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# QUALITY UPGRADING OF EGYPTIAN COTTONS

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## Abstract

Older generations of Egyptian cotton varieties are seasonally upgraded by new generations. This is a direct result of the deterioration of fiber quality and/or yield per acre of the old varieties. One of the latest upgrade varieties is the so-called Giza-90. This study focuses on the impact of this new variety on yarn quality and processing performance. Six yarns were ring spun in yarn counts (tex): 14.8, 16.4, 19.37, 24.6, 29.5 and 37. Corresponding optimum twist multipliers were 4616, 4455, 4527, 4464, 4454, and 4623 consequently. Evaluation of fiber quality was performed using the so-called Fiber Quality Index (FQI), which is a function of the 50% span length, fiber tenacity, and Micronaire values. Yarn quality was also expressed using a Yarn Quality Index (YQI), which is a function of yarn strength, and yarn mass irregularity. The recorded quality of Giza-90 cotton fibers was: UHM = 28.7 mm, Uniformity Index = 84, Tenacity 34.5 cN per tex, Breaking Elongation 7.7%, Mic = 4.10, Color Reflectance Rd = 66, yellowness (+ b) = 11.4, trash count = 60 and spinning consistency Index SCI = 149. The yarn quality level of 14.8 tex yarn that produced from Giza-90cotton was: Tenacity = 15.7cN per tex, Breaking Elongation = 4.8%, CVm % = 20.5 and Hairiness (UT3 standard) = 5.2. Quality levels of produced yarns were tabulated, exhibited and statistically analyzed. This paper discusses the significance of this upgrade variety.

## Introduction

Any new type of cotton fibre is evaluated by the measures of the technological values. The technological values can be considered by the different views of the cotton measures (5). In a typical marketing system, cotton prices may be affected by several factors including laws of supply and demand, regional factors, fibre attributes and possible chaotic changes from one crop to another. In any situation, however, fibre attributes present the primary factor in determining both of the yarn quality and the premiums and discounts. In view of the revolutionary development in the powerful testing systems HVI® and AFIS®, it has been revealed that the market value of a new generation cotton has yet to reflect its technological worth(5). The establishment of a market value of a new cotton variety is truly representative of its actual technological worth that is faced by three main challenges. The first one is the substantial differences in view of what constitutes fibre quality as expressed by different organization involved in the cotton industry. The second challenge involves the impact of the current market structure. The third challenge is the lack of a systematic model to scientifically evaluate the cotton quality of the new generation of cotton fibers (5).

The properties of Giza-90 cotton fibers can be evaluated using a single index that is so- called fibre quality index FQI (9), which is calculated by formula:

$$FQI = (L \times S \times m / Mic)$$

Where L is the 50% span length of cotton fibre in mm as measured by the Digital Fibrograph, S is the fibre tenacity in cN per tex at 3.2 mm length as measured by Stelometer, m is the maturity coefficient as expressed and measured according to British standards, and Mic is the Micronaire reading.

Cevasteanov (7) has established the following cotton fiber length (in mm) relationships:

staple length = 1.02 model length + 2.6 and modal length = 1.19 mean length – 2.6

Cotton fibre quality is the most dominant factor that determines, to a considerable extent, the quality of yarns, fabrics, apparel and ready made garments. Any error or negligence in the selection of the raw cotton material can not be corrected by any means in the subsequent processes (8). In the work (3) it has been concluded that the fiber – machine interaction affects to a certain extent on the yarn quality that is processed on both of: carded and combed lines using the ring spinning frame.

The tendency of cotton to form neps in processing is property that concerns the people working in cotton breeding, growing, distribution and manufacturing into yarn and fabric (6). It is well known that the nep potential of the cotton fibers is a function of the aspect ratio L / d , where L is the fibre length and d is the fibre diameter. In man made fibers it is defined by slenderness ratio where its value can predict problems during the processing of man made fibers (7).

The quality of yarns is generally understood in terms of unevenness characteristics, strength, appearance… etc. Nowadays hairiness of yarns is gaining importance with regard to fabric appearance and generation of neps (9). In work (4), it has mentioned a definition of the yarn quality factor YQF where it is defined as follow:

$$YQF = \frac{CSP \times \text{Yarn Tenacity in cN per tex}}{U\,\%}$$

Where, CSP – count strength product, U% - mean percent deviation as measured by Uster Evenness Tester, and yarn tenacity – single end strength in cN per tex.

## Experimental Work

The experimental work is divided to two parts. First part is concerns with the testing procedures for cottons and yarns. The specifications of cotton fibers Giza–90, Giza-83, and Giza-80 are measured by using traditional instruments and HVI. Yarns characteristics are tested by Off-line instruments, most of them are made by Uster® Technologies. All the tests were carried out according to the ASTM recommendations. Second part is dealing with the spinning schedules, as given in Table (1), to produce the tabulated yarn tex under the industrial conditions inside a spinning mill. The used spinning twist multipliers for the produced yarns are given in table (2), where the tex system is applied.

Table (1) Spinning schedules

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Ring spinning m/c | tex | 14.8 | 16.4 | 19.7 | 24.6 | 29.5 | 37 |
| Flyer | tex | 740 | 740 | 740 | 740 | 740 | 740 |
| Draw Frame | ktex | 4.65 | 4.65 | 4.65 | 4.65 | 4.65 | 4.65 |
| Card | ktex | 4.65 | 4.65 | 4.65 | 4.65 | 4.65 | 4.65 |

Table (2): Yarns Twist

| | | | | | | |
|---|---|---|---|---|---|---|
| tex | 14.8 | 16.4 | 19.7 | 24.6 | 29.5 | 37 |
| TPM | 1200 | 1100 | 1020 | 900 | 820 | 760 |
| Twist Factors in tex | 4616 | 4455 | 4527 | 4464 | 4454 | 4623 |

## Results & Discussions

The results and the discussions will be divided to two parts. The first part deals with the fiber quality while the second part deals with the yarn quality.

**A. Fibre Quality**

Fibre properties of Giza-90 & Giza-83 are illustrated in the following table:

Table (3): Fiber properties of Giza–90 & Giza–83 cottons

| Property/ Cotton | UHM (mm) | Unf % | Mic | Mat | Str cN/tex | Elong % | Rd | +b | Trash Area% | Trash Cnt | SCI | Neps per gram |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Giza-90 | 28.8 | 84 | 4.11 | 0.87 | 34.4 | 7.6 | 66.1 | 11.4 | 0..8 | 61 | 149 | 60 |
| Giza-83 | 29.1 | 83 | 4.42 | 0.92 | 34.6 | 7.7 | 66.5 | 11.2 | .8 | 56 | 146 | 56 |

The nep potential of Giza–90 cotton has been computed with its ancestor Giza-83 and with their nearest neighbor Giza-80. Theoretically, the nep potential is directly proportional to the slenderness ratio (S.R) which it is equal to ($L_f/d_f$). A general formula to calculate the mean fibre diameter in microns, as given in work (1) is:

$$d_f = 35.7 * \sqrt{\frac{tex_f}{\rho_f}}$$

Where,

$\rho_f$- fiber density in gram mass per cm$^3$ and

$tex_f$ - fiber tex.

For cotton fiber, where $\rho_f$ = 1.52g per cm$^3$, the mean fibre diameter in microns is calculated by:

$$d_f = 29 * \sqrt{tex_f}$$

Taking the Mic into consideration, the values for cotton fibers Giza–90, Giza-83, and Giza-80 are given in the following table.

Table (4): Aspect Ratios

| cotton variety | $d_f$ µ m | $L_f$ mm | ($L_f/d_f$) | Measured neps per g. (HVI) |
|---|---|---|---|---|
| Giza-80 | 11.7 | 30.8 | 2620 | 63 |
| Giza-83 | 12.0 | 29.1 | 2410 | 56 |
| Giza–90 | 11.65 | 28.8 | 2470 | 60 |

As shown from table (3), Giza-80 is a little neppy compared to Giza-90. This can be due to the difference in the slenderness ratio (9%). The same trend is not found for Giza–83 where the difference with Giza-90 is only 2.5% but in the direction of Giza-90 it is more neppy. This trend is confirmed by the HVI nep count.

The fiber quality index (FQI) has been calculated for Giza–80, Giza-83, and Giza-90 by using the formula in the work (10), where the variables of the FQI were determined experimentally by the traditional instruments. In addition to that, the equation of Cevasteanov (7) has been incorporated. Table (4) shows the summary of the calculations. It is shown from table (5) that the values of FQI & SCI for Giza–90 take place between Giza–83 and Giza–80.

Table (5): Fiber Quality Index (FQI)

| Cotton variety | L | S | m | Mic | FQI | SCI of the HVI |
|---|---|---|---|---|---|---|
| Giza-80 | 25.4 | 38.1 | 0.97 | 4.17 | 225 | 169 |
| Giza-83 | 24.0 | 34.6 | 0.99 | 4.42 | 200 | 146 |
| Giza–90 | 23.8 | 34.4 | 0.95 | 4. 11 | 189 | 149 |

The cotton fiber stiffness and toughness index are calculated for Giza–90, Giza-83, and Giza-80 using the definitions mentioned in the work (1) as follow:

$$Stiffness = \frac{cN/tex}{Elong\%}$$

$$Toughness = cN/tex * Elong\% * Const$$

The different calculations are summarized in table (6).

Table (6): Calculated values of fiber Stiffness and Toughness

| Cotton variety | Stiffness ( Young's modulus in cN/ tex) | Toughness index cN $tex^{-1}$ |
|---|---|---|
| Giza-80 | 544.3 | 1.330 |
| Giza-83 | 443 | 1.332 |
| Giza–90 | 452.6 | 1.307 |

As shown in table (6), Giza–90cotton takes half the way between Giza-80 and Giza-83 where it's stiffness is 2.16% higher than the stiffness of Giza–83. In case of Giza–80, stiffness is 20% higher them Giza–90. This can lead to more stiff yarn that is spun from Giza–80 than yarn spun from Giza–90 cotton. Referring to fiber toughness index, it is shown from table (6) that all types of the cotton variety Giza–80, Giza-83, and Giza-90 are close to each other where this can lead to equality of potential energy absorption for sudden loads.

The spinning consistency index (SCI) as defined and measured by HVI is 169, 146 & 149 for Giza–80, Giza-83, and Giza-90 respectively. This can mean that the spinning performance will be better for Giza–80 than both of Giza-83 and Giza-90.

**B. Yarn Quality**

For both of cottons Giza-83 and Giza-90, the same yarn counts in tex 14.8, 16.4, 19.7, 24.6, 29.5 & 37 were spun on a ring spinning frame as carded yarns. The yarn characteristics of Giza-83 cotton carded yarns are given in table (7). The characteristics of Giza-90 cotton carded yarns are given in table (8). All these results are given in Figures (1 to 13).

Table (7) Characteristics of different yarns produced from Giza-83 cotton.

| | | | | | | |
|---|---|---|---|---|---|---|
| *Tex* | 37 | 29.5 | 24.6 | 19.7 | 16.4 | 14.8 |
| $R_H$ | 20 | 19.23 | 18.5 | 18 | 17.12 | 15.86 |
| $E_H$ | 7.72 | 7 | 6.66 | 6.34 | 5.81 | 5.1 |
| $W_H$ | 1138.4 | 795.1 | 641.2 | 479.1 | 371 | 290.7 |
| $CV_{RH}\%$ | 9.75 | 10 | 10.2 | 10.41 | 10.6 | 10.8 |
| $CV_{EH}\%$ | 9.2 | 9.5 | 9.5 | 9.93 | 9.93 | 10.2 |
| $CV_{WH}\%$ | 14.66 | 14.66 | 15.89 | 16.1 | 17.02 | 17.5 |
| $CV_m\%$ | 16.1 | 16.2 | 17.2 | 18.7 | 19 | 19.4 |
| $CV_b\%$ | 3.78 | 3.6 | 3.22 | 3 | 2.84 | 2.65 |
| *Thin* | 13 | 28.4 | 38.3 | 94.61 | 141.1 | 236.53 |
| *Neps* | 425.7 | 473.1 | 662.3 | 898.8 | 700 | 1324.5 |
| *Thick* | 473.1 | 662.3 | 851.5 | 946.1 | 1230 | 1700.3 |
| *H'* | 7.57 | 6.62 | 7.1 | 5.87 | 4.12 | 4.91 |
| $CV_{H'}$ | 1.8 | 1.61 | 1.61 | 1.51 | 1.42 | 1.42 |

* Yarn imperfections are measured per one Km of the yarn.

Table (8) Characteristics of different yarns produced from G90 cotton.

| | | | | | | |
|---|---|---|---|---|---|---|
| *Tex* | 37 | 29.5 | 24.6 | 19.7 | 16.4 | 14.8 |
| $R_H$ | 19 | 18.2 | 17.5 | 17 | 16.2 | 15 |
| $E_H$ | 7.3 | 6.6 | 6.3 | 6 | 5.5 | 4.8 |
| $W_H$ | 1077 | 752 | 607 | 423 | 351 | 275 |
| $CV_{RH}\%$ | 10.3 | 10.6 | 10.8 | 11 | 11.2 | 11.2 |
| $CV_{EH}\%$ | 9.8 | 10 | 10 | 10.5 | 10.5 | 10.8 |
| $CV_{WH}\%$ | 15.5 | 15.5 | 16.8 | 17 | 18 | 18.5 |
| $CV_m\%$ | 17 | 17.8 | 18.2 | 19.2 | 20 | 20.5 |
| $CV_b\%$ | 4 | 3.8 | 3.4 | 3.2 | 3 | 2.8 |
| *Thin* | 14 | 30 | 40 | 100 | 150 | 250 |
| *Neps* | 450 | 500 | 700 | 950 | 1100 | 1400 |
| *Thick* | 500 | 700 | 900 | 1000 | 1300 | 1800 |
| *H'* | 8 | 7 | 7.5 | 6.2 | 5.6 | 5.2 |
| $CV_{H'}$ | 1.9 | 1.7 | 1.7 | 1.6 | 1.5 | 1.5 |

*Legend:*

*Tex* Yarn # in Tex system.
$R_H$ Yarn tenacity in $CN.tex^{-1}$.
$E_H$ Yarn breaking extension in %.
$W_H$ Work done required for yarn break.
$CV_{RH}\%$ C.V% of yarn tenacity.
$CV_{EH}\%$ C.V% of yarn breaking elongation.
$CV_{WH}\%$ C.V% of yarn breaking work done.
$CV_m\%$ C.V% of yarn mass.
$CV_b\%$ Yarn count C.V%.
*Thin* Thin places per one yarn Km.
*Neps* Neps per one Km. of yarn.
*Thick* Thick places per one yarn Km.
*H'* Yarn Hairiness.
$CV_{H'}$ C.V% of yarn Hairiness.

It is well known that any fiber or yarn property can be digitized through off-line instruments. These digits have a profile – most probably a normal distribution. Such as any statistical distribution, it has the mean value (as a measure of central tendency) and the dispersion value as a measure for dispersion around the mean value and it is expressed as C.V%. Figures (1 to 7) in consequence represent the yarn characteristics as mean values for:

- yarn tenacity $R_H$ in cN per tex versus yarn tex.

- yarn breaking elongation $E_H$vs. Yarn tex.

- yarn breaking work done in cN. Cm tex $^{-1}$ VS yarn tex.

- yarn hairiness H in # of hairs per cm VS. Yarn tex.

- yarn imperfections ( thin places, neps and thick places) per one yarn km vs. yarn tex.

Generally speaking all these exhibits clear that Giza–90 is less performed w.r.t Giza–83. This may be related to F.Q.I: of Giza-83 that is better than F.Q.I of Giza-90 cotton by bout 6%. Seemingly this value 6% is consistent because its effect is clear for all the observed yarn properties except the yarn imperfection where both of Giza–90 cotton & Giza-83 cotton are highly adjacent and embodied. It must be noted that the values of yarn imperfections are relatively high because these yarns were spun in a spinning mill where the conversion system of fibers to yarn was the carded type.

Figures (8 to 13) show the different variability of the yarn characteristics for mass variation up to other variations that are expressed as C.V%. The consequences of these exhibits are,

- yarn mass variation CV m% vs. yarn tex.
- yarn single end strength variation $CV_{RH}$ vs. yarn tex.
- yarn breaking elongation variation $CV_{EH}$ vs. yarn tex.
- yarn work done variation $CV_{wH}$ vs. yarn tex.
- yarn count variation $CV_b$ vs yarn vs. yarn tex.
- yarn hairiness variation $CV_H$ vs. yarn tex.

In spite of Giza–90 cotton has high uniformity index UI = 84 that it is large with respect to Giza-83 (UI = 83), we find that the variabilities of Giza–90 yarns characteristics are higher than that for Giza–83. Even if we consider UI for both cotton are closer, the gap in results is so much clear.

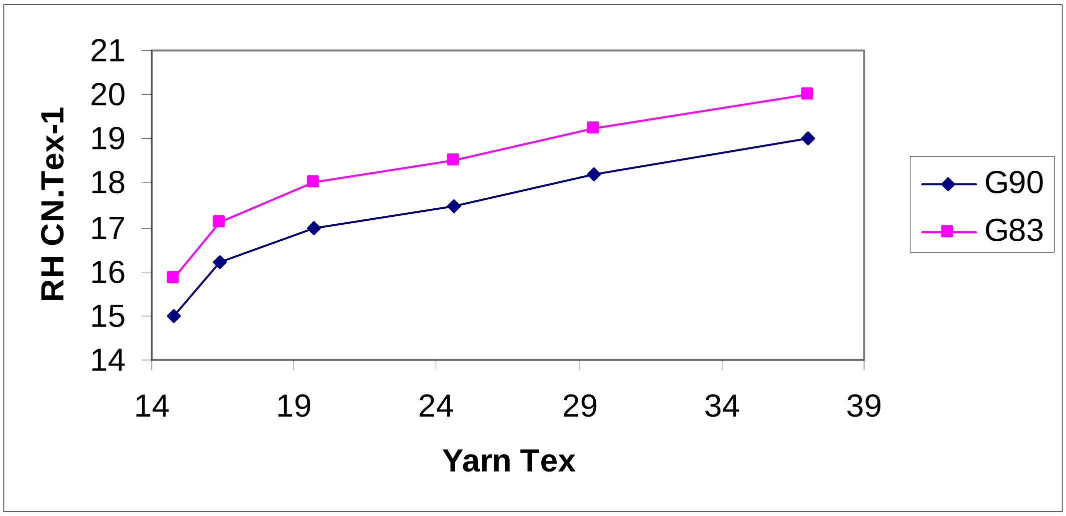


**Fig.(1) Yarn tenacity $R_H$ in CN.Tex$^{-1}$ VS. Yarn Tex**

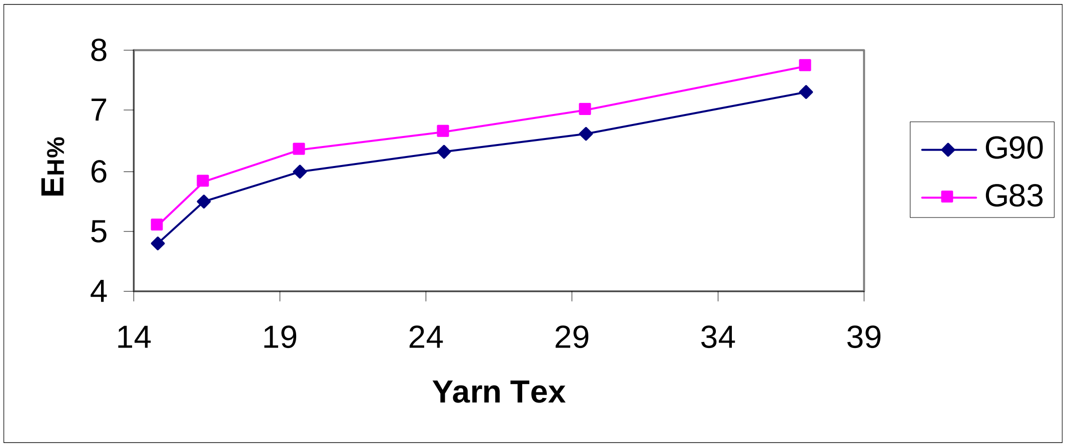


**Fig.(2) Yarn breaking extensions $E_H$ in % VS. Yarn Tex**

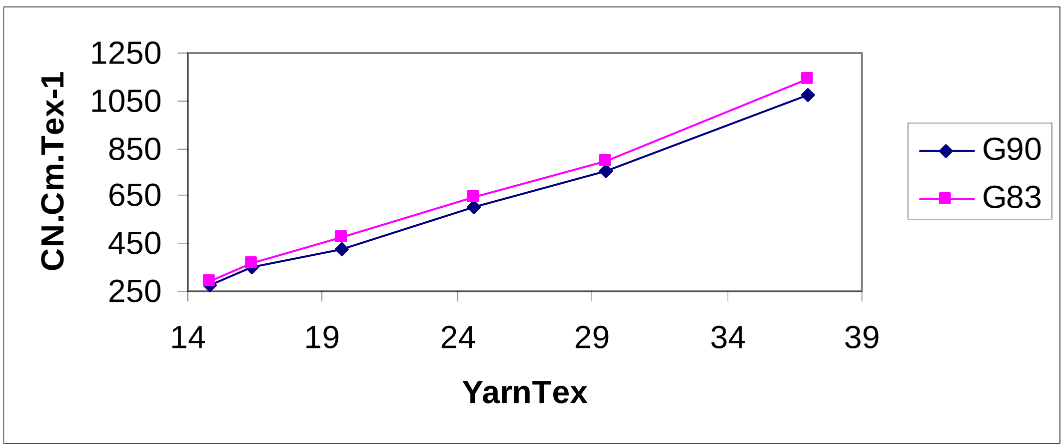


**Fig. (3) Yarn work done in CN.Cm.tex$^{-1}$ VS. Yarn Tex**

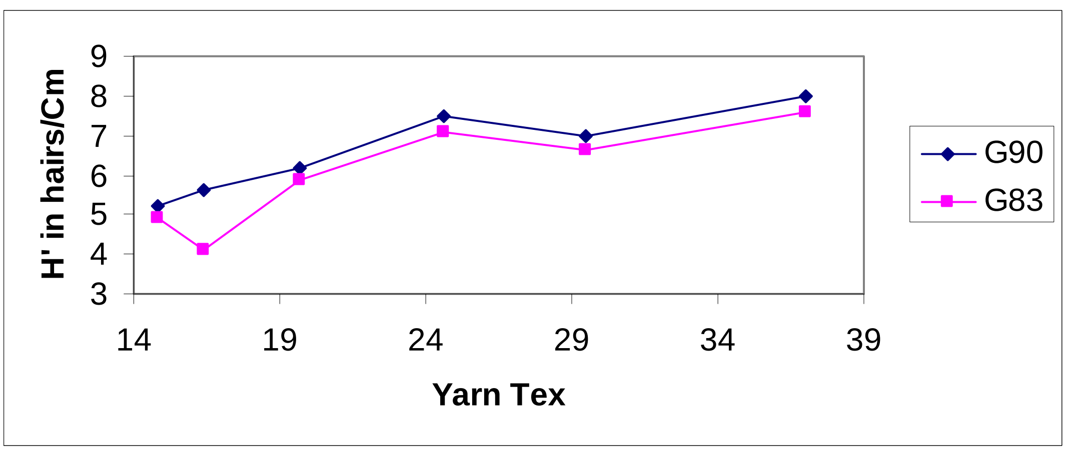


**Fig.(4) Yarn H' in hairs per Cm VS. Yarn Tex**

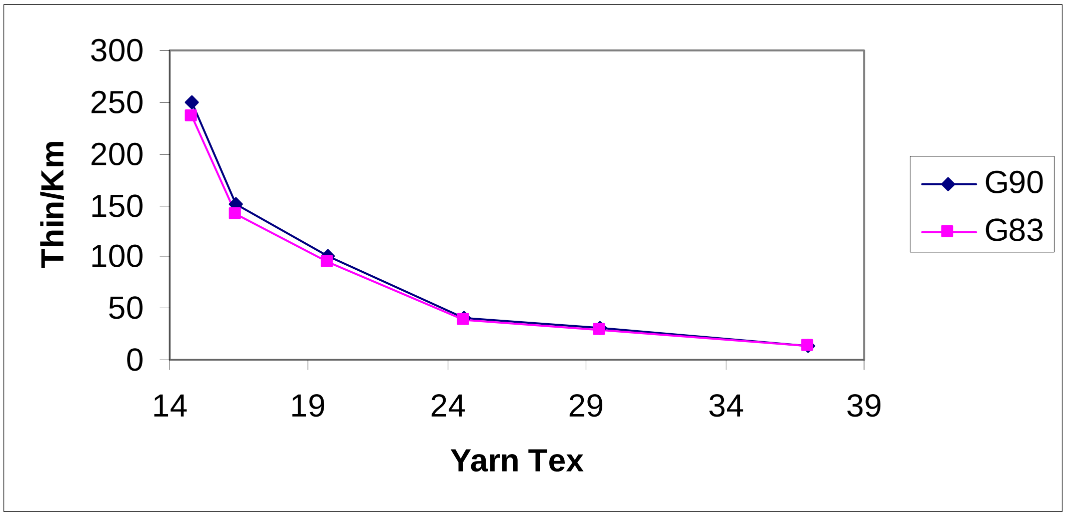


**Fig.(5) Yarn Thin places per Km VS. Yarn Tex**

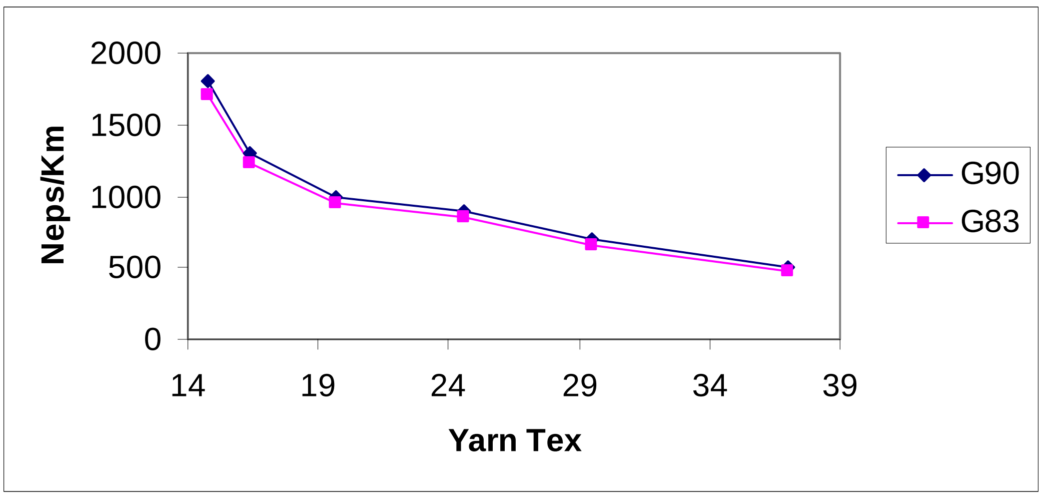


**Fig.(6) Yarn Neps per Km VS. Yarn Tex**

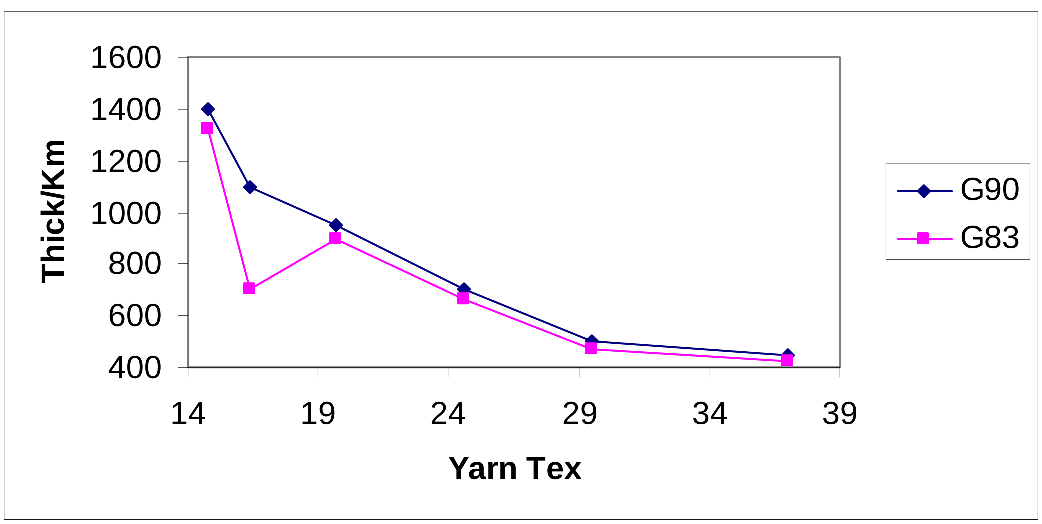


**Fig.(7) Yarn Thick places per Km VS. Yarn Tex**

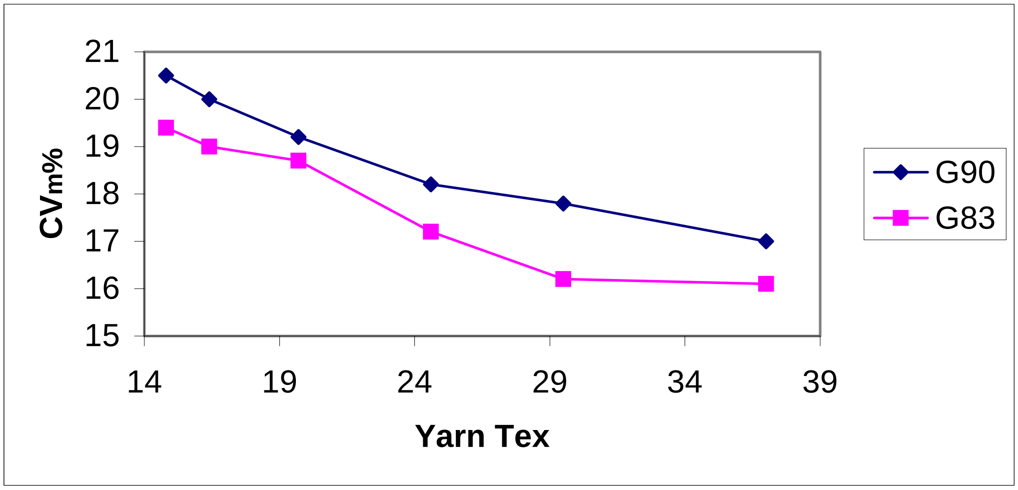


**Fig.(8) CV% of yarn mass VS. Yarn Tex**

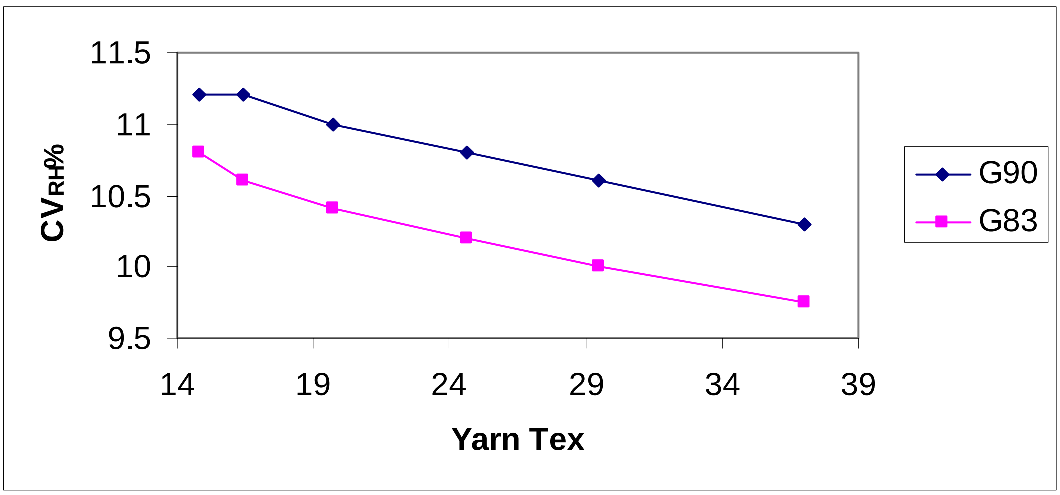


**Fig.(9) CV% of yarn tenacity VS. Yarn Tex**

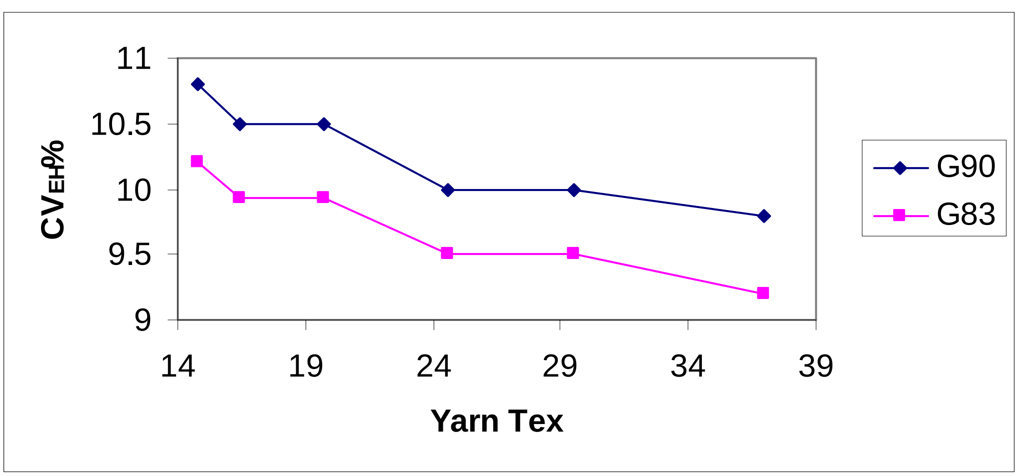


**Fig.(10) CV% of yarn breaking extension in % VS. Yarn Tex**

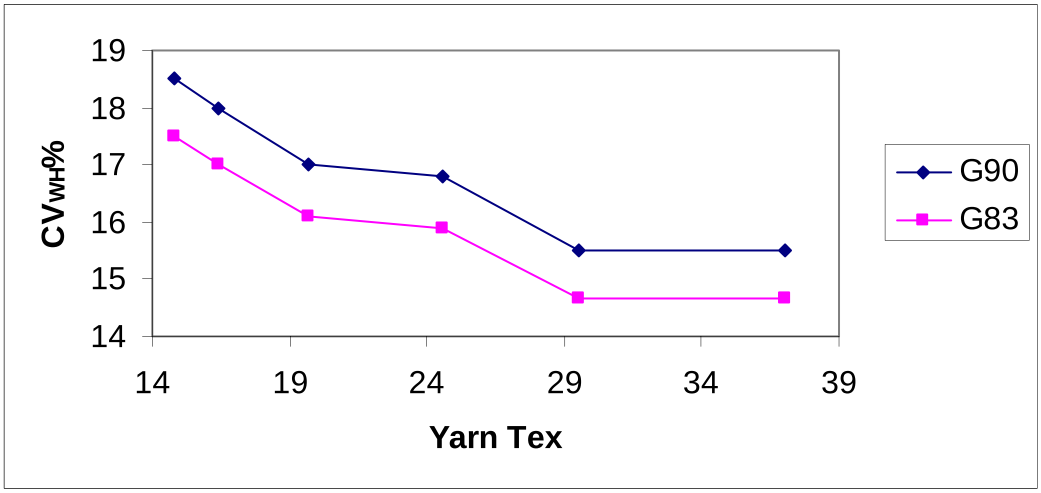


**Fig.(11) CV% of yarn work done VS. Yarn Tex**

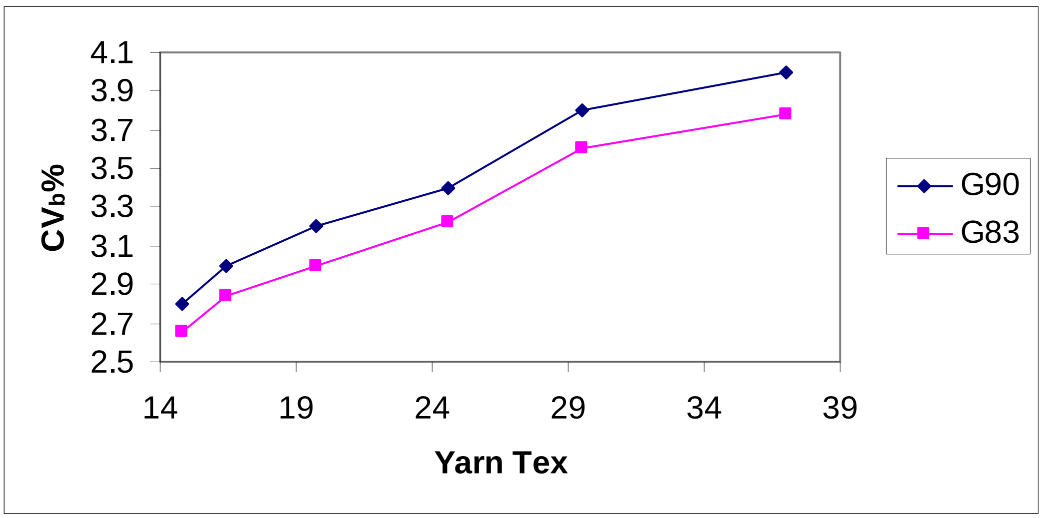


**Fig.(12) CV% of yarn count % VS. Yarn Tex**

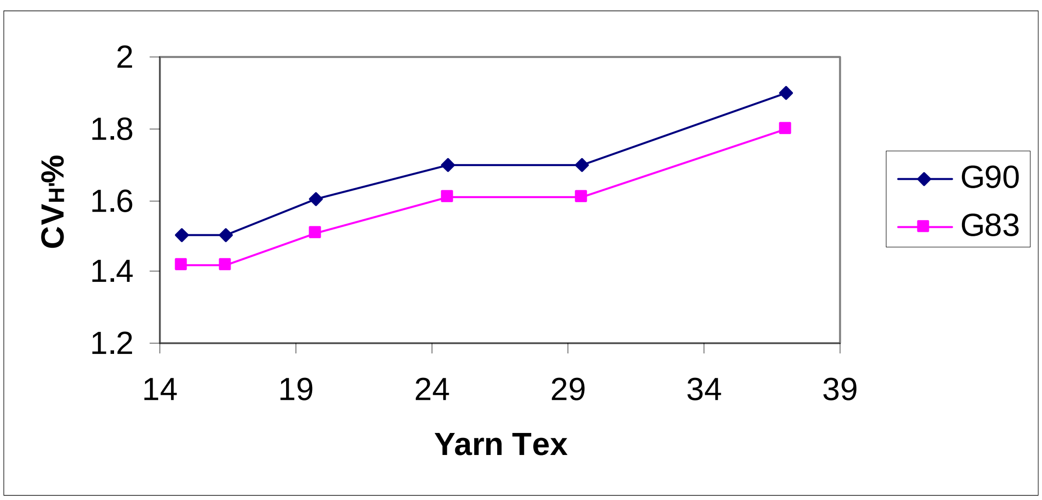


**Fig.(13) CV% of yarn Hairiness VS. Yarn Tex**

**Relative Yarn Quality Factor RYQF**:

To compare the quality levels of the ring spun carded yarns from Giza- 90 cotton fiber with the same yarns produced from Giza – 83 that are produced under the same conditions & the yarn quality factor YQF has been calculated. All the calculations are summarized in tables (8 & 9) where the quality factor consists of : count – strength product CSP, single – end strength in cN . $Tex^{-1}$ and Uster value U% it has been found from these tables that the relative yarns quality is changing from 84% to 90%. This means that the carded ring spun yarns of Giza–90 cotton is less always in quality level for the same yarns produced from Giza–83 cotton. The variations in the values of the R.Y.Q.F are depending upon the yarn tex and their spinnable twist factors, where:

$$R.Y.Q.F = \frac{(Y.Q.F)\ \text{of Giza–90 yarns}}{(Y.Q.F)\ \text{of Giza-83 yarns}} \times 100$$

Table (9) Comparative values of CSP & U% for carded yarns for both of Giza-90 & Giza-83.

| Tex | | 37 | 29.5 | 24.6 | 19.7 | 16.4 | 14.8 |
|---|---|---|---|---|---|---|---|
| CSP | Giza-90 | 909.3 | 852.7 | 801.2 | 747.1 | 688 | 610.7 |
| | Giza-83 | 960 | 914.5 | 852.4 | 799.4 | 738.80 | 654.7 |
| U% | Giza-90 | 13.6 | 14.2 | 14.56 | 15.4 | 16 | 15.3 |
| | Giza-83 | 13.0 | 13.0 | 13.8 | 15 | 15.2 | 15.52 |

*CSP:* Count strength product in hks.
*U%:* % mean deviation –USTER value.

Table (10) Comparative values of Y.Q.F & R.Y.Q.F. for both of Giza-90 & Giza-83 cottons

| Tex | | 37 | 29.5 | 24.6 | 19.7 | 16.4 | 14.8 |
|---|---|---|---|---|---|---|---|
| Y.Q.F | Giza-90 | 1270.3 | 1093 | 963 | 824.7 | 696.6 | 598.7 |
| | Giza-83 | 1477 | 1274.3 | 1142.7 | 959.3 | 832.1 | 669.0 |
| R.Y.Q.F% | | 86 | 85.2 | 84.2 | 86 | 84.7 | 89.5 |

*Y.Q.F:* Yarn Quality Factor.
*R.Y.Q.F.:* Relative Yarn Quality Factor = $\frac{\text{(YQF) Giza-90}}{\text{(YQF) Giza-83}}$.

The percentage mean value for *R.Y.Q.F* for carded yarns for both of Giza-90 & Giza-83 = 86%.

## Conclusions

From the previous results & discussions the following conclusions can be drawn out.

1- Giza–90 cotton is produced to fulfill the potential of Giza–83 with respect to yield per acre and resistance to plantation diseases and insects.

2- Giza–90 cotton may be replace Giza–83 cotton due to the closeness in Mic. values where there is 8 % percent difference .

3- Giza–83 cotton fibers give in general, better results than Giza–90 cotton fibers as expressed by F.Q.I, where it equals 200 and 189.2 for both of Giza–83 and Giza–90 respectively .

4- Nep potential (Neps per gram ) of Giza–90 cotton fibers (60) is higher than Giza–83 cotton fibers ( 56).

5- The mean diameter of the cotton fiber in µm can be determined by formula: $d_f = 29 * \sqrt{tex_f}$

6- The yarn chrematistics that are produced from Giza–83 have a higher quality profile with respect to similar yarns of Giza–90 cotton .This achievement includes both of the mean value and the coefficient of variation CV% for each characteristic.

7- The yarn imperfections per one Km. for yarns that are produced from of Giza-90 and Giza–83 cottons are relatively high because they are industrially produced inside a cotton spinning mill.

8- The ratio of F.Q.I for Giza-90cotton is 94.6 % of such F.Q.I of Giza-83 cotton (F.Q.I – fiber quality index).

9- The relative yarn quality factor of the carded ring spun yarns ofGiza-90cotton is ranging from 84 % to 90 % compared with the same equivalent yarns from Giza-83 cotton.

10- The cotton fibre properties of Giza-90& Giza-83are illustrated in the following table (3).

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