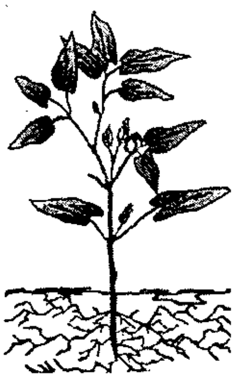

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REFERENCE MODELS FOR COTTON FIBER MATURITY AND FINENESS MEASUREMENTS ON CULTIVATED EGYPTIAN VARIETIES

[3]

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Keywords: Cotton, Fiber, Maturity, Fineness, Micronaire, Perimeter

ABSTRACT

Micronaire value in cotton fiber assessment is a combined measure of fiber fineness and maturity. Fineness and maturity are important because yarn made from fine fibers is stronger, and mature fibers absorb dye better. So, the fineness and maturity of cotton are important properties for the spinner, grower, dyer and buyer, as well as breeder. These measurements need to be determined reliably, quickly and economically. The objective of the current study is to employ micronire value as a substitute for assessing cotton fineness and maturity for Egyptian cotton with no prior information about these measurements. Models were derived to aid understanding the functional dependence of fineness (H), maturity and micronaire value. All three fiber properties are combinations of wall thickness and perimeter. Variability in (R^2) between each paired of fiber properties (micronaire value (MIC), maturity ratio (M) and fineness (H)) has been employed, to understand the models. The models were computer simulated over the full range of thickness and perimeter values. Three lint grades viz., Fully Good (FG), Good (G), and Fully Good Fair (FGF) from each of eight cultivated varieties were tested at the laboratories of the Grading Research Section, Cotton Research Institute, Giza. All samples were obtained from 2006 and 2007 seasons. Overall results revealing that the experimental will be able to predict the fiber maturity as he can measure the micronaire value of definite a variety with fixed fiber perimeter using this model:

Maturity ratio (M) = 0.3238 + 0.5273 (MIC) - 0.0292 (P) $R^2 = 0.679^{**}$

Also, predicting to fiber fineness (H) using micronaire instrument for specific variety with fixed perimeter can be estimated using this equation:

Fiber fineness (H)= -7.177+3.34 (MIC) + 3.255(P) $R^2 = 0.969^{**}$

INTRODUCTION

Micronaire value is regarded as an indicator of both fineness (linear density) and maturity (degree of cell-wall development). For a given cotton type, a relatively low micronaire has been a processing problem. A low micronaire however, may indicate fine fibers with adequate maturity. Similarly, growers may be discounted for high micronaire when, the fibers have adequate fineness and good maturity, because high micronaire fibers are normally coarse, which is undesirable from the point of view of spinning and yarn evenness, **(Ramey, 1982).**

Fineness is generally expressed as gravimetric fineness or linear density (wall area times a constant), and maturity is generally expressed as maturity ratio (wall area divided by perimeter squared) **(Lord and Heap, 1988).**

One of the first practical tools to measure fineness and maturity was the determination of linear density and maturity ratio on the Shirley Developments Limited Fineness and Maturity Tester

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(FMT). This test has been improved successively by (**Montalvo and Faught, 1999; Von Hoven *et al* 2001**).

A big problem associated with cotton fiber quality is related to the control and management of cotton fiber maturity and fineness. This is because of absence of rapid and accurate measures for cotton fiber maturity and fineness. For example using micronaire test method, an air flow technique that measures a combination of fiber maturity and fiber fineness (weight per unit length), fine mature cotton can have the same micronaire value as coarse immature fiber. Thus there is a need for a new measurement technique to separate these effects, (**Von Hoven *et al* 2001**).

As a consequence, an averaged wall thickness and perimeter are fundamental with respect to an averaged wall area. Exploring the relationships on a basic level can be beneficial by demonstrating how a unique wall thickness and perimeter value together give a micronaire-fineness-maturity combination.

Objectives of this research were to use fineness and maturity components – wall thickness and perimeter – to develop models for fineness, maturity, and micronaire; to simulate the interaction of fineness and maturity and the resultant micronaire; to quantify the relative sensitivity of the models to changes in thickness and perimeter; and to demonstrate variability in the coefficients of determination. (R^2) between micronaire and the other variables.

MATERIALS AND METHODS

To predict fiber maturity and fineness measurements, eight Egyptian cultivated varieties were used in this study during 2006 and 2007 seasons.

Three lint grades of the samples representing, Fully Good (FG), Good (G) and Fully Good Fair (FGF) each of eight cotton cultivated varieties; Giza 87 (G.87), G.45, G.88, G.85, G.89, G.86, G.90 and G.80. Cotton samples were obtained from the "Cotton Arbitration and Testing General Organization". These materials used to cover different levels of maturity and wall thickness (three lint grades of each of variety) and different levels of fiber perimeter values (different varieties). The study goes on to show how wall thickness and perimeter together affect fineness (H), maturity ratio (M) and micronaire value (MIC).

Representative a total of 240 (3x8x10) samples of approximately (2 pounds) was taken from each of the three lint grade. Each grade was homogenized according to the protocol used by Cotton Research Institute to produce reframes cottons. Means were calculated from the ten repeats of each lint grade for each variety.

1- Maturity ratio: Was measured by the sodium hydroxide swelling method (**Lord, 1961**). (**ASTM, 1998**). (**D-1449-59**), for testing in which the swollen fibers are classed into two classes, normal fibers (N) and, dead fibers (D) are counted and the testing results are reported as two figures (N-D). Maturity ratio is calculated from this equation:

$$MR = (N-D)/200 + 0.70$$

2- Gravimetric fineness: as fineness by weight, linear density is defined as the mass, per unit length of the fiber. This method, known as the cut/weigh method, has been in use in Cotton Res. Institute for a long time.

3- Intrinsic fineness: known as biological fineness, it is defined as the perimeter of cross- section. The average fiber perimeters of the eight varieties were done by the image analysis, in International Textile Center, Lubbock, TX. *(Eric F.Hequet) Different varieties have different perimeters defining their fiber fineness.

Variation in coefficients of determination (R^2) between fineness and maturity; fineness and micronaire; and micronaire and maturity; of cultivated varieties of Egyptian cotton are discussed.

Statistical analysis, simple correlation and multiple regressions (Stepwise) analyses were employed to study these relationships according to **Draper and Smith (1966)**, using SAS software, SAS institute, (1997).

RESULTS AND DISCUSSION

Fiber fineness and maturity are two of the most important cotton fiber quality parameters which affect cotton processing and quality of the end product. The main aim of the present study was to setting reference models for predicting cotton fiber maturity and fineness measurements.

Meaning and models

As indicated before, micronaire value represents an indicator for both maturity and fineness (fiber size), (**Heap, 2000**). Thus, micronaire is a combined measure of cotton fineness and maturity. There is a direct relationship between micronaire and the product MH (maturity x fineness by weight). This relationship was first substantiated for a set of 100 fibers cotton (**Lord, 1956**).

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$MH = 3.86 (MIC)^2 + 18.16 (MIC) + 13$, With an R^2 of 0.9809.

The relationship has been confirmed by several workers with very similar results:

R^2 = 0.998 (**Lord and Heap, 1988**), R^2 = 0.988 (**Mitchell, 1976**), R^2 = 0.999

(Bremen round tests, sited from **Heap, 2000**); and R^2 = 0.917 (image analysis, sited from **Thibodeaux and Evans, 1986**).

Fineness and maturity

Fineness and maturity can be expressed in various ways (**Ramey, 1982, Lord and Heap, 1988, Montalvo and Faught, 1996**). Fineness (H): is gravimetric fineness and known as fineness by weight, weight per unit length, millitex (linear density). Gravimetric fineness depends on both fibers intrinsic and maturity. **Ramey, (1982)** stated that, the density of the cell wall is taken as 1.52g/cm^3, in the current study, the diameter and perimeter could be calculated, by this equation:

Fineness by weight (H)=1.52 X (Aw) fiber wall area

Maturity ratio is the average degree of thickening, it assesses wall thickening relative to standard maturity level of [N (Normal Fiber) – D (Dead Fiber)] = 60. This reference level is an optimum level reached only by high grades. The references level, when M=1, corresponds to an absolute average degree of thickening of θ equal to 0.577. So, maturity ratio is the degree of thickening divided by 0.577 and is dimensionless. Degree of thickening (θ) is wall area divided by the area of circle having the same perimeter (**Lord and Heap, 1988**):

$$M = \theta/0.577 \text{ where } \theta = 4(3.14) \times Aw/P^2.$$

For testing, usually only the two classes (N) normal fiber and (D) dead fiber are counted and the testing results are reported as two figures (N-D). Maturity ratio (M) is calculated from the equation:

$$M = \{(N-D)/200\} + 0.70.$$

Fundamentals

Micronaire has been used as a substitute for assessing cotton fineness and maturity, when these measures are not available. Variability in R^2 coefficient of determination of the models described for each pair of fiber properties (micronaire and maturity; micronaire and fineness; maturity and fineness) has been observed. The objective of this research was to study models between micronaire, fineness and maturity in terms of the fiber perimeters (different varieties), and wall thickness (different lint grades).

The mean values, standard error and coefficient of variance (c.v %) of micronaire value (MIC), maturity ratio (M), fineness by weight (H) and fiber perimeters (P) ranged in eight Egyptian cotton varieties for three different lint grades, are shown in **Table (1)**. It can be noticed that as the variety is changed from (G.87) to (G.80), the range of micronaire value, fineness by weight and maturity ratio increased according to increasing perimeter of variety. Thus, the eight varieties could be arranged in ascending order according to their average fiber perimeters as follows; G.87, G.45, G.88, G.85, G.89, G.86, G.90 and G.80, for their fiber perimeter, 33 to 35, 36-38, 39-41, 42-44, 45-47, 48-50, 51-53 and 54-56 micron, respectively.

I- Relationship between maturity and fineness at constant perimeters

To understand the relationship between maturity ratio (M) and fineness by weight (H) (linear density) in terms of eight fiber perimeters for different studied varieties and for three walls thickness (three different lint grades) generated computer simulated data. Models were studied to understand the variability in coefficients of determination (R^2) between maturity and fineness, to show how wall thickness and perimeters together affect maturity and fineness.

Figure (1); shows that fineness by weight is plotted against maturity ratio at eight perimeter values, it could be arrange fiber properties and its relation with fiber fineness (H) in a descending order as follows: the product KMP^2, R^2 = 0.779; (M,P^2), R^2 = 0.508; and P, R^2 = 0.379, respectively.

1- **Fineness by weight (H) = (0.07318) MP^2 R^2 = 0.779****
2- **Fineness by weight (H) = 51.82 – 0.3598 (M) + 0.0348 (P^2) R^2 = 0.508****
3- **Fineness by weight (H) = (3.736) X P R^2 = 0.379***

It could be noticed that when fineness is plotted against maturity ratio at constant perimeter with the same variety, where, both fineness and maturity are functions of wall area (H = (0.07318) X MP^2). This is the equation for a straight line – at constant

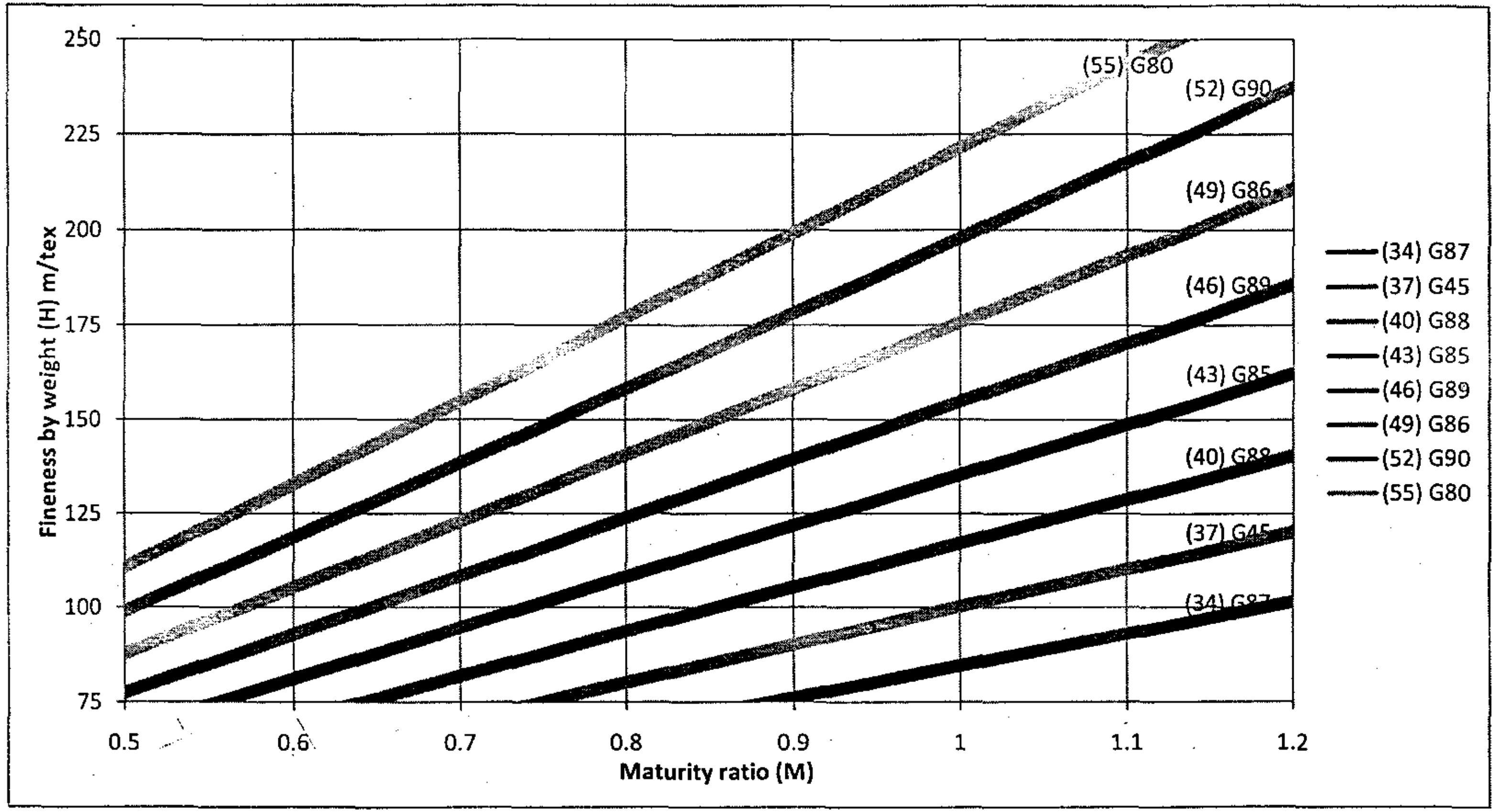


Figure 1. Relationship between maturity ratio and fineness by weight at eight perimeters (34, 37, 40, 43, 46, 49, 52 and 55 microns)
$H = (0.07318)MP^2$ $R^2 = 0.779^{**}$

Table1. Descriptive statistics of fiber properties; Perimeter, Micronaire value (MIC) Fineness (H.W) and Maturity ratio (M) for each variety

Varieties	Perimeter (μm)	Micronaire value	Hair weight	Maturity ratio
Giza 87	< 33 – 35	2.4 – 3.6	90 – 103	0.86 – 0.94
Giza 45	< 36 – 38	2.3 – 3.7	95 – 126	0.84 – 0.97
Giza 88	< 39 – 41	2.3 – 4.4	115 – 154	0.88 – 1.09
Giza 85	< 42 – 44	3.3 – 4.4	126 – 162	0.78 – 1.13
Giza 89	< 45 – 47	3.2 – 4.8	130 – 185	0.68 – 1.16
Giza 86	< 48 – 50	2.9 – 5.1	136 – 196	0.65 – 1.17
Giza 90	< 51 – 53	2.6 – 4.6	135 – 200	0.62 – 1.17
Giza 80	< 54 – 56	2.6 – 4.8	144 – 216	0.56 – 1.20
Minimum	33 μm	2.3	90	0.56
Maximum	56 μm	5.1	216	1.20
Mean	44.5	4.2	155	0.88
Std.Dev.	1.5	0.49	18.46	0.21
C.V. %	3.4	11.8	11.9	22.7

perimeter (P) - that passes through the origin. These results are in agreement with **(Thibodeaux, 1998)** but with distribution of fineness and maturity for a smaller range of perimeters (43-58) micron.

II- Relationship between maturity and fineness at constant micronaire values

The maturity – fineness by weight – micronaire model described by **(Lord, 1956)** equation has been confirmed by several researchers, R^2 = 0.988 **(Michell, 1976)**, R^2 = 0.998 **(Lord and Heap, 1988)**, R^2 = 0.990 (Bremen round tests), and R^2 = 0.917 (Image analysis).

$$MH = 3.86\,(MIC)^2 + 18.16\,(MIC) + 13 \qquad R^2 = 0.998^{**}$$

This equation is used in here to understand what happens when the independent variables are changed. At fixed micronaire value (MIC), maturity (M) is inversely proportional to fineness by weight (H) and vise verse.

The inverse relationships between fineness by weight (H) and maturity ratio (M) at constant micronaire, at four values of micronaire (2.5, 3, 4, and 5) are shown in **Figure (2)**. This relationship does not reveal the changes in the fundamental measures of wall thickness and perimeter. Theses results are in agreement finding with **(Thibodeaux, 1998)**.

$$\text{Fiber fineness } (H) = 17.87 + 59.16\,(MIC) - 90.81(M) \qquad R^2 = 0.996^{**}$$

III- Relationship between micronaire value and fineness at constant eight perimeters

Within each variety; at constant fiber perimeter a linear increase in the average of micronaire value with increase fineness was observed **(Figure 3)**.

This relationships has been confirmed with very similar results, where R^2 = 0.786** Bremen round test; and R^2 = 0.598**, **Heap, 2000**. The model was derived by one independent.

$$\text{Fineness by weight } (H) = -37.76 + 48.31\,(MIC) \qquad R^2 = 0.693^{**}$$

$$\text{Fiber fineness } (H) = -7.177 + 3.34\,(MIC) + 3.255(P) \qquad R^2 = 0.969^{**}$$

So, micronaire value has been used as a substitute for assessing fineness (H) when the later measure is not available.

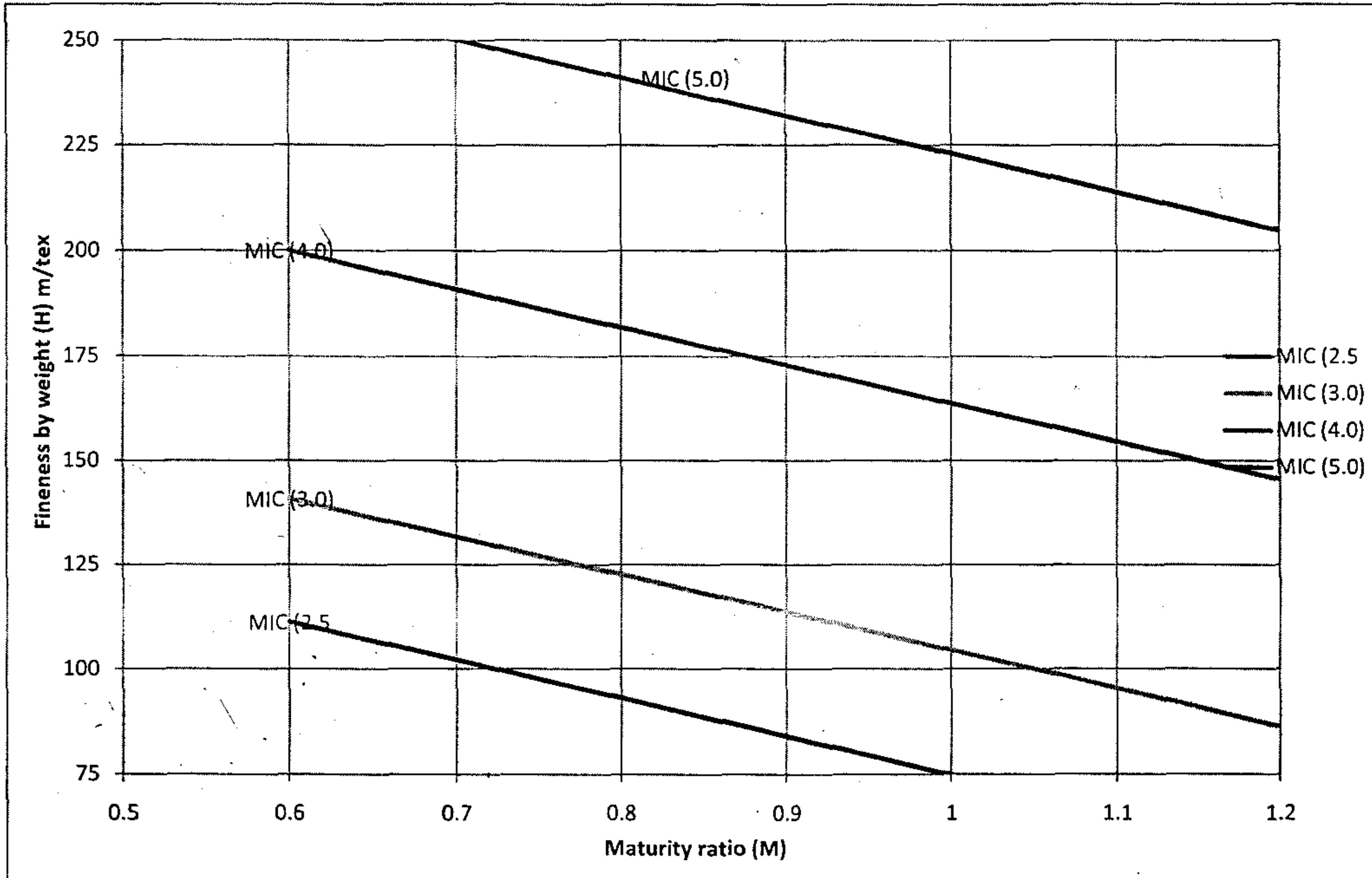


Figure 2. The inverse relationship between maturity ratio and fineness by weight at constant micronaire value
$H = 17.87 + 59.16\ (MIC) - 90.81\ (M) \qquad R^2 = 0.996^{**}$

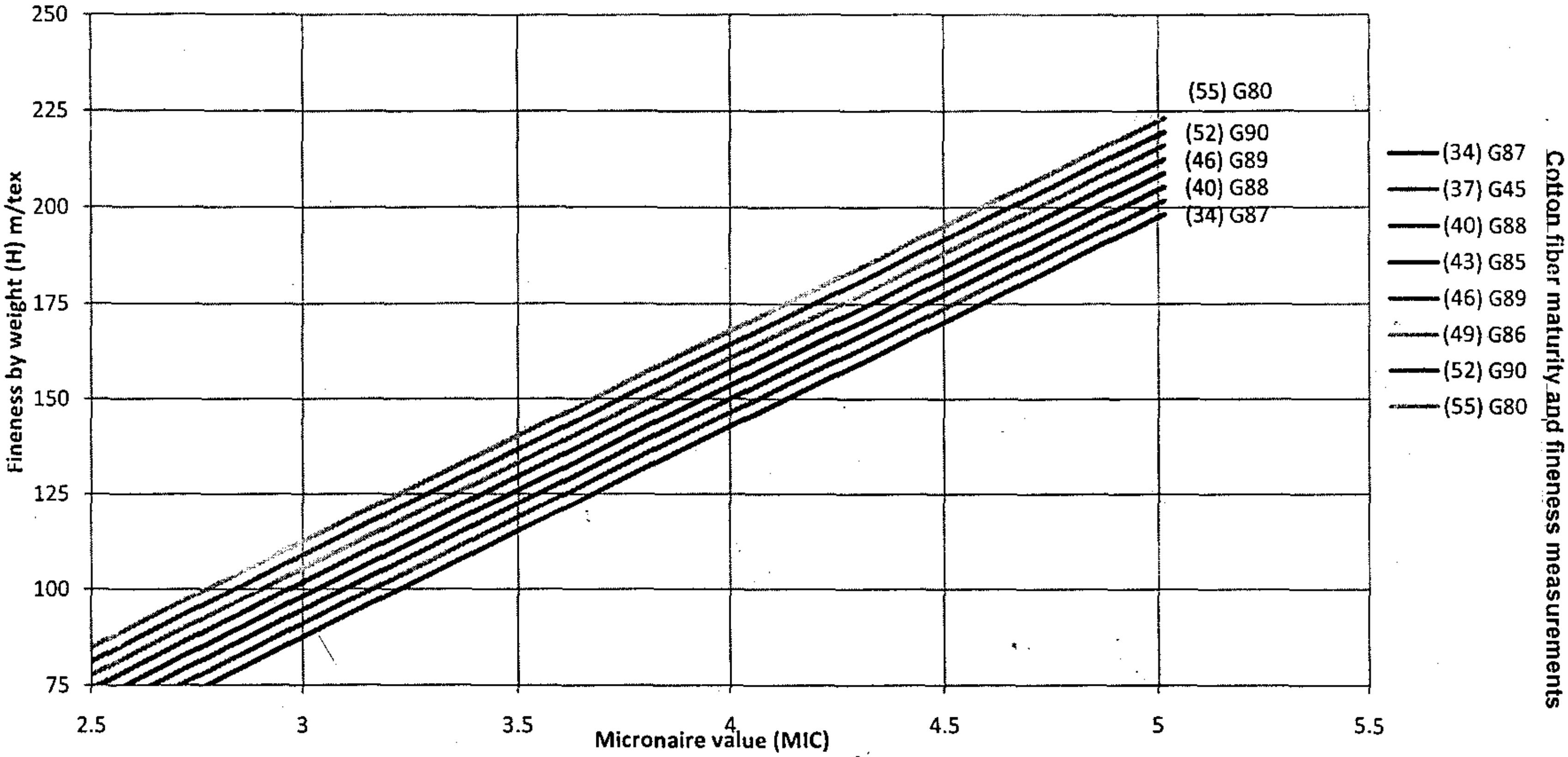


Figure 3. Relationship between micronaire value and fineness by weight at eight perimeter values (34, 37, 40, 43, 46, 49, 52, 55 microns)

H = -7.177 + 3.34 (MIC) + 3.255 (P) $R^2 = 0.969^{**}$

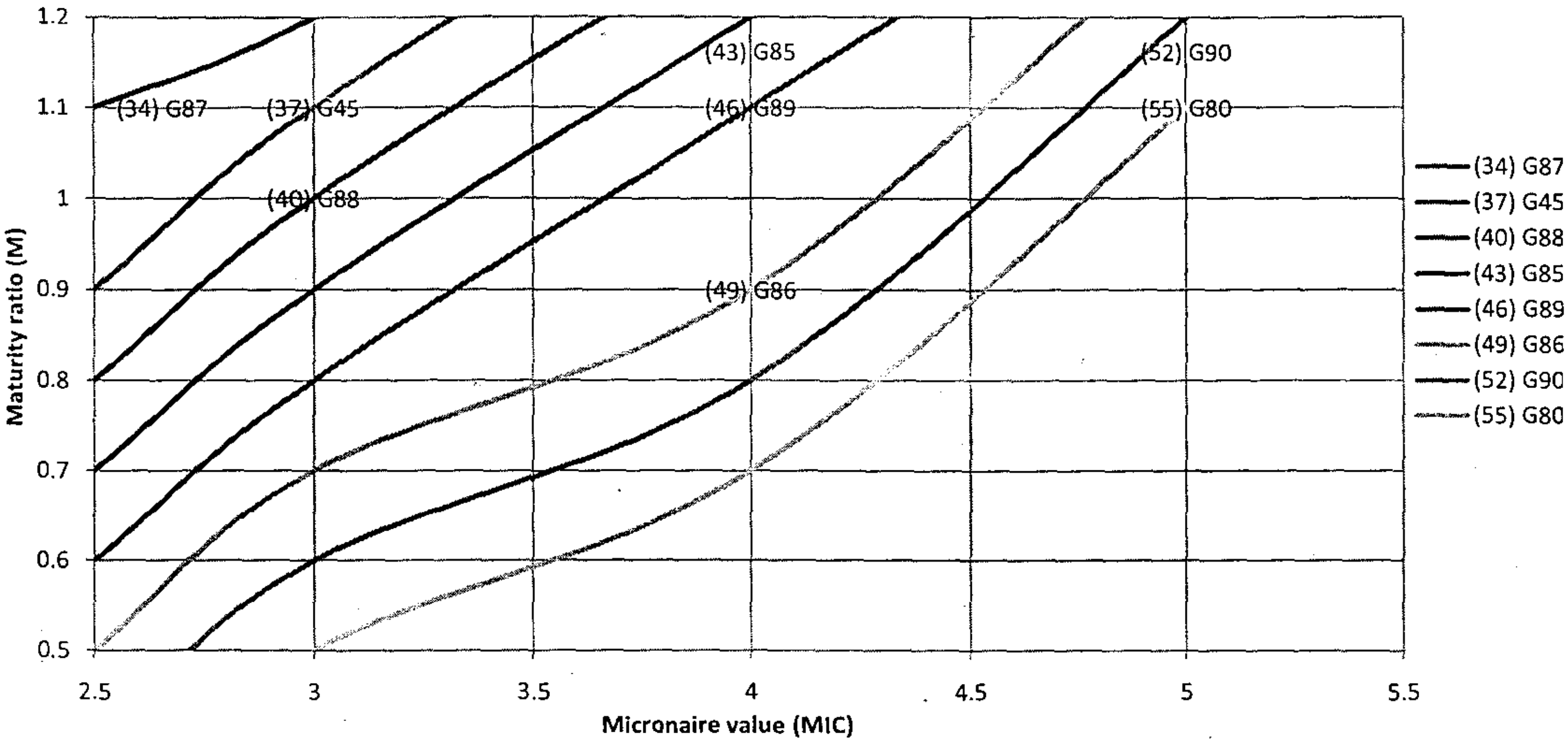


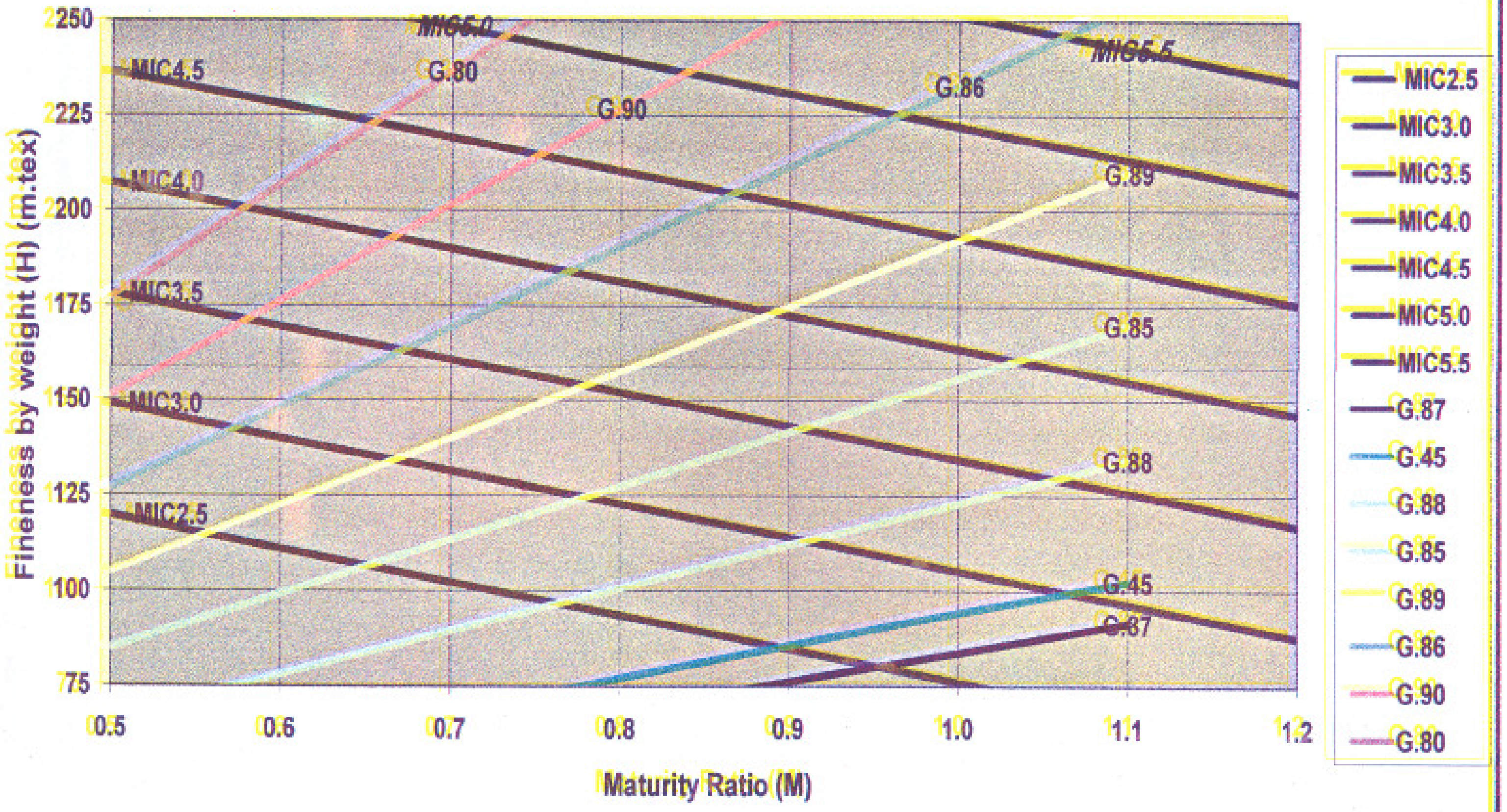
Figure 4. Relationship between micronaire value and maturity ratio at eight perimeter values (34, 37, 40, 43, 46, 49, 52, 55 microns)

$M = 0.3238 + 0.5273\ (MIC) - 0.0292\ (P)$ $\quad R^2 = 0.679^{**}$

Figure 5. Dependence of micronaire at eight perimeter values on maturity ratio and fineness by weight

Maturity (M) = 0.3238 + 0.5273 (MIC) – 0.0292 (P)

Fiber fineness (H) = -7.177 + 3.34 (MIC) + 3.255 (P)



IV- Relationship between micronaire value and maturity at constant eight perimeters

In each of the studied varieties, the prediction equation and coefficients of determination R^2 for the relationship between micronaire value and maturity ratio are presented in **(Figure 4)**. It could be noticed that micronaire value strongly and positively correlated to maturity ratio at all varieties. The regression slopping of micronaire value to maturity ratio differed from one variety to another according to specific fiber perimeter.

The two remaining plots in the series, **Figures 3 and 4** depict micronaire value versus fineness (H) and maturity (M), respectively, at constant perimeters. This is due to the fact that all three fiber characteristics- micronaire, fineness, and maturity- are functions of wall area. At constant perimeter (P), MIC is a function of H, and MIC is a function of M.

1- Maturity (M) = 0.4783+0.1392 (MIC)
R^2 = 0.756**
2- Maturity (M) = 0.238 + 0.576 (MIC)– 0.0094 (H)
R^2 = 0.964**
3- Maturity (M)= 0.3238+0.5273 (MIC) – 0.0292(P)
R^2 = 0.679**
4- Fineness (H) = 119.18–0.674 (M) – 0.597 (MIC)
R^2 = 0.441*

Conclusion

Models were derived to aid understanding the functional dependence of micronaire, fineness and maturity on the fiber's cross-sectional dimensions. All three fiber properties are combinations of wall thickness and perimeter. Plots of micronaire versus fineness and micronaire versus maturity ratio give a family of linear lines each representing a fixed perimeter. The breeders, spinners and dyers can predict the fiber maturity and fineness parameters derived from cotton fiber micronaire value that were measured by micronaire instrument and definite variety with fixed perimeters. **(Figure 5)**.

Maturity (M) = 0.3238 + 0.5273 (MIC) – 0.0292 (P)
R^2 = 0.679**
Fiber fineness (H) = -7.177+3.34 (MIC)+3.255 (P)
R^2 = 0.969**

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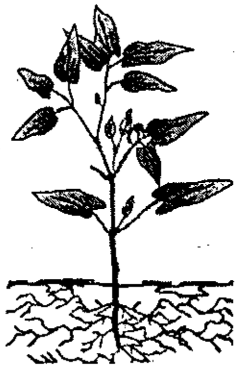
حوليــات العلــوم الزراعية
جامعة عين شمس ، القاهرة
مجلد(٥٤)، عدد (١)، ٣٧-٤٨، ٢٠٠٩



إستنباط قياسات النعومة والنضج لشعر القطن بمعلومية قراءة الميكرونير ومحيط الشعر فى الأصناف المصرية المنزرعة

[٣]

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الموجـــز

تعتبر قياسات النعومة والنضج لشعر القطن من أهم صفات جودة خيوط غزل القطن , والتي يعتمد عليها الغزال والمربي لانعكاس تأثيرها علي كفاءة التشغيل وتكلفة الإنتاج , لذا كانت أهم أهداف هذا البحث إيجاد نموذج لتقييم النعومة والنضج بطريقة سريعة ودقيقة بشرط معلومية محيط الصنف وقراءة الميكرونير ــ بديلا للطرق المباشرة التقليدية – باستخدام الصودا الكاوية لتقدير النضج أوطريقة النعومة بالوزن" لتقدير الكثافة الطولية" وكلا الطريقتين من الطرق المباشرة إلا أنهما يحتاجا وقت وجهد كبير بالإضافة إلي اعتمادهما بشكل كبير علي مهارة القائم بالعمل , حيث أن التباينات في هذه الطرق يرجع إلي تأثير القائم بالعمل أكثر من التباينات التي ترجع إلي الجهاز المستخدم.

استخدم ثمانية أصناف من الاقطان المصرية المنزرعة لإيجاد مدي واسع للنعومة الذاتية (محيط الشعرة)
جـ ٨٧ , جـ ٤٥ , جـ ٨٨ , جـ ٨٥ , جـ ٨٦ , جـ ٨٩ , جـ ٩٠ , جـ ٨٠ حيث تم تقسيم محيط الشعرة إلي ثمانية فئات هي ٣٣- ٣٥ , ٣٦ – ٣٨ , ٣٩ – ٤١ , ٤٢- ٤٤ ,٤٥ – ٤٧ , ٤٨ – ٥٠ , ٥١ – ٥٣ , ٥٤- ٥٦ "ميكرون" يقع كل صنف داخل فئة من هذه الفئات الثمانية–على الترتيب– حيث تم تحديد النعومة الذاتية لأصناف القطن المصري تحت الدراسة بمعامل المركز العالمي للنسيج Lubbock بولاية تكساس–الولايات المتحدة الأمريكية– واعتبارها هي الأساس كذلك تم سحب عينات قطن شعرمن ثلاث رتب مختلفة (درجة تغليظ) وهي فولي جود , جود , فولي جود فير,من عينات هيئة التحكيم واختبارات القطن بهدف إيجاد ثلاث مستويات من النضج لكل صنف خلال موسمي٢٠٠٦ ، ٢٠٠٧.
وقد تضمنت الدراسة العلاقة بين الثلاث أبعاد الرئيسية وهي قراءة الميكرونير والنعومة بالوزن ودرجة النضج.

ويمكن تلخيص النتائج

١- أظهرت النتائج علاقة موجبة عالية, في كل الأصناف تحت الدراسة, بين النعومة بالوزن (الكثافة الطولية) ودرجة النضج وكانت هذه

تحكيـم: أ.د عبد المقصود محروس المراكبى
أ.د ضياء أحمـد هاشـم القاضـى

العلاقة في صورة مستقيمة حيث تمثلها المعادلة التالية

Fineness by weight (H) = (0.07318) MP^2
$R^2 = 0.779^{**}$

٢- أظهرت النتائج إن قراءة الميكرونير والنعومة بالوزن بينهم علاقة قوية مؤكدة لكل صنف على حده حيث كانت المعادلة التى تمثل هذه العلاقة كما يلي :

Fineness by weight (H) = -37.76 + 48.31 (MIC)
$R^2 = 0.693^{**}$

٣- في كل صنف من الأصناف تحت الدراسة فأن قراءة الميكرونير ارتبطت ارتباطا موجبا عاليا مع درجة النضج تنظمها المعادلة التالية

Maturity (M) = 0.4783+0.1392 (MIC)
$R^2 = 0.756^{**}$

٤- بإستعمال صفة محيط الشعرة (بمعلومية الصنف) وكذلك قراءة الميكرونير للعينة يمكن استنتاج درجة النضج والنعومة بالوزن من خلال المعادلتين التاليتين

Maturity (M) = 0.3238 + 0.5273 (MIC) – 0.0292 (P)
$R^2 = 0.679^{**}$

Fiber fineness (H) = -7.177+3.34 (MIC)+3.255 (P)
$R^2 = 0.969^{**}$

٥- يستطيع الآن المربى والغزال وأصحاب مصانع الغزل والصباغة التنبؤ وبطريقة غير مباشرة وسريعة بل وعالية الدقة وبإستخدام فقط جهاز الميكرونير ومعلومية محيط شعرات الصنف معرفة النعومة بالوزن للعينة وكذلك النضج في الحال مما يعتبرفائدة عظيمة لعمليات الغزل والصباغة.