI) and those obtained on industrial scale (Misr Iran spinning and weaving Company)

Whilst the above results were quite satisfactory using the pilot unit, it was necessary to obtain the results were paralleled on the industrial scale and for this purpose, a 5 cottons, covering the whole Egyptian ELS range, were spun to 160's combed ring yams with 4.0 twist multiplier were compared. These checks, made by spinning duplicated samples at pilot spinning mill, cotton research institute and in Misr Iran spinning and weaving company.

Table 4. Regression coefficients, t-values and significance level of variables of the linear regression model for yarn evenness.

Statistical parameter	Constant	Evenness	UQL (mm)	Fineness millitex	IFC	Neps	Fiber	Yarn count (Tex)
B*	1.018	0.178	0.234	-0.558	0.359	0.819	-0.569	0.037
std Error	0.022	0.058	0.048	0.01	0.030	0.007	0.023	0.071
T	0.17	6.93	0.422	-1.01	5.34	1.833	-0.099	0.314
Significant	0.063	0.025	0.013	0.011	0.003	0.005	0.034	0.031

* Partial regression coefficient.

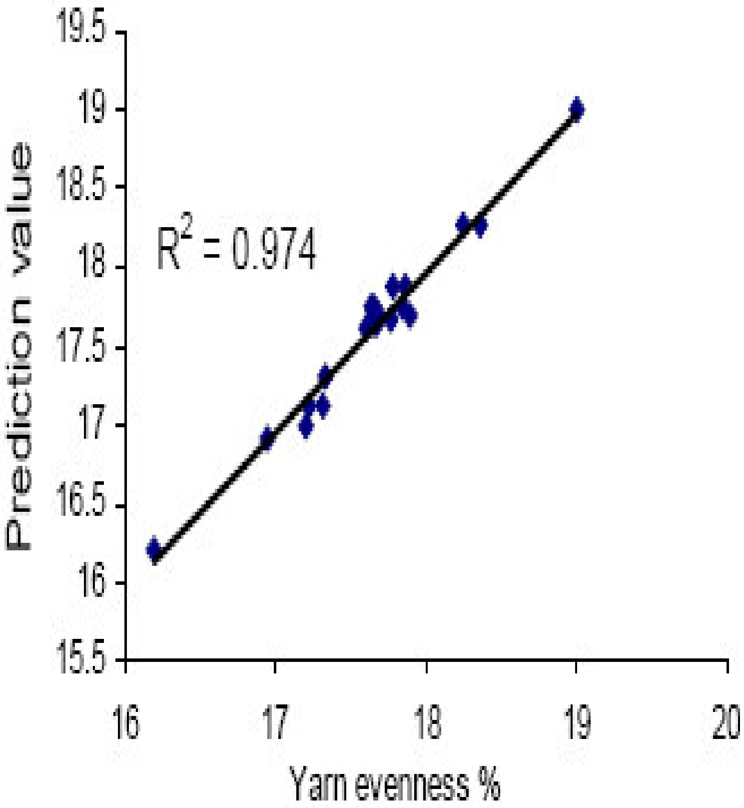

Figure 4. Prediction versus observed yarn evenness

Table 5. Regression coefficients, t-values and significance level of variables of the linear regression model for yarn hairiness.

Statistical Parameter	Constant	Short Fiber Content	Fineness Millitex	IFC	UQL (mm)	Yarn count (Tex)
B*	0.93	0. 05	-2.3	0.060	-0.143	0. 706
std Error	2.35	1.23	0.235	.023	1.23	0.021
T	0.714	1.19	-3.54	2.1	-6.67	3.31
Significant	0.023	0.024	0.000	0.029	0.020	0.003

* Partial regression coefficient.

The results are shown in Table 7. The relative order of yarn characteristics were the same at the count level. Further and on the continent, show that no major change of relative position was found.

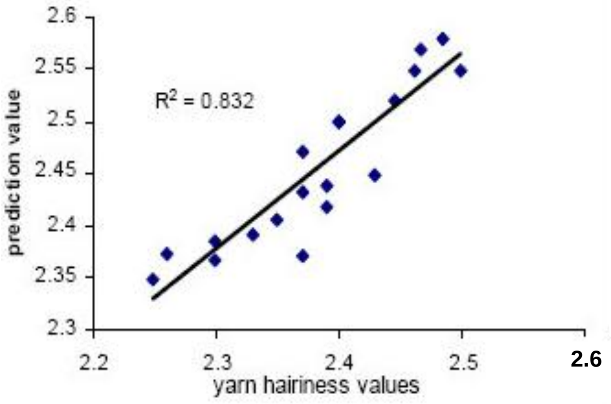

Figure 5. Prediction value versus observed yarn hairiness values.

Table 6. Yarn properties for different yarn counts of ELS Egyptian cottons.

Cottons	Strength (g/tex)	Elongation (%)	Evenness (c.v.%)	Thin places	Thick places	No. of neps	Hairiness
				Ne 140			
Giza 45	23.39	4.4	15.22	63	96	136	2.27
Giza 87	23.38	4.4	15.06	79	118	125	2.32
77 X bima	23.45	4.6	15.18	50	92	117	2.32
Giza 88	20.22	3.7	17.49	110	141	104	1.99
84X74X68	20.00	3.9	17.05	109	159	116	1.96
				Ne 160			
Giza 45	21.59	3.8	15.68	156	203	150	1.89
Giza 87	21.53	3.6	16.99	78	165	193	1.96
77 X bima	21.47	3.0	15.58	66	127	137	2.08
84X74X68	18.46	3.1	17.61	117	102	118	2.07
Giza 88	18.55	2.6	16.49	135	157	124	1.80
				Ne 170			
Giza 45	21.39	4.9	18.22	63	96	176	1.67
Giza 87	21.18	4.2	18.06	79	118	165	2.32
77 X bima	21.25	4.6	17.58	50	92	137	2.32
Giza 88	17.22	3.7	18.49	110	141	134	1.99
84X74X68	17.22	3.9	18.05	109	159	136	2.26

Table 7. Pilot spinning mill and industrial scale (Misr Iran) yarn properties.

ELS Cottons	Strength (g/tex)		Elongation (%)		Evenness (C.V. %)	
	CRI	Misr Iran	CRI	MisrIran	CRI	Misr Iran
Giza 45	21.39	21.36	3.80	3.61	15.68	17.20
Giza 87	21.53	21.42	3.60	3. 40	16.99	17.50
Giza 88	20.55	20.56	3.60	4.12	16.49	16.80
G.77 x Pima	22.47	22.46	3.00	3.74	15.58	17.13
G.84x (G.74x G.68)	21.46	19.69	3.11	2.98	17.61	17.90
Mean	21.48	21.09	3.2	3.5	16.47	16.31
L.S.D at 0.05 level	N.S		0.17		N.S	

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