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FIBER FINENESS AND MATURITY AND THEIR RELATION TO OTHER TECHNOLOGICAL PROPERTIES IN 15 EGYPTIAN COTTON GENOTYPES

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ABSTRACT

The present study was carried out to determine: 1) fiber fineness and maturity of uncollapsed and collapsed fibers of different cotton genotypes as affected by measuring method and growing season and 2) the relationship of fiber fineness (diameter) and maturity (degree of thickening) with other fiber quality properties. Fifteen Egyptian cotton varieties and promising lines representing all the Egyptian cotton categories were grown in Giza Research Station during 2006 and 2007 seasons. Fibers taken from green bolls (M_1) or preserved (M_2) were used to determine fiber fineness and maturity of uncollapsed fibers. Causticaire method was used to determine fineness and maturity of the swollen fibers (M_3). Cross-section parameters by image analysis technique were used for measuring fineness and maturity of dry collapsed fibers. Combined analysis indicated that fiber diameter of fresh uncollapsed fibers from green boll (M_1) ranged in the studied cottons from 15.3 μ in Giza 45 to 19.7 μ in Giza 80, while the swollen fiber diameter (M_3) ranged from 14.6 μ in Giza 45 to 18.1 μ in Giza 80. Swollen fiber diameter (M_3) averaged 5.6% and 6.1% lower than uncollapsed fibers of M_1 and M_2, respectively. Degree of thickening of uncollapsed fresh fibers (M_1) ranged from 77.3 in Giza 45 to 89% in Giza 80, while degree of thickening of the swollen (M_3) averaged 1.8% and 3.4% lower than M_1 and M_2, respectively. Seasonal environmental conditions did not significantly affect fiber fineness, while fiber maturity was highly affected. Cross-section area and perimeter of collapsed dry fiber obtained from image analyzer ranged from 132.7 μ^2 and 40.6 μ in Giza 45 to 222.8 μ^2 and 54.8 μ in Giza 80, respectively. Selection for smaller diameter improves fiber length and its uniformity as well as fiber strength. Fiber maturity was positively associated with micronaire value, maturity ratio and fiber elongation and inversely with fiber length and strength.

Key words: ***Cotton genotypes, Fineness, Maturity, Causticaire, Image analysis, HVI, Correlation, Fiber properties.***

INTRODUCTION

Fiber fineness and maturity are two of the most important fiber properties due to their effect on cotton processing, spinning potential and the quality of the end product. Finer cottons are usually of higher quality and could be spun to finer counts with higher quality than coarser cottons. On the other hand, immature fibers are usually weak fibers, they cause pronounced fiber and yarn neppiness, irregularity and dying troubles.

From a botanical point of view, a cotton fiber is a tubular out growth of a specific diameter born from a single epidermal cell of the seed. This out growth elongates first as a thin walled tubular structure to its maximum length within 15-25 days post anthesis (elongation phase) and as the elongation ceases, secondary wall formation and cellulose deposition begins and continues for additional 20-30 days depending on the cotton variety (genetic structure) and growth environmental conditions (Lord 1961).

There are two famous terms for fiber fineness: 1- intrinsic fineness that is defined as the diameter of the uncollapsed fiber in the green boll (diameter of circular cross section) and 2- gravimetric fineness which is known as mass per unit length or linear density. Gravimetric fineness expresses both intrinsic fineness and maturity.

Measuring the diameter and wall thickness of the fibers obtained from the boll just before opening is considered the most accurate method for measuring intrinsic fineness and wall thickness. On the other hand, measuring fiber diameter (ribbon width) and wall thickness of the swollen fibers treated by 18% sodium hydroxide (causticaire method) can provide a relatively rapid estimate of the fiber diameter and degree of thickening, however the obtained results are strongly affected by treatment technique (Fransen *et al* 1985).

Different methods are used for measuring fiber fineness and maturity whether separately or in combination as air permeability, dye ability, polarized light, near infrared spectroscopy, single and dual compression air flow method like micronaire, micromat and arealometer. Recently, the image analysis of the fiber cross sections provides reliable unbiased accurate technique for determining fiber fineness and maturity (Thibodeaux and Rajeskaran 1999). This technique depends entail on using a computer program to obtain direct measurements of cotton fiber cross sectional characteristics as wall thickness, ribbon width (cross-sectional diameter), maturity ratio and degree of thickening. Although image analysis technique is very slow due to the long time and efforts of preparing fibers cross-sections, it could be used as a reference method for evaluating the other methodology and techniques of measuring fiber fineness and maturity parameters of the dry cotton fiber which are commonly used with the large numbers of samples in cotton breeding programs, cotton trading and cotton spinning industry as well (Xu and Huang 2004).

Fiber fineness estimated as fiber diameter or perimeter was the fiber quality characteristic practically unaffected by environmental effects (Lord 1981), whereas fiber maturity (relative cell wall thickening) was highly influenced by environmental effects and cultivar x year interaction (Greef and Humman 1988, Hake *et al* 1990, Guthrie *et al* 1993, Goynes *et al* 1995 and Montalvo and Von Hoven 2007).

Estimation of fiber fineness and maturity was carried out by many workers using different devices in Egyptian cotton as well as comparisons between Egyptian and American Upland cotton (Hebert *et al* 1979, Berlin *et al* 1981, Ramey 1982, Nawar *et al* 1989, Seif *et al* 1995 and Abd-Fattah *et al* 2009). Correlation between both fiber fineness and maturity with other fiber properties were also reported by Lord (1981), Kamal (1983), Kloth (1998), Hequet *et al* (2000), Abd El-Gawad (2001) and Mohamed *et al* (2007).

The main objectives of this study are: 1) to determine fiber fineness and maturity of some Egyptian cotton varieties and promising lines from green boll data (uncollapsed fibers) and causticaire method (swollen fibers), 2) to determine fiber fineness and maturity from dry fiber data using image analysis technique and 3) to estimate the relationships between fiber fineness and maturity measurements with other fiber properties of Egyptian cotton, using the High Volume Instrument (HVI).

MATERIALS AND METHODS

Aiming to study fiber fineness and maturity of some Egyptian cotton genotypes, 15 cotton varieties and promising lines were used namely; Giza 45, Giza 87, Giza 70, Giza 88, Giza 92 and a promising strain pedigreed from the cross G77 x PS6 as extra-long staple (ELS) genotypes. Giza 85, Giza 86, Giza 89 and a promising strain derived from G89 x G86 and another strain from G.89 x PS6 as Delta long-staple (LS) genotypes, as well as four cvs (Giza 80, Giza 83, Giza 90 and Giza 91) referred to as Middle and Upper Egypt long-staple (LS) genotypes. The 15 genotypes were grown at Giza Research Station, Agric. Res. Center in 2006 and 2007 seasons. Sowing dates were 20 and 26 April in the two respective seasons. The experimental layout was a randomized complete block design with three replications. Each plot included 3 rows, 4 m long and 65 cm apart. Hill spacing was 30 cm within the row, leaving two plants per hill at thinning. Normal agronomic practices were followed as recommended. Samples of green bolls were picked from the plants just before boll opening, which was 47-50 days counted from the day of anthesis in selected labeled flowers according to each genotype. In this age, the fibers enclosed within the green bolls are fully-mature but still fresh having a circular cross-section, thereafter the boll starts cracking and opening and the enclosed fibers began to dry, collapse, form convolutions and mostly lose its circularity. The picked green bolls were transported directly to the lab then divided to two groups. Bolls of the first group were opened; some of the fresh fibers were placed on a glass slide in few drops of water to avoid drying then tested using a special microscope connected to image analysis system. Another set of fresh fibers of each boll was kept in a preserving solution (25% glacial acetic acid + 75% methanol) to avoid losing water and drying, then later tested using the image analysis system. The second group of the bolls was stored in the lab until opened and dried naturally. The dry fibers of each boll were placed on a glass slide then treated with 18% sodium hydroxide (causticare method) and tested using the image analysis system.

Cross-section preparation for image analysis

Preparation of fiber cross section was conducted according to the procedure explained and used by Boylston *et al* (1993). In this technique, a large bundle of fibers were fastened at one end with a piece of fine wire. The wire with fiber bundle attached at the end was threaded through a labeled 8 cm length tycoon (polyvinyl chloride) tubing ¼" (3.1 mm) in diameter. The bundle at the end of the wire was dipped in the embedding medium in a small beaker and allowed to soak for few seconds to remove air bubbles from the fiber bundle. The bottom of the tube was also under the surface of the liquid embedding medium. Then cuts of fibers were taken from the embedded bundle using rotary microtome with diamond knife. Fiber cross-sections were mounted on a glass slide then tested using a microscope attached with a camera and measured using a computer image analysis system to determine the following fiber properties:

1- Fiber diameter in microns (expressed as the large width of the fiber cross-section).
2- Fiber perimeter in (μ) as follows: Perimeter = 3.14 x fiber diameter.
3- Secondary wall thickness: area of cellulose deposition (μ^2).
4- Degree of thickening = area of cellulose (μ^2) x 100/area of a circule having fiber perimeter (μ^2) (Lord 1981).

The High Volume Instrument (HVI Spectrum 2) was used according to ASTM (1991) for measuring the other fiber properties:

a- Fiber length parameters: Upper Half Mean Length in mm (UHM), length uniformity index % (UI %) and short fiber index % (SFI %).
b- The tensile strength or breaking tenacity (g/tex) and elongation %.
c- Micronaire value and maturity ratio (MR).
d- Lint color measurements: two color components, i.e. lightness (reflectance degree Rd %) and degree of yellowness (+b).

Experimental design and statistical analysis

A factorial experiment in complete randomized block design of three replications was used to analyze the variance in the obtained data of fiber fineness and maturity of the different cotton genotypes in the two seasons, in order to study the differences between cotton genotypes, growing seasons and measuring methods. The analysis of variance and LSD test at 0.05 were carried out according to Snedecor and Cochran (1986). Correlation analysis was used to study the interrelationships between fiber fineness and maturity measurements with other fiber characteristics.

RESULTS AND DISCUSSION

Fiber diameter (intrinsic fineness) of cotton genotypes

The mean values of fiber diameter (μ) pertaining cotton genotypes (G), seasons (S), measuring method (M) and their interactions are presented in Table (1). The statistical analysis of variance revealed that the effect of cotton genotypes, growing seasons, measuring methods and their interactions on fiber diameter was statistically significant whether measured from green boll directly (M_1) or after keeping fibers in preserving solution till testing (M_2) or by using causticaire method (M_3) except that the effect of growing season was insignificant on fiber diameter.

Diameter of uncollapsed fresh fiber from green boll

The combined data presented in Table (1) indicated that means of fiber diameter of uncollapsed fibers obtained from the green boll and tested directly ranged from 15.3 μ in G.45 to 19.7 μ in G.80 (M_1), while ranged from 15.4 in G.45 to 19.6 μ in G.80 when determined from the fibers taken from green bolls and preserved in preserving solution until testing (M_2). The results did not show significant differences in fiber diameter among the two extra long extra fine varieties G.45 and G.87, however, the promising line from cross (G.77 x PS6) showed slightly bigger diameter than both of them. The recorded means were 15.3, 15.6 and 15.7 μ for the fresh fibers of the three genotypes, respectively, while were 15.4, 15.7 and 16.1 μ for the preserved fibers of the same three genotypes. The newly released cv. G.92 proved to be finer (smaller diameter) than both of G.70 and G.88 which did not show significant difference in fiber diameter. The recorded means of the fresh fiber diameter of the three genotypes were 15.9, 16.8 and 16.6 μ, respectively, while were 16.1, 17.0 and 16.7 μ for the preserved fibers of the three genotypes, respectively. The Delta long staple genotypes proved to be coarser than the ELS Egyptian cottons; they could be arranged in ascending order according to the diameter of their fresh and preserved fibers as follows: G.85, cross (G.89 x G.86), G.89, G.86 and cross (G.89 x PS6). The recorded means of the diameter measured from the fresh fibers of these genotypes were 17.6, 17.6, 17.8, 18.1 and 18.2 μ, respectively, while were 17.6, 17.5, 17.9, 18.0 and 18.2 μ for the preserved fibers of the Delta cottons, respectively. These results indicated that G.85, cross (G.89 x G.86) and G.89 showed nearly similar intrinsic fineness and were finer than both of G.86 and cross (G.89 x PS6) that showed nearly similar intrinsic fineness. The four Upper Egypt long staple (LS) varieties proved to be coarser than the other ELS and Delta long staple cottons. These varieties could be arranged in ascending order according to the diameter of their fresh and preserved fiber, as follows: G.90, G.83, G.91 and G.80. The recorded means of fresh fiber diameter of these varieties were 19.1, 19.2, 19.3 and 19.7 μ, respectively, while were 19.1, 19.3, 19.3 and 19.6 μ for its preserved fiber diameter, respectively. The results indicated that G.90 is the finest one in this group and G.80 is the coarsest, while both of G.83 and G.91 were nearly of similar fineness and slightly coarser than G.90 but finer than G.80.

Comparing the means of fresh fiber diameter with those obtained from preserved fibers, no significant difference was found between the two techniques. The recorded means of both were 17.5 and 17.6 μ, respectively. Moreover the two techniques ranked the cottons of each group in the same manner with slight increase in diameter measurements of the preserved fibers in most cases. This indicates that it does not matter to test the fresh fibers directly after picking the green bolls from the field or keeping the fibers in preserving solution until testing; both techniques will provide nearly similar values of fiber diameter with a very slight increase in the values obtained from the preserved fibers.

Diameter of swollen fibers

With regard to diameter of the swollen fibers determined by the causticaire method (dry fibers treated by 18% sodium hydroxide), the combined data in Table (1) cleared that the swollen fiber diameter ranged from 14.6 μ in G.45 to 18.1 μ in G.80. The swollen fiber diameter of the different Egyptian cotton varieties and promising lines either ELS or LS exhibited in most cases the same trend of uncollapsed fiber diameter obtained from green boll data. Mohamed *et al* (2007) found significant differences in fiber diameter between the different Egyptian cottons. However, ranking of genotypes according to their diameter was not essentially the same either for uncollapsed fibers (green boll data) (M_1 and M_2) or swollen fiber treated by 18% sodium hydroxide (M_3).

Effect of measuring method on fiber diameter measurements

Comparing the diameter means of uncollapsed fibers obtained from green bolls just before opening (47-50 days age) with those obtained from causticaire method for the same boll age (Table 1), combined data revealed that fiber diameter measurements obtained from causticaire method were 2.7 to 8.5% lower than those of the uncollapsed fresh fibers in the case of G.92 and G.90, respectively with a mean decrease of 5.6% for all genotypes. The decrease amounted 3.5 to 8.8% lower than those obtained from preserved fibers for the two respective *cvs* with a mean decease of 6.1% for all genotypes. However, the amount of this decrease differed from one variety to another with no trend to be higher or lower in coarse or fine genotypes. On the other hand, causticaire method appeared to be not sensitive to the small differences in fiber diameter of genotypes within each group. The results suggest that cotton breeders and spinners can rely on causticaire data but they have to consider the decrease in its measurements compared to

Table 1. Diameter (µ) of the uncollopsed fresh fibers from green boll (M_1) and fresh fibers preserved by solution (M_2) as well as dry fibers determined by causticaire method (M_3) for 15 Egyptian cotton genotypes (G) in 2006 and 2007 seasons (S).

Genotypes (G)	M_1 (µ)	M_2 (µ)	M_3 (µ)	Mean (µ)	M_1 (µ)	M_2 (µ)	M_3 (µ)	Mean (µ)	M_1 (µ)	M_2 (µ)	M_3 (µ)	Mean (µ)	Percent decrease of $(M_1-M_3)/M_1$ %	Percent decrease of $(M_2-M_3)/M_2$ %
	2006 season				2007 season				Combined analysis					
G.45	15.4	15.5	14.7	15.2	15.2	15.3	14.6	15.0	15.3	15.4	14.6	15.1	4.5	5.1
G.87	15.5	15.7	14.8	15.3	15.6	15.7	14.4	15.2	15.6	15.7	14.6	15.3	6.2	6.8
G.77*PS6	15.7	16.2	14.9	15.4	15.7	16.0	15.5	15.7	15.7	16.1	15.2	15.7	2.7	5.5
G.70	16.8	17.0	16.1	15.7	16.9	17.0	16.4	16.8	16.8	17.0	16.3	16.7	3.4	4.3
G.88	16.6	16.7	16.2	15.8	16.7	16.7	16.0	16.5	16.6	16.7	16.1	16.5	3.2	3.8
G.92	15.9	16.0	15.6	15.8	16.0	16.1	15.4	15.9	15.9	16.1	15.5	15.8	2.8	3.5
G.85	17.5	17.6	16.3	16.0	17.6	17.7	16.5	17.3	17.6	17.6	16.4	17.2	6.8	7.2
G.86	18.2	18.0	16.9	16.2	18.0	18.1	16.7	17.6	18.1	18.0	16.8	17.6	7.2	6.9
G.89	17.7	17.9	17.1	16.4	17.8	17.9	16.5	17.4	17.8	17.9	16.8	17.5	5.5	6.0
G.89*86	17.6	17.5	17.1	16.5	17.6	17.6	16.4	17.2	17.6	17.5	16.7	17.3	5.0	4.6
G.89*PS6	18.2	18.1	17.4	16.8	18.1	18.3	16.8	17.7	18.2	18.2	17.1	17.8	5.9	6.2
G.80	19.7	19.6	18.1	17.1	19.7	19.5	18.2	19.1	19.7	19.6	18.1	19.1	8.0	7.5
G.90	19.1	19.2	17.7	17.4	19.0	19.0	17.2	18.4	19.1	19.1	17.4	18.5	8.5	8.8
G.83	19.2	19.4	17.9	17.7	19.2	19.2	17.6	18.6	19.2	19.3	17.7	18.7	7.6	8.1
G.91	19.2	19.3	18.0	17.9	19.3	19.3	18.1	18.9	19.3	19.3	18.1	18.9	6.2	6.5
Mean	17.5	17.6	16.6	18.0	17.5	17.6	16.4	17.2	17.5	17.6	16.5	17.2	5.6	6.1
L.S.D at 0.05:														
G				0.28				0.27				0.32		
S												N.S.		
M				0.34				0.35				0.44		
G x M				0.36				0.34				0.48		
G x S												0.41		
S x M												0.54		
S x G x M												0.68		

green boll data and the insensitivity of the method. In this respect, Fransen *et al* (1985) reported that causticaire method is strongly affected by treatment technique.

Effect of growing seasons on fiber diameter

Data in Table (1) cleared that growing season did not significantly affect fiber diameter measured by the different methods, which is in line with Lord (1981).

The interactions G x M, G x S, S x M, as well as G x S x M were significant indicating differential response of fiber fineness of the studied varieties and promising crosses to differences in growing seasons and measuring method.

Degree of thickening (fiber maturity) of cotton genotypes

The results (Table 2) revealed that the effect of cotton genotypes, growing seasons, measuring methods and their interactions on degree of thickening was statistically significant when measured from green boll directly, after keeping fibers in preserving solution till testing or by using causticaire method.

Degree of thickening of uncollapsed fresh fibers from green boll data

The combined data presented in Table (2) indicated that mean of fiber degree of thickening of uncollapsed fibers ranged from 77.3% for G.45 to 89.0% for G.80 for the fibers obtained from the green bolls and tested directly, while ranged from 79.9% for G.45 to 89.3% for G.80 when determined from the fibers taken from green bolls and preserved in preserving solution. Within the extra long extra fine cottons, G.87 and the promising line from the cross (G.77 x PS6) showed higher maturity than G.45. The respective means of degree of thickening were 79.6, 79.9 and 77.3% when determined from fresh fibers and 81.0, 82.0 and 79.9% for the preserved fibers of these cottons. As for the other extra long cottons, the promising variety G.92 proved to be more mature than both of G.70 and G.88. The respective means of degree of thickening were 83.9, 81.6 and 81.7% when measured from fresh fibers, while were 86.5, 84.7 and 86.0% for the preserved fibers, respectively. Regarding the Delta long staple cottons, it showed a relatively similar degree of thickening being around 86 % ± 1, however, G.85 and the line from cross (G.89 x PS6) showed slightly lower maturity than the other Delta LS cottons. Concerning Upper Egypt LS cotton cultivars, G.80 showed the highest degree of thickening followed by G.91, while G.90 and G.83 showed a relatively lower maturity than both of G.80 and G.91. The respective means of degree of thickening for G.80, G.91, G.90 and G.83 were 89.0, 86.4, 85.4 and 85.3% when determined from fresh fibers tested directly, while were 89.3, 87.3, 86.4 and 86.4% for the preserved fibers, respectively. Comparing the means of degree of

Table 2. Degree of thickening % of the uncollapsed fresh fibers from green boll (M_1) and fresh fibers preserved by solution (M_2) as well as dry fibers determined by causticaire method (M_3) for 15 Egyptian cotton genotypes (G) in 2006 and 2007 seasons (S).

Genotypes (G)	M_1 (%)	M_2 (%)	M_3 (%)	Mean (%)	M_1 (%)	M_2 (%)	M_3 (%)	Mean (%)	M_1 (%)	M_2 (%)	M_3 (%)	Mean (%)	Percent decrease of $(M_1-M_3)/M_1$ %	Percent decrease of $(M_2-M_3)/M_2$ %
	2006 season				2007 season				Combined analysis					
G.45	81.5	85.7	79.8	82.3	73.0	74.1	72.5	73.2	77.3	79.9	76.2	77.8	1.4	4.7
G.87	85.0	86.6	84.6	85.4	74.2	75.4	73.8	74.5	79.6	81.0	79.2	79.9	0.5	2.3
G.77*PS6	83.9	86.6	79.0	83.2	75.8	77.4	74.5	75.9	79.9	82.0	76.8	79.5	3.9	6.4
G.70	85.8	86.7	84.1	85.5	77.4	82.8	76.9	79.0	81.6	84.7	80.5	82.3	1.4	5.0
G.88	86.4	87.5	85.6	86.5	76.9	84.4	76.5	79.3	81.7	86.0	81.0	82.9	0.8	5.7
G.92	87.4	87.9	86.4	87.3	80.3	85.1	79.6	81.7	83.9	86.5	83.0	84.5	1.0	4.0
G.85	88.5	88.9	87.7	88.4	83.3	83.1	81.4	82.6	85.9	86.0	84.5	85.5	1.6	1.7
G.86	89.3	89.7	88.3	89.1	83.1	84.6	81.0	82.9	86.2	87.2	84.6	86.0	1.8	2.9
G.89	89.6	88.0	87.2	88.3	84.6	85.7	82.8	84.4	87.1	86.9	85.0	86.3	2.5	2.2
G.89*86	89.3	88.8	86.8	88.3	83.2	85.2	82.3	83.6	86.2	87.0	84.6	85.9	1.9	2.8
G.89*PS6	87.3	88.8	86.7	87.6	83.7	83.3	82.0	83.0	85.5	86.0	84.3	85.3	1.4	2.0
G.80	90.0	90.5	88.5	89.7	88.0	88.1	83.7	86.6	89.0	89.3	86.1	88.1	3.3	3.7
G.90	88.0	88.3	85.5	87.3	82.8	84.5	81.9	83.1	85.4	86.4	83.7	85.2	2.0	3.1
G.83	87.1	89.1	87.2	87.8	83.6	83.6	82.2	83.1	85.3	86.4	84.7	85.5	0.8	1.9
G.91	89.7	90.7	86.2	88.9	83.0	83.9	83.1	83.3	86.4	87.3	84.6	86.1	2.0	3.0
Mean	87.3	88.7	85.4	87.1	80.9	82.8	79.6	81.1	84.1	85.5	82.6	84.0	1.8	3.4
L.S.D at 0.05:														
G				0.43				0.40				0.45		
S												0.61		
M				0.64				0.60				0.68		
G x M				0.76				0.74				0.80		
G x S												0.85		
S x M												0.90		
S x G x M												1.06		

thickening obtained from fresh fibers tested directly with those obtained from preserved fibers, the results indicated that mean degree of thickening of the preserved fibers is about 1.4% higher than that measured from fresh fibers directly, however this difference varied from one variety to another. On the other hand, the two techniques ranked the different cottons even within each group by the same manner, indicating that it is possible to use the two techniques in measuring degree of thickening of the uncollapsed fibers with a slight increase in the values obtained from keeping fibers in preserving solution until testing.

Degree of thickening of the swollen fibers determined by causticaire method

The combined data in Table (2) indicated that the degree of thickening of the swollen fibers (dry fibers treated by 18% sodium hydroxide) for the studied Egyptian cotton varieties and promising lines ranged from 76.2% in G.45 to 86.1% in G.80.

The results indicated that degree of thickening of the different genotypes obtained from causticaire method showed the same trend of green boll data and ranked the genotypes of each group by the same way. The recorded means of degree of thickening obtained from causticaire method were 76.2, 79.2 and 76.8% for G.45, G.87 and line from cross (G.77 x PS6) extra long extra fine cottons, while were 80.5, 81 and 83% for G.70, G.88 and G.92 extra long staple cottons, and ranged from 84.3 – 85.0% for the Delta long staple cottons with no big difference between the cottons of this group, while ranged in the Upper Egypt cvs. from 83.7% for G.90 to 86.1% for G.80. Results of degree of thickening obtained from the different methods indicated that fiber maturity of the extra long extra fine cottons were lower than fiber maturity of the other extra long staple cottons which showed lower fiber maturity than the Delta and Upper Egypt long staple. Moreover, most of the Delta and Upper Egypt long staple cottons showed relatively similar values of fiber maturity, except G.86, G.89 and G.80 which recorded higher values of fiber maturity regardless the testing method. Bradow *et al* (1996) and Goynes *et al* (1995) found significant differences in fiber maturity of their tested cottons.

Effect of measuring method on degree of thickening (fiber maturity)

Comparing the degree of thickening % of uncollapsed fibers obtained from green boll just before opening (47-50 days age) whether tested directly or after keeping in preserving solution with those obtained from causticaire method for the same boll age, the results indicated that values of degree of thickening % obtained from causticaire method averaged 1.8% lower than those obtained from fresh fibers while averaged 3.4% lower than those obtained from preserved fibers. However, the amount of this decrease differed from one genotype to another with no trend to be higher or lower in coarse or fine cottons. Moreover the results indicated that causticaire method is not sensitive enough to specify the small differences in fiber maturity between cottons compared to green boll data (as in Delta long staple cottons). Fransen *et al* (1985) reported that causticaire method is strongly affected by treatment technique. Voljanic *et al* (1986) reported that causticaire method is shown to give no real picture of fiber maturity.

Effect of growing season on degree of thickening (fiber maturity)

The results in Table (2) showed that the degree of thickening % was significantly affected by growing season. The results revealed that 2006 season showed higher mean of degree of thickening compared to 2007 season. The recorded means in 2006 were 87.3, 88.7 and 85.4% for uncollapsed fresh fibers, preserved fibers and causticaire method with a mean of 87.1% while being 80.9, 82.8 and 79.6% for the three techniques with a mean of 81.1% in 2007 season. The seasonal effect is expected since cellulose deposition in the secondary wall is a metabolic process affected so much by the environmental conditions including temperature, humidity, sunlight, location, availability of water and nutrients besides all crop management practices. Hake *et al* (1990) and Guthrie *et al* (1993) reported that both of cotton genotype and growing condition affected significantly cellulose deposition. The interactions G x M, G x S, S x M, as well as G x S x M were statistically significant indicating differential response of fiber maturity of the studied varieties and crosses to differences in growing season and measuring methods.

Determination of fiber fineness and maturity from dry fibers (collapsed fibers) using image analysis technique

Image analysis technique is acknowledged as a reference method to determine accurately fiber fineness and maturity parameters, *via* testing big numbers of fibers cross sections using a special microscope provided with a digital camera connected to a computer that has a special software enables measuring dimensions, areas and perimeters of irregular objects as the cross sections of cotton fibers.

The means of cross section area, perimeter, diameter and degree of thickening (%) pertaining cotton genotypes, seasons and combined data are presented in Table (3). The combined analysis indicated that G.45 recorded the lowest mean of collapsed fiber cross section area, perimeter and diameter of the cross section (the finest). The respective recorded means were 132.7 μ^2, 40.6 μ and 14.4 μ. Whereas G.80 showed the highest mean for these parameters (the coarsest); the respective recorded means were 222.8 μ^2, 54.8 μ and 19.9 μ. The extra-long staple (ELS) genotypes proved to be the finest category. Their cross-sectional area ranged from 132.7 μ^2 for G. 45 to 149.9 μ^2 for G. 70 and the fiber perimeter ranged from 40.2 μ for G.

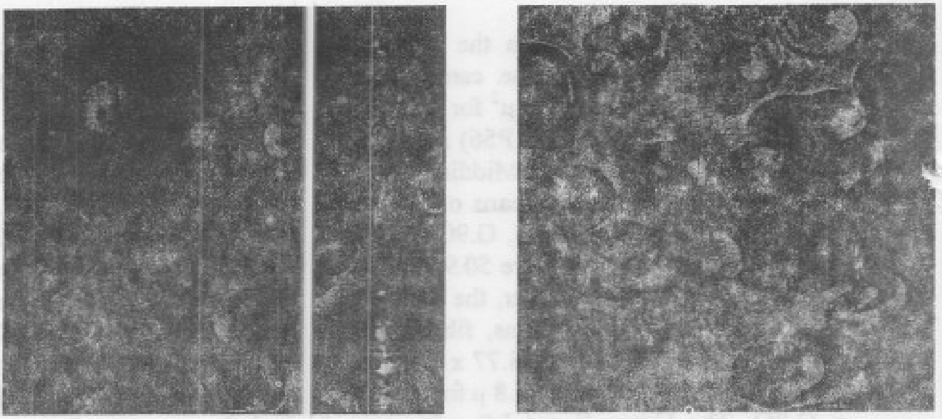
Table 3. Fiber cross section parameters of collapsed fibers of the Egyptian cotton genotypes determined by Image Analyzer in 2006 and 2007 seasons (S) and coml

Genotypes(G)	Area μ^2	Perimeter μ	Diameter μ	Degree of thickening %	Area μ^2	Perimeter μ	Diameter μ	Degree of thickening %	Area μ^2	Perimeter μ	Diameter μ	Degree of thickening %
	2006 season				2007 season				Combined analysis			
G.45	133.6	41.0	14.2	79.5	131.8	40.1	14.5	75.3	132.7	40.6	14.4	77.4
G.87	135.0	40.5	14.0	78.2	133.1	39.8	14.3	74.6	134.1	40.2	14.2	76.4
G.77*PS6	134.0	41.3	13.6	77.7	132.6	40.6	14.5	75.3	133.3	41.0	14.1	76.5
G.70	151.3	45.1	15.0	78.3	148.4	45.8	15.3	75.4	149.9	45.5	15.2	76.9
G.88	148.2	44.0	14.6	79.4	145.4	43.7	14.8	76.3	146.8	43.9	14.7	77.9
G.92	146.6	43.1	14.2	78.7	141.5	43.0	14.7	76.3	144.1	43.1	14.5	77.5
G.85	163.5	47.5	15.8	76.8	160.3	46.8	15.8	74.8	161.9	47.2	15.8	75.8
G.86	169.4	48.8	16.8	80.1	166.4	49.0	16.5	78.1	167.9	48.9	16.7	79.1
G.89	165.3	48.1	16.3	79.3	162.3	47.8	16.2	76.8	163.8	48.0	16.3	78.1
G.89*G.86	161.7	47.8	16.4	79.1	158.3	47.5	16.2	75.8	160.0	47.7	16.3	77.5
G.89*PS6	172.3	49.0	16.6	78.9	167.4	48.8	16.8	75.9	169.9	48.9	16.7	77.4
G.80	225.5	55.4	20.0	80.0	220.1	54.2	19.8	77.8	222.8	54.8	19.9	78.9
G.90	196.5	50.8	18.3	79.5	190.2	50.2	18.8	76.8	193.4	50.5	18.6	78.2
G.83	194.6	51.2	18.6	77.9	188.9	50.6	19.0	75.2	191.8	50.9	18.8	76.6
G.91	217.4	53.6	19.0	79.2	210.2	52.7	19.5	76.4	213.8	53.2	19.3	77.8
Mean	167.7	47.2	16.2	78.8	163.8	46.7	16.5	76.1	165.7	46.9	16.3	77.5
L.S.D at 0.05:												
G	1.34	0.75	0.78	0.75	1.68	0.76	0.70	0.70	1.40	0.52	0.51	0.50
S									0.52	0.19	0.19	0.18
G x S									2.03	n.s.	n.s.	0.71

87 to 45.5 μ for G.70. On the other hand, the Delta long-staple (LS) genotypes proved to be the category of medium fineness, with cross-sections ranging from 160.0 μ^2 for line from cross (G.89 x G.86) to 169.9 μ^2 for line from cross (G.89 x P56) and exhibited comparable values of fiber perimeter. The Upper and Middle Egypt cvs are considered the coarsest category. Their recorded means of cross-sectional area were 191.8, 193.4, 213.8 and 222.8 μ^2 for G.83, G.90, G.91 and G.80, respectively, while the means of fiber perimeter were 50.9, 50.5, 53.2 and 54.8 μ in the same order. With regard to fiber diameter, the data presented in Table (3) revealed that within the ELS finest cottons, fiber diameter ranged from 14.1 μ for the promising line from cross (G.77 x P56) to 15.2 μ for G.70, while ranged in the Delta LS cottons from 15.8 μ for G.85 to 16.7 μ for line from cross (G.89 x G.86). The Upper Egypt LS cultivars exhibited the coarsest diameters ranging from 18.6 μ for G.90 to 19.9 μ for G.80. It is worthy to note that fiber diameter values determined by image analyzer are comparable to those assessed by the causticaire method but both values are relatively lower than those assessed from green boll data (Table 1). Figure (1) illustrates the cross-sectional view showing various shapes of G.45 fibers (the finest extra-long staple cv.) versus the different shapes of G.80 (the coarsest long-staple cv.). Image analysis instrument was used to measure fiber maturity (degree of thickening). The combined data (Table 3) revealed that this character ranged from 75.8% for G.85 to 79.1% for G.86, both are Delta LS cvs. The results also indicated that the effect of growing season on degree of thickening obtained from image analyzer was statistically significant with 2006 season being of higher maturity (78.8%) as compared to 2007 season of lower maturity (76.1%), which are in line with the results obtained previously from green boll and causticare methods (Table 2). In this respect, Hake *et al* (1990) and Guthrie *et al* (1993) reported that both of cotton genotypes and growing seasons affected degree of cellulose deposition in secondary wall of fibers.

Relationships of fiber fineness and maturity with other fiber quality properties

At first, the different technological fiber properties pertaining the 15 cotton genotypes studied were determined by using the High Volume Instrument (HVI). Performance and combined analysis are recorded in Table (4). Within each fiber property, significant differences existed between the 15 genotypes, accordingly the simple correlation (r) values were calculated between these properties and fiber fineness (diameter) and maturity (degree of thickening) determined by three methods: 1- fresh fibers from green boll (M_1), 2- preserved fibers (M_2) and 3- causticaire method (M_3) as previously shown in Table (1). The "r" values are presented in Table (5).



G 45 X40 G80 X40

Fig. 1. Cross-sectional view of Egyptian cotton fibers showing various shapes of the finest extra-long staple cv. Giza 45 versus different shapes of the coarsest long-staple cv. Giza 80.

Fiber diameter obtained from fresh, preserved and causticaire methods showed highly significant positive "r" values with micronaire reading (Mic), short fiber index (SFI) and fiber elongation. This indicates that selection for fine small diameter resulted in low micronaire, low short fiber content and low fiber elongation. On the other hand, fiber fineness measurements showed highly significant negative "r" values with fiber length (UHM), length uniformity index (UI) and fiber strength, indicating that selection for narrow diameter improves fiber length and its uniformity as well as increasing fiber strength. Fiber fineness showed insignificant association with maturity ratio (MR) and color reflectance (Rd %) and yellowness (+b).

The association between degree of thickening (maturity) and other fiber properties are positive and significant with micronaire value, maturity ratio, short fiber index and fiber elongation, while inverse negative "r" values existed with fiber length and fiber strength, indicating that higher fiber maturity is correlated with higher values of micronaire, maturity ratio, short fiber content and fiber elongation, while higher fiber maturity was generally correlated with shorter and weaker fibers. These results are in agreement with those obtained by Lord (1981), Kamal (1983), Hequet *et al* (2000) and Mohamed *et al* (2007).

Table 4. Mean performance of fiber quality properties measured by HVI for 15 cotton genotypes (combined analysis).

Genotypes	Micronaire (unit)	Maturity ratio	Fiber length (UHM) (mm)	Length uniformity index (%)	Short fiber index (%)	Fiber strength (g/tex)	Elongation (%)	Lint color reflectance (Rd%)	Lint color yellowness (+b)
G.45	3.16	0.91	36.48	88.88	6.14	46.74	6.78	70.72	9.31
G.87	3.16	0.93	36.45	88.97	6.14	46.24	7.29	72.53	9.49
G.77*PS6	3.13	0.94	37.17	87.61	5.79	48.09	6.70	66.42	11.34
G.70	4.14	0.90	36.17	87.65	6.58	45.19	6.94	70.33	9.47
G.88	3.91	0.95	35.85	88.14	6.21	48.06	6.32	65.67	11.42
G.92	3.65	0.94	34.19	88.98	6.29	45.85	6.85	71.62	8.84
G.85	3.98	0.95	30.25	87.04	6.70	41.69	7.36	72.72	9.04
G.86	4.43	0.96	33.13	85.99	6.16	45.74	6.59	73.89	9.57
G.89	4.25	0.95	32.17	87.17	7.46	42.18	7.23	74.42	8.86
G.89*86	4.20	0.95	33.24	87.82	7.50	43.74	7.57	73.07	9.48
G.89*PS6	4.42	0.96	30.95	87.18	8.45	40.73	7.29	73.49	9.33
G.80	4.51	0.95	32.03	86.80	7.92	38.87	7.76	65.51	12.13
G.90	4.18	0.94	30.38	86.09	8.12	36.26	8.21	67.04	11.75
G.83	4.36	0.96	31.31	87.00	6.68	38.17	7.92	67.01	11.54
G.91	4.29	0.96	31.78	86.68	7.45	40.07	7.41	66.53	11.58
Mean	3.98	0.94	33.44	87.47	6.91	43.17	7.21	70.06	10.21
L.S.D 0.05	0.12	0.04	0.11	1.10	0.13	0.09	0.15	0.11	0.09

Table 5. Correlation coefficients (r) between fiber properties measured by HVI and fiber fineness (μ) and maturity (%) determined by three methods; fresh fibers (M_1), preserved fibers (M_2) and causticaire (M_3).

Treatment	Micronaire (unit)	Maturity ratio (%)	Fiber length (UHM) (mm)	Length uniformity index (%)	Short fiber index (%)	Fiber strength (g/tex)	Elongation (%)	Lint color reflectance (Rd%)	Lint color yellowness (+b)
"r" between fiber properties and fiber fineness (diameter):									
Fresh (M_1)	0.890**	0.356	-0.830**	-0.816**	0.837**	-0.884**	0.660**	-0.405	0.455
Preserved (M_2)	0.867**	0.309	-0.819**	-0.846**	0.815**	-0.893**	0.657**	-0.426	0.494
Causticaire (M_3)	0.920**	0.422	-0.789**	-0.758**	0.819**	-0.829**	0.586*	-0.429	0.441
"r" between fiber properties and fiber maturity (degree of thickening):									
Fresh (M_1)	0.901**	0.546*	-0.841**	-0.498	0.734**	-0.634*	0.532*	-0.084	0.095
Preserved (M_2)	0.899**	0.655**	-0.710**	-0.357	0.649**	-0.504*	0.567*	-0.232	0.181
Causticaire (M_3)	0.905**	0.594*	-0.862**	-0.457	0.754**	-0.633*	0.535*	-0.041	0.022

*, **: denote significant at 5% and 1% levels of probability, respectively.

CONCLUSION

The cotton breeder who employed his selection for fineness and maturity in numerous numbers of individual plants grown in the field during segregating generations can rely on early estimation of both traits *via* using uncollapsed fresh fibers from green bolls just before opening whether tested directly or after keeping in preserving solution until testing. These two methods are considered rapid, accurate and reliable as compared to estimates obtained from dry collapsed fibers obtained by causticaire method or by different instruments that provide estimates of both traits in combinations, such as Micronaire device or else.

The cotton breeder and spinner can also rely on the recent image analyzer, which provide reliable unbiased accurate determinations of fiber fineness and maturity of the dry fibers. Although the image analyzer is slow due to the long time and efforts of preparing fiber cross-sections, it could be used as a reference method for evaluating the other methodology and techniques for testing dry fibers in breeding programs, cotton trading and spinning industry.

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نعومة ونضج التيلة وعلاقتهما بالصفات التكنولوجية الاخرى في ١٥ تركيب وراثي من القطن المصرى

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نعومة التيلة تعنى دقة الشعرات أو بمعنى آخر صغر محيط أو قطر المقطع العرضى للشعرات وهى أهم ما يميز القطن المصرى عن غيره من الاقطان بجانب صفات أخرى هامة مثل طول ومتانة التيلة. أما نضج التيلة فهى درجة سمك جدار الشعرة أو درجة ترسيب طبقات السليلوز فى الجدار الثانوى للشعرات – وللنعومة والنضج أهمية كبيرة فى جودة المنتج النهائى سواء خيوط الغزل أو النسج ويعطيهما مربى القطن اهتماما متزايدا عند انتخاب سلالات جديدة ممتازة – ونظرا لصعوبة قياس النعومة والنضج بدقة وتداخل قياساتهما وتأثر كل منهما بالاخرى ولاختلاف دقة القياس واشتراك بعض الاجهزة مثل الميكرونير وغيره فى تقدير الصفتين معا لذلك من المهم اجراء تقييم دقيق منفصل لكل صفة منهما على حدة بدلا من تقييمهما معا فى قياسة واحدة أقل دقة ببعض الاجهزة. لذلك تم اجراء هذا البحث بهدف:

١ – تقدير نعومة ونضج التيلة لخمس عشرة تركيب وراثى من القطن من الشعرات الغضة غير المنقبضة ومن الشعرات الجافة المنقبضة. أخذت الشعرات الغضة من اللوزات الخضراء قبل تفتحها مباشرة وتكون فى هذه الحالة عبارة عن خلية أسطوانية قناتها ممتلئة بالبروتوبلازم الحى الذى يعطيها الشكل الاسطوانى وبذلك يسهل قياس قطر الشعرة بدقة وأيضا قياس درجة ترسيب السليلوز فى الجدار الثانوى. وهذه الطريقة تنقسم الى: أ- تقدير النعومة والنضج من الشعرات الغضة مباشرة بواسطة ميكروسكوب متصل بجهاز Image analyzer أو ب- حفظ الشعرات الغضة فى محلول حفظ (٧٥% ميثانول + ٢٥% حامض خليك ثلجى) لبقائها منتفخة أسطوانية حتى وقت الفحص. الشعرات الجافة المنقبضة فتم قياسها بمعاملة الشعرات بمحلول الصودا الكاوية ١٨% لاحداث انتفاخ بالسليلوز بغرض اعادتها الى الشكل الاسطوانى. كما تم تقدير قياسات النعومة (مساحة المقطع العرضى – محيط الشعرة – قطر الشعرة) وكذلك النضج (درجة تغليظ الجدار الثانوى %) باستخدام جهاز تحليل الصور Image analyzer. وكان الهدف الثانى هو دراسة العلاقة بين قياسات كل من النعومة والنضج بالصفات الاخرى لجودة التيلة مقدرة بجهاز HVI.

استخدم لهذا الغرض ١٥ من الاصناف وبعض السلالات ناتجة من هجن مبشرة من القطن المصرى تمثل ٦ منها الاصناف فائقة طول التيلة وهي: جيزة ٤٥ – جيزة ٨٧ – جيزة ٧٠ – جيزة ٨٨ – جيزة ٩٢ – سلالة من هجين (جيزة ٧٧ x بيما س٦) – وخمسة أصناف تمثل فئة الطويل التيلة بالوجه البحرى وهى: جيزة ٨٥ – جيزة ٨٦ – جيزة ٨٩ – سلالة من هجين (جيزة ٨٩ x جيزة ٨٦) – سلالة من هجين (جيزة ٨٩ x بيما س٦) وأربعة أصناف تمثل فئه الطويل التيلة بالوجة القبلى وهى: جيزة ٨٠ – جيزة ٩٠ – جيزة ٨٣ – جيزة ٩١. تم زراعة هذه التراكيب الوراثية بمحطة بحوث مركز البحوث الزراعية بالجيزة فى تصميم قطاعات كاملة العشوائية من ٣ مكررات فى موسم ٢٠٠٦ وكررت التجربة موسم ٢٠٠٧. وتتلخص أهم النتائج فيما يلى:

١- أظهر التحليل التجميعى أن قطر الشعرات الفضة المقدر من اللوزات الخضراء مباشرة يتراوح من ١٥.٣ ميكرون فى الصنف جيزة ٤٥ الفائق الطول الى ١٩.٧ ميكرون لصنف جيزة ٨٠ الطويل التيلة بالوجة القبلى. وأعطت طريقة الحفظ بالمحلول نفس الاتجاه – بينما كان قطر الشعرة الجافة المعاملة بالصودا الكاوية يتراوح من ١٤.٦ الى ١٨.١ ميكرون لنفس الصنفين على الترتيب وهى قيم منخفضة بمتوسط قدره ٥.٦% عن القطر المقاس من الشعيرات الغضة مباشرة و٦.١% عن طريقة الحفظ واختلف هذا النقص من صنف لآخر. وتراوح قطر ومحيط ومساحة المقطع العرضى فى الشعرات الجافة باستخدام تكنيك Image analysis الحديثة من ١٤.٣ ميكرون ، ٤٠.٦ ميكرون ، ١٣٢.٧ ميكرون مربع فى صنف جيزة ٤٥ الى ١٩.٩ ميكرون ، ٥٤.٨ ميكرون ، ٢٢٢.٨ ميكرون مربع فى جيزة ٨٠ على الترتيب متوافقا مع الطرق السابقة.

٢- كان جيزة ٤٥ الأقل نضجا حيث درجة تسمك الجدار به ٧٧.٣% بينما جيزة ٨٠ أكثر الأصناف نضجا بدرجة سمك الجدار ٨٩% وبمتوسط ٨٤.١% لجميع الأصناف وأعطت طريقة محلول الحفظ نفس الاتجاه ولكن بزيادة طفيفة عن الطريقة الأولى كما أعطت طريقة الصودا الكاوية نفس الاتجاه تقريبا ولكن تقديراتها تقل بدرجة ١.٨% ، ٣.٤% عن قياس الشعيرات الغضة مباشرة أو عن طريقة الحفظ على الترتيب.

٣- أظهرت النعومة أنها صفة صنفية لا تتغير معنويا بالتغيرات البينية الموسمية بينما درجة النضج شديدة التأثر بالتغيرات البينية.

٤- أوضحت دراسة معامل الارتباط أن الانتخاب لصفة النعومة يكون مصحوبا بزيادة طول التيلة ودرجة انتظام الطول وبتحسن فى متانة التيلة – بينما وجدت علاقة موجبة ومعنوية بين درجة ترسيب السليلوز بالجدار الثانوى وكل من قراءة الميكرونير ونسبة نضج الشعيرات ودرجة الاستطالة وعلاقة سالبة مع طول التيلة ومتانتها.

٥- يمكن لمربى القطن الذى يمارس الانتخاب فى أعداد ضخمة من النباتات الفردية فى الأجيال الانعزالية أن يعتمد على التقييم المبكر لصفتى النعومة والنضج من الشعيرات الغضة باللوز الأخضر قبل تفتحه مباشرة باعتبارها الطريقة القياسية والأكثر دقة. أما طريقة قياس الشعيرات الجافة بجهاز Image Analyzer فهى طريقة دقيقة لتقدير النعومة والنضج للشعرات الجافة ولكنها بطيئة فى تحضير العينات ويمكن الاعتماد عليها فى التربية والصناعة كمرجع لطرق التقييم الاخرى.