Extent of Accord Between Egyptian Cotton Fiber Fineness and Maturity Parameters Measured By The Image Analyzer and Their Corresponding Parameters Estimated From The Micromat Data

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ABSTRACT

The present study was conducted to explore the possibility of utilizing the Micromat data for estimation of fiber fineness and maturity parameters of Egyptian cotton, corresponding to those same parameters provided by the Image Analyzer. The intention is to avoid the exhaustive and time –consuming procedures of the Image Analyzer, in case of the existence of a satisfactory accord between the Micromat estimations and the Image Analyzer determinations. However, equations reported previously by the other workers were employed in this study to estimate fiber fineness and maturity parameters from the Micromat data. The concerned parameters are fiber perimeter (P), diameter (D), degree of thickening (θ) and area of secondary cell wall (ASCW). Those same parameters were also measured by the Image Analyzer.

The materials used in this study comprised 7 commercial Egyptian cotton varieties which are classified according to the local classification in Egypt as either extra-long staple (ELS), i.e. Giza 45, Giza 87 and Giza 88 or long staple (LS),i.e. Giza 80, Giza 85, Giza 86 and Giza 90.

The findings of both the Micromat and the Image Analyzer generally clarified that, Giza 87 appeared to have the finest fibers among the Egyptian cotton varieties, followed in order by Giza 45 and Giza88 which all belong to the ELS category. On the other hand, with regard to the LS varieties, both Giza 85 and Giza 86 seemed to have obviously finer fibers than Giza 90 and Giza 80. The latter, i.e. Giza 80 is in fact the variety that proved to have the coarsest fibers among the Egyptian cottons. With respect to cotton fiber maturity, the values of this character were interfering without any definite trend related to staple length category of either the ELS or the LS class. However, among the Egyptian cotton varieties altogether, Giza 86 variety revealed the highest value of maturity ratio (MR), while Giza 85 had the least value in this connection.

The relationships of fiber fineness and maturity parameters estimated from the Micromat data with their corresponding parameters determined by the Image Analyzer indicated the existence of highly significant positive coefficients of regression and correlation as well as considerable determination coefficients within each of those relationships. Accordingly, it could be stated that there is a fairly satisfactory accord between the Micromat estimations and the Image Analyzer determinations. Thus, the utilization of the Micromat data for estimation fiber fineness and maturity parameters as reliable substitutes for the similar parameters provided by the Image Analyzer would be quite justifiable

INTRODUCTION

Fineness and maturity are major quality characteristics of cotton fibers which are closely related to yarn and end product quality .As a matter of fact, fine and mature cotton fibers are the most popular and functionally required by spinners. Fiber fineness and maturity in combination are mostly and ordinarily expressed in terms of Micronaire reading. However, Ethridge *et al*., (1982) used multiple regression techniques to select the best functional expression for the impacts of fiber properties measured by the High Volume Instrument (HVI) on the strength of open -end spun yarns. They found that while most of the significant fiber properties were approximately linear on their impact on yarn strength, Micronaire exhibited an impact that departed drastically from linearity .Further ,the results indicated that when yarn strength was the only quality consideration in the spinning operation ,low Micronaire cottons appeared to be a better raw materiel than the high Micronaire reading. Nevertheless, Ramey (1982) pointed out that the Micronaire is a useful test for assessing maturity and thereby gravimetric fineness when it is known that the samples do not vary appreciably in biological fineness. However, the biological fineness among the samples being tested is variable, Micronaire readings are misleading.

In order to avoid any equivocal conceptions, it seems rational to express each of cotton fiber fineness and maturity independently. In such a case, cotton breeders and cotton spinners would be able to base their work on reliable and better understanding. Nevertheless, Ramey (1982) referred to that biological fineness is defined either as the perimeter or the diameter of the cross section of the fiber if that section is taken to be circular .The perimeter of course= π x the diameter .However, fiber fineness influences handle, luster, fiber cohesion, yarn strength, yarn uniformity and color.

With respect to cotton fiber maturity, Lord (1981) pointed out that fiber maturity is now generally accepted as meaning that the fiber wall has developed to an acceptable level of thickening .However, Ramey (1982) clarified that a knowledge of the wall thickness alone does not provide a measure of the extent to which the secondary wall filled the space inside the primary wall because the proportion filled by a given wall thickness depends upon the diameter of the fiber. In order to provide a measure of this proportion that is independent of cell diameter, the ratio θ was introduced by Peirce and Lord (1939). It is defined as follows: degree of thickening (θ) =Area of cell wall /Area of circle having the same perimeter.

Fiber maturity has a fundamental importance as determining factor in the overall quality of cotton. When fiber maturity decreases, processing difficulties result as revealed by increasing ends-down in spinning and decreased yarn quality. The presence of immature fibers in a cotton sample gives rise to imperfections particularly neps in the spun yarns .Neps in the woven fabrics create difficulties in obtaining uniformity of dyeing .

Thibodeaux *et al.*, (2000) stated that image analysis of the cross section of cotton fibers constitutes an excellent reference method for maturity and fineness measurements, Hequet and Wyatt (2001) reported that image analysis is too slow to be of practical use in commercial operations or plant breeding programs. They further clarified that both image analysis of the cross sections and the advanced fiber information system (AFIS) are giving much more useful information. The results are extremely encouraging because they show that the AFIS is giving very good correlation with the image analysis, especially for perimeter. Xu and Huang (2004) stated that cross sectional analysis of cotton fiber provides direct accurate measurements of fiber perimeter and maturity, which are often regarded as the reference data for validation or calibrating other indirect measurements of these important cotton fiber properties. Montalvo (2005) conducted a study to develop and compare models between Micronaire reading, fineness and maturity in terms of the cross sectional dimensions of wall thickness and perimeter. He referred to that formulas were derived to aid in understanding the functional dependence of fineness, maturity and Micronaire on the fiber's cross-sectional dimensions. all three fiber properties are combinations of wall thickness and perimeter. Additionally, the Micronaire model is significantly more sensitive to a change in wall thickness compared with the same change in perimeter, especially at small thickness values where Micronaire reading is almost independent of perimeter .As thickness increased, i.e., for high Micronaire cottons, the sensitivity to the perimeter becomes larger .These simulations show how wall thickness and perimeter together affect fineness and maturity and ultimately Micronaire.

MATERIALS AND METHODS

The materials used in this study comprised seven commercial Egyptian cotton varieties which were grown in 2006 season .According to the local classification in Egypt , the three varieties Giza 45 , Giza 87 and Giza 88 belong to the extra –long staple (ELS) category ,while Giza 80, Giza 85, Giza 86 and Giza 90 belong to the long staple (LS) category . The Micromat instrument was used to determine micronaire reading, maturity ratio (MR), hair weight (HW) and standard hair weight or standard fineness (Hs) which was derived from the ratio HW/MR (ASTM -D; 2818-1982). These measurements were conducted at the laboratories of the Cotton Research Institute, Giza, Egypt under controlled atmospheric conditions.

The Image Analyzer was used to measure fiber perimeter, fiber diameter (D), degree of thickening (θ), and area of secondary cell wall (ASCW). These measurements were carried out at The International Textile Center, Lubbock, Texas, USA. The following equations were employed to determine fiber fineness and maturity parameters from the Micromat data corresponding to those measured on the Image Analyzer.

Perimeter (P) =3.7853. $\sqrt{\ }$ Hs (Hequet and Wyatt 2001), while diameter (D) was calculated as the ratio P/ π (3.14) or as D =1.2055. $\sqrt{\ }$ Hs

Degree of thickening (θ) =0.577xMR (Peirce and Lord - 1939)

Cell wall area (Aw)= π(R^2_2 - R^2_1).Aw is the cell wall area (cross sectional area minus lumen area), R_1 represents the inside radius and R_2 represents the outside radius (Hequet *et al* .,2006).In the present study this parameter is expressed as area of secondary cell wall (ASCW)and was calculated as the ratio HW/ η (Ramey,1982) ,where η is the cellulose density which equals 1.52

The statistical dealing with the data obtained in this study was performed according to the procedures outlined by Little and Hills (1978).

RESULTS AND DISCUSSION

<u>Fiber intrinsic fineness, fiber maturity and combined measures of fineness and maturity of Egyptian cotton varieties.</u>

The Micromat data recorded in Table (1) demonstrate the average values of the standard fineness (Hs) which is an indication of fiber intrinsic fineness, maturity ratio (MR) as an indication of fiber maturity and both Micronaire reading (Mic) and hair weight (HW) as combined measures of fiber fineness and maturity. These data clearly reveal that , generally , the extra long staple (ELS) Egyptian cotton varieties are obviously intrinsically finer than the long staple (LS) varieties on account of the values of the standard fineness (Hs). This result is naturally wholly expected .Nevertheless, the values of maturity ratio (MR), of either the ELS varieties or the LS ones, are generally close to each other. On the other hand, the values of both Micronaire reading and hair weight, as combined measures of fiber fineness and maturity were in general agreement with the standard fineness (Hs) data .However, it could be generally stated that, among the ELS varieties, Giza 45 and Giza 87 appeared to be much finer than Giza 88 variety. As for the LS varieties, Giza 85 was found to have the finest fibers within this category, while Giza 80 proved to have the coarsest fibers in this respect, whereas Giza 86 ranked second and Giza 90 third on account of the values of the standard fineness (Hs) .With regard to fiber maturity (MR), the values of this character of either the ELS or the LS varieties were interfering without any definite trend related to staple length category. Generally, Giza 86 variety revealed the highest value of maturity ratio (MR=0.98) while Giza85 fibers appeared to have the least level of fiber maturity (MR=0.90), among the Egyptian cotton varieties altogether. The data of the image analysis of the Egyptian cotton varieties are shown in Table 2 indicated that the values of fiber perimeter (P) were in complete accord with those of fiber diameter (D) for all the studied varieties .Those values clarified that Giza 87 variety had the lowest values of both fiber perimeter (P) and diameter (D) in the ELS category followed in order by Giza 45 and Giza 88. With regard to the LS varieties, Giza 86 proved to be the finest in this category and followed in order by Giza 85, Giza 90 and Giza 80 .Hence, on the whole, it could be stated that Giza 87 is the finest Egyptian cotton variety, while Giza 80 is the coarsest one in this concern.

As for the determinations of cotton fiber maturity obtained from the Image Analysis, it was noticeable that the values of the degree of thickening (θ) of either the ELS or the LS varieties differed slightly from each other and these differences were mostly statistically insignificant .No incisive conclusion regarding the ranking of the Egyptian cotton varieties in accordance with the degree of thickening could be reached. By contrast, the average values of ASCW of the ELS cottons was evidently lower than those of the LS varieties, with only one exception, i.e., the ELS variety Giza 88 Table (2). Generally Giza 80 came first regarding the area of secondary cell wall (ASCW) whereas Giza 87 (ELS) ranked last in this respect. These findings imply that the absolute value of degree of thickening (θ) does not appear to be sufficient enough to wholly define cotton fiber maturity. Ramey(1982)confirmed this conclusion where he stated that a knowledge of the wall thickness alone does not provide a measure of the extent to which the secondary wall fills the space inside the primary wall because the proportion filled by a given wall thickness depends upon the diameter of the fiber. Nevertheless, in conformity with this statement of Ramey (1982) it could be generally concluded in the present study that the area of the secondary cell wall (ASCW) appeared to be more accurate and more reliable in denoting and expressing maturity of cotton fibers.

Extent of agreement between fiber fineness and maturity parameters determined by the Image Analyzer and those estimated by the Micromat data: -

Data of Table (3) show fiber fineness and maturity parameters of perimeter (P), diameter (D), area of secondary cell wall (ASCW) and degree of thickening (θ), estimated from the Micromat determinations, using the formulas previously reported in the Materials & Methods section. These Micromat estimations were correlated with their corresponding determinations provided by the Image Analyzer. The aim is to investigate the interrelationships of both data in order to explore the possibility of utilizing the data of Micromat to predict fiber fineness and maturity parameters of Egyptian cotton as an alternative of the image analysis procedure.

Figures 1, 2, 3 and 4 depict the relations of each datum provided by the Image Analyzer with its corresponding datum estimated from the Micromat determinations. By reference to the aforementioned figures, and considering the highly significant positive coefficients of regression and correlation(r) as well as the considerable determination coefficients (R^2) were found, it could be generally stated that there is a fairly satisfactory accord between the determinations of fiber fineness and maturity parameters provided by the Image Analyzer and their corresponding parameters estimated from the Micromat data. In such a case the utilization of the Micromat data to estimate fiber fineness and maturity parameters as substitutes for the similar parameters ordinarily provided by the Image Analyzer would be quite justifiable .In fact the processing procedures of the image analysis are time consuming and exhaustive ,while the Micromat procedure is characterized by speed, simplicity and sufficiency. Thereupon, Micromat instrument could be strongly recommended to be employed to estimate accurately and reliably the same determinations of the Image Analyzer. In this respect, it seems worthwhile to note that Xu and Haung (2004) stated that cross-sectional analysis of cotton fibers provided direct accurate measurements of fiber fineness and maturity which are often regarded as the reference data for validating or calibrating other indirect measurements of these important cotton properties. They added that cross-sectional methods using image analysis had not been broadly applied to cotton quality evaluations because of the tedious procedures for both preparing cotton samples and processing cross-sectional image. Furthermore, Hequet and Wyatt (2001) reported that both image analysis of the cross-sections and the AFIS data were giving much more useful information and the results were extremely encouraging showing that the AFIS gave very good correlation with the image analysis especially for the perimeter.

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Table(1):Average values of micronaire reading (Mic),maturity ratio(MR),hair weight (HW) and standard fineness(Hs) of the Egyptian extra long staple (ELS) and long staple(LS)cotton varieties measured by the Micromat instrument.

Cotton varieties	MIC	MR	H.W [millitex]	Hs [millitex]
ELS				
Giza 45	3.1	0.94	115.3	122.6
Giza 87	3.2	0.96	117.1	122.0
Giza 88	3.8	0.93	133.2	143.2
Mean	**3.4**	**0.94**	**121.9**	**129.7**
LS				
Giza 80	4.4	0.91	160.6	176.5
Giza 85	3.7	0.90	142.0	157.8
Giza 86	4.3	0.98	160.3	163.6
Giza 90	4.0	0.95	158.0	166.3
Mean	**4.1**	**0.94**	**155.2**	**166.1**
LSD 0.05	**0.26**	**0.016**	**18.3**	**19.94**

Table(2): Average values of perimeter (P),diameter (D),area of secondary cell wall(ASCW) and degree of thickening (Theta-θ) of the Egyptian extra long staple (ELS) and long staple(LS) cotton varieties measured by the Image Analyzer instrument.

Cotton varieties	P [μ]	D[μ]	ASCW[μ]²	Theta[θ]
ELS				
Giza 45	41.6	13.2	79.7	0.58
Giza 87	39.1	12.4	72.9	0.60
Giza 88	43.5	13.8	92.5	0.62
Mean	**41.4**	**13.2**	**81.7**	**0.60**
LS				
Giza 80	50.8	16.2	99.6	0.51
Giza 85	45.2	14.4	81.7	0.51
Giza 86	44.7	14.2	93.4	0.59
Giza 90	46.4	14.8	96.4	0.57
Mean	**46.8**	**14.9**	**92.8**	**0.55**
LSD 0.05	**0.29**	**0.31**	**1.37**	**0.03**

Table(3):Average values of perimeter (P),diameter (D),area of secondary cell wall(ASCW) and degree of thickening (Theta-θ)of the Egyptian extra long staple (ELS) and long staple(LS)cotton varieties estimated by the Micromat data.

Cotton varieties	P[μ]	D[μ]	ASCW[μ]²	Theta[θ]
ELS				
Giza 45	42.0	13.4	75.7	0.53
Giza 87	41.8	13.3	77.0	0.55
Giza 88	45.3	14.4	87.6	0.54
Mean	**43.0**	**13.7**	**80.1**	**0.54**
LS				
Giza 80	50.8	16.0	105.7	0.51
Giza 85	47.5	15.1	93.4	0.52
Giza 86	48.4	15.4	105.5	0.57
Giza 90	48.8	15.5	103.9	0.55
Mean	**48.9**	**15.5**	**102.1**	**0.53**
LSD 0.05	**0.18**	**0.15**	**0.25**	**N.S**

Fig 1:Relation of perimeter determined on the Image Analyzer and that estimated from the Micromat data

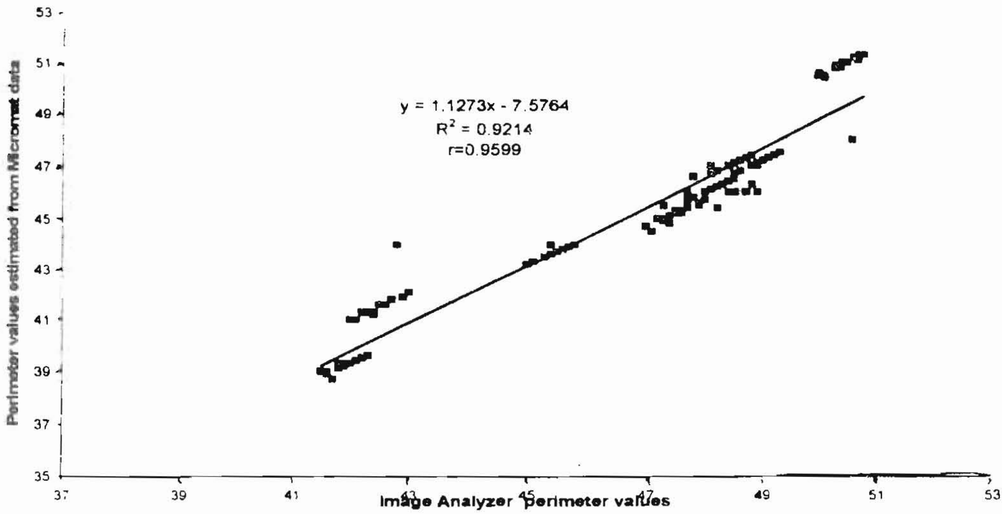


Fig 2 :Relation of diameter derterminded on the Image Analyzer and that estimated from the Micromat data

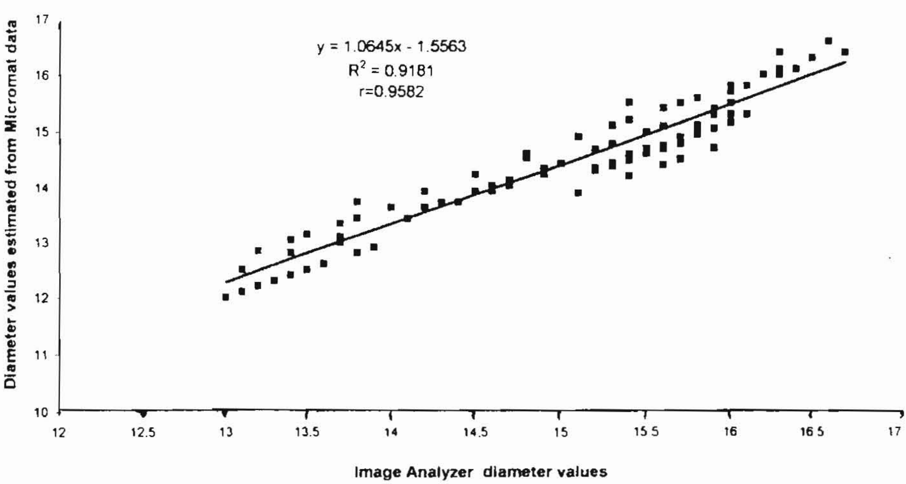


Fig 3:Relation of area of secondary cell wall (ASCW) determined on the Image Analyzer and that estimated from the Micromat data

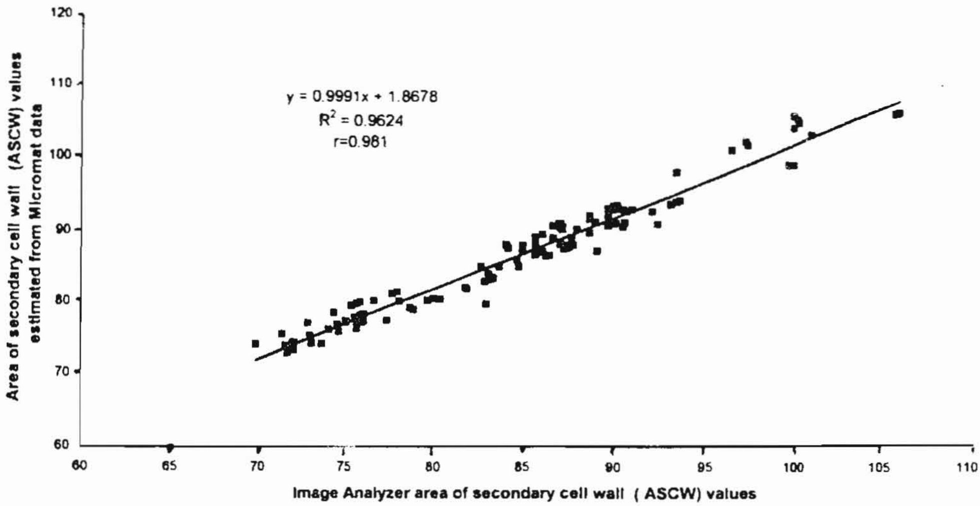
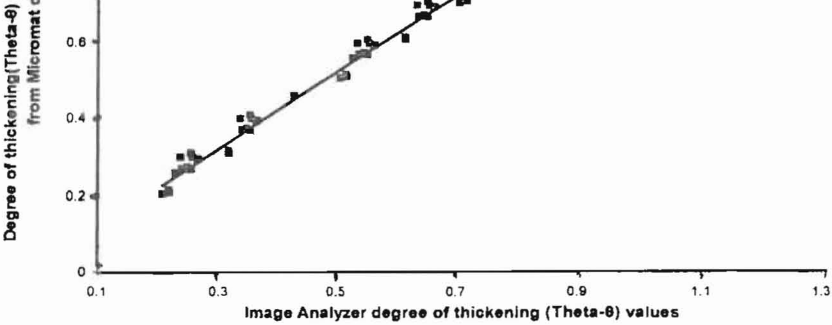


Fig 4:Relation of degree of thickening (Theta-θ) determined on the Image Analyzer and that estimated from the Micromat data



الملخص العربى

مدي التوافق بين مدلولات النعومة والنضج لشعرات القطن المصري المقاسه بجهاز تحليل الصور ونظيراتها المقدرة بجهاز الميكرومات

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أجريت هذه الدراسة لتحديد امكانيه استخدام بيانات جهاز الميكرومات لتقدير مدلولات النعومة والنضج لشعرات القطن المصري المناظرة لتلك التي يتم قياسها بجهاز تحليل الصور . والهدف من ذلك هو تجنب إجراء القياسات المضنية والتي تستغرق وقت طويل بجهاز تحليل الصور ذلك في حاله ما إذ كان هناك توافق مرضي بين تلك القياسات ونظيراتها المقدرة من بيانات جهاز الميكرومات. وقد استخدم لهذا الغرض معادلات لحساب مدلولات النعومة والنضج لشعيرات أصناف القطن المصري من واقع بيانات الميكرومات وتشمل تلك المدلولات محيط الشعرة(P) وقطر الشعرة(D) ودرجه تغليظ الجدار الثانوي (θ) ونسبه المساحة التي يشغلها الجدار الثانوي من مساحه المقطع العرضي للشعرة (ASCW) .

وقدم استخدم في هذه الدراسة سبعه أصناف من القطن المصري ألتجاريه والتي تصنف تبعا للعرف السائد في مصر إما كأصناف فائقة الطول ELS (جيزة ٤٥، جيزة ٨٧ ، جيزة ٨٨) أو طويلة التيلة LS (جيزة ٨٠، جيزة ٨٥ ، جيزة ٨٦ ،جيزة ٩٠) .

وقد إشارات النتائج المتحصل عليها من هذه الدراسة إلي إن كل من جهاز تحليل الصور وجهاز الميكرومات أوضحا بصفه عامه إن شعرات الصنف جيزة ٨٧ هي الأنعم بين أصناف القطن المصري ويليها في هذا المقام شعرات الصنفان جيزة ٤٥ وجيزة ٨٨ وجميع هذه الأصناف تنتمي إلي طبقه الأصناف فائقة الطول . ومن ناحية أخري فبالنسبة للأقطان الطويلة التيلة فقد كانت شعرات الصنفان جيزة ٨٥ وجيزة ٨٦ انعم بدرجه واضحة عن تلك الخاصة بالصنفان جيزة٩٠ وجيزة ٨٠ وهذا الأخير هو في الواقع يعتبر اخشن أصناف القطن المصري . وفيما يتعلق بنضج شعرات القطن قد كانت قيم هذه الصفة تتداخل فيما بين طبقتي الأصناف فائقة الطول أو طويلة التيلة. وبصفه عامة قد كانت شعرات الصنف جيزة ٨٦ هي الأكثر نضجا بينما كان شعرات الصنف جيزة ٨٥ هي الأقل نضجا بين أصناف القطن المصري إجمالا.

وقد أظهرت العلاقات بين مدلولات النعومة والنضج المقدرة من بيانات جهاز الميكرومات ونظيراتها ألمقاسه بجهاز تحليل الصور إلي أن معاملات الارتباط والانحدار والتقدير بين هذه المتغيرات كانت عاليه المعنوية وموجبه مما يؤشر إلي وجود توافق مرضي بدرجه كبيره بين تقديرات الميكرومـــات وقياســـات جهاز تحليل الصور وعلي ذلك فان استخدام بيانات جهاز الميكرومات لتقدير مدلولات نعومـــه و نـــضج شعرات القطن كبديل يمكن التعويل عليه لقياس هذه المدلولات بجهاز تحليل الصور هو أمر مبرر تماما.