Develop and compare new software based on Ramey and Lord Equations to calculate fineness and maturity parameters using HVI instrument

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Abstract

The present study was conducted to explore the possibility of utilizing the data of the HVI to estimate fiber fineness and maturity parameters of Egyptian cotton, corresponding to those same parameters provided by both of micromat instrument and Image Analyzer. 15 Egyptian genotypes produced by cotton research institute. As well as two upland cotton samples from Sudan were used in theses study during 2012 season. The sample tested using the HVI, Micromat and the Image Analyzer instruments.

.Data of degree of thickening, area of secondary cell wall and perimeter showed no significant difference, excellent correlation and determining factor between both of the Image analysis data and the data extracted from the equation used for HVI software. Thus, it could easy to add new characters to the HVI output data and simulate both of the micromat and Image analyzer instruments successfully. This saves time, efforts, labors and energy.

Introduction

The fineness of cotton is important because yarn made from fine fiber is generally stronger and more uniform than yarn from coarse fibers. Fiber maturity is important because mature fibers, those with well developed cell walls, absorb dye better and are less prone to cause defects of various sorts in the finished product. Fineness and maturity can be measured in accurate way using microscope or image analyzer (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, but it is time consuming .Thus, there is a need for an accurate and rapid method for measuring cotton fiber fineness and maturity characters. Scientists develop a lot of instruments for measuring fineness and maturity parameters the most famous instrument is micronaire instrument (Ramy1982, Lord and Heap 1988 ,Heap (2000) micronaire measure fineness and maturity in one reading called micronaire reading .Montalvo (2005) found that micronaire is an indicator of air permeability it's regarded as an indication of both fineness and maturity (degree of cell wall development). ,but in fact Micronaire measurements are considerate to be a combination of fiber fineness and maturity (Thibodeaux et al., 2000) . Normal micronaire reading don't tell us whether the fiber is coarse

and immature or fine and mature. For given type of cotton fineness is genetic so, its variation is limited. A relatively low micronaire has been used as a predictor of a low maturity. Low micronaire may also indicate fine fiber with adequate maturity. So, there was a need to develop new instrument for measuring fineness and maturity separately. The micronaire tester (Shirley development L =D., stock port, England) is being used to measure fineness and maturity (Buco et al., 1998, Montalvo et al.,2001). The micromat is a current model of a series of instruments manufactured by the company to measure fineness and maturity and generally is referred to as the fineness and maturity tester (FMT). This instrument is a double compression airflow device that measures the pressure drop of air drown through a fixed mass that that is compressed , during the test to two different densities .the initial and second stage pressure drops are referred to as PL,PH, respectively and are converted to fineness and maturity and perimeter by appropriate empirical equations (SDL089 manal,1994,Momtalvo and Grimball,1994)The FMT equations were calibrate against the British Standard Methods and image analysis (Von Hoven et al., 2001 Montalvo, and Von Hoven 2003).

.with fineness, Ramey and Lord's equations it could be successfully estimate all the image analyzer measurements which need time and effort. (Hequet and Wyatt 2001, Hequet et al., 2006 Arafa et al., 2009) and it could be utilize easily using HVI instrument when it converted to simple software.

Materials and methods

To estimate fiber maturity, gravimetric and intrinsic fineness measurements, using HVI instrument 15 Egyptian genotypes named., (Giza 88, Giza 92, Giza 93, [G.84 (G.70xG.51b)] defined as C1, Giza 45, Giza 87, Giza 80, Giza 90, 90xAus. - defined as C2, G.83x58x G.80 defined asC3, 10229xG86 defined asC4, Giza 86, green cotton, dark brown and light brown cotton)produced by cotton research institute. As well as two upland cotton samples from Sudan were used in theses study during 2012 season. Under most the genotypes we used two maturity ratio levels. These materials used to cover different levels of fiber of micronaire and diameter values (different genotypes) to be tested for micronaire and maturity by HVI instrument. The same specimens were tested on Micromat to get the micronaire value (mic), maturity ratio (MR), fineness in millitex (Fin), Ph and PL. The cross sections and the Images for the same samples were processed at the Textile Consolidation Fund, Alexandria, Egypt. While, The Image Analyzer located in the fiber structural and microscopic lab, cotton research institute, Giza, was used to analyze the images to calculate fiber perimeter with [µ], area of secondary cell wall (ASCW) with [µ] ² and degree of thickness (θ), Table 1.
Sampling and testing were done according to ASTM 1986) and ITMF User Guide, 2001. The results of HVI micronaire and maturity were averaged and used to calculate the PL and Ph values from Lord’s FMT models.

Statistical analysis:
Simple correlation coefficient, regression equation and T-test were performed using SPSS 11.0 software. T-test was performed to test the “equal means” of cotton fiber fineness and maturity parameters obtained from Micromat and

Image analyzer instruments vs. HVI instrument. The null hypothesis was that the mean values of a certain fiber parameter from two treatments were equal. All tests were conducted under the significant level of 95% according to Little, and Hills (1978).

Results and discussion

It's familiar that Micromat instrument software based on the Lord's formula to calculate micronaire, fineness and maturity readings as follows:

Mic= (850/PL+40) +0.6
MR=0.247*PL$^{0.125}$ (PL/Ph) ^{2}
Fin= (60000/ PL)*(Ph / PL) $^{1.75}$

During the pervious study(Arafa and Arafa 2012) used the micronaire readings and maturity ratio measured by HVI instrument to calculate back the PL and Ph values which used principally to calibrate the Micromat instrument as follows:

PL =(1)/(mic-0.6)*(850/1)-(40)
Ph=SQRT (0.247*PL$^{0.125}$/MR)

Thus it could be easy to calculate fineness when the third formula is applied .The pervious study proceeded by (Arafa and Arafa 2012)indicated the congruency of the micromat fineness and calculated fineness using HVI Instrument . This because when we reversed the equations we have calculated character from accurate character (mic, MR).Thus, we add new accurate character (Fin) not predictable. This described the congruency between the fineness readings according to the pervious study.

Maturity ratio (MR %) fineness (H) were calculated from the following equation

..Maturity ratio (MR %) = $\frac{\theta}{0.577}$ according to (Peirce. and Lord 1939)

$\therefore \theta$ = Maturity ratio x 0.577

It could be calculated directly using HVI data

..Fineness (fin) = ASCW X ŋ according to (Ramy1982)

Where as ŋ= cell wall density=1.52

$\therefore$ASCW = Fin/ ŋ

However; standard fineness (H_s) was calculated from (Lord 1956) equation as follows:

Standard fineness (Hs) = Fin/MR

..P =3.7853 $\sqrt{}$ Hs according to (Hequet and wyatt 2001)

Where as p= perimeter

with P= 2r π, and 2r=Diameter (D) .Where r= diameter

So, π X D= 3.7853 $\sqrt{}$ **Hs**

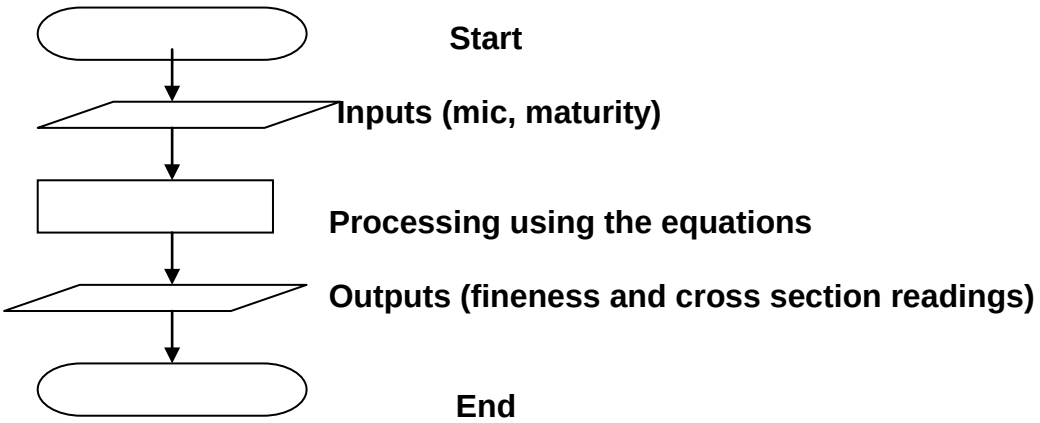
∴D=3.7853 $\sqrt{}$ **Hs / π** or **D=P/π**

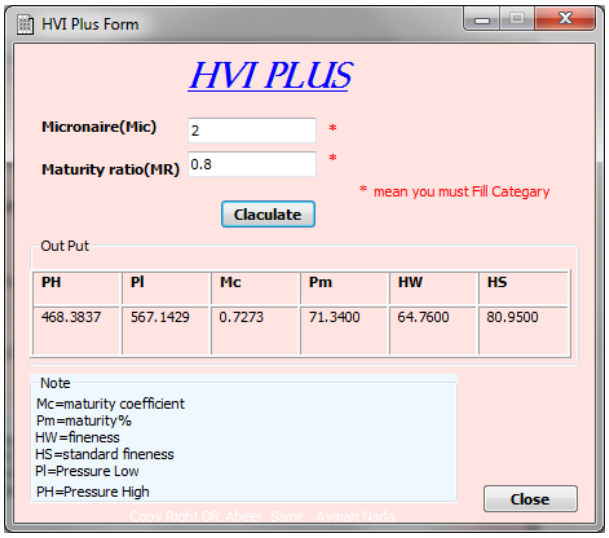
Where as, π=3.14

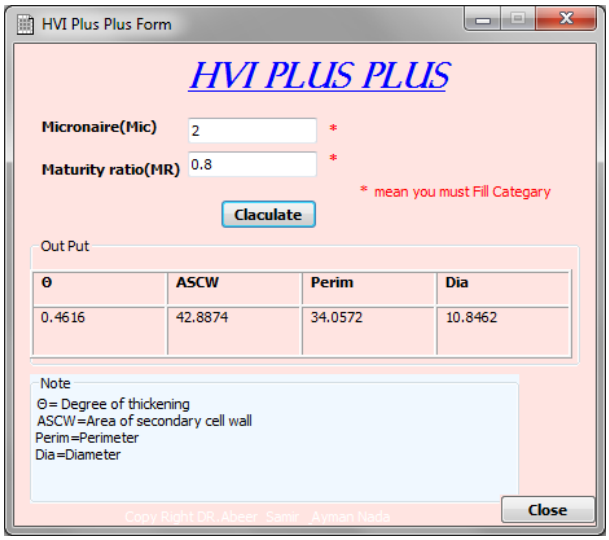
∴ Diameter (D) =1.2055 $\sqrt{}$ **Hs** **or =** $\frac{perimeter}{3.14}$ (Arafa et al., 2009).

Data were analyzed and summarized in Table 2. which indicated that no significant difference was observed between the means of theta obtained from Image analyzer and their corresponding values calculated by HVI Also, all the calculated data by HVI are either equal or less than theses measured by HVI by 0.01-0.03 units This results explained the very high correlation r = 0.98, and the excellent determining factor R^2=0.96 mentioned in Fig.3, Table 2, indicated that the area of secondary cell wall readings of Image analyzer instrument were slightly higher than that of HVI instrument. Nevertheless, the correlation and the determining factor between them are high, r = 0.99 and R^2 = 0.99 as shown in Fig.4. Also the difference between the two means is within the acceptable range. Data of perimeter showed no significant difference and good correlation r = 0.96, R^2 = 0.93 as revealed in Fig.5 between both of the Image analysis data and the data extracted from the equation used for HVI software fig. 1 and 2. therefore, it could be successfully simulate both of the micromat and Image analyzer instruments and save the time , efforts, labors and energy by adding this new characters to the HVI output data .

Fig. 1, the software flowchart







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References

1. Arafa A.S. and Arafa. 2012. H.M Calibrating the micromat instrument using the HVI output data. The 11th Meeting of the Inter-Regional Cooperative Research Network on Cotton for the Mediterranean and Middle East Regions Antalya, Turkey.

2. Arafa A.S.; A.E. Ibrahim and Mostafa M.K. (2009). 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 J. Adv. Agric. Res. ,14:(2) (Fac. Agric. Saba Bashs. Alex.

3. American, Society for Testing and Materials; ASTM (1982).

4. Buco, S.M., J.G. Montalvo, Jr., and S.E. Faught. 1998. Analysis of cotton maturity and fineness by multiple NIR HVIs. Part I. Data analysis. p. 1623-1625. In Proc. Beltwide Cotton Conf., San Diego, CA. 5-9 Jan. 1998. Natl. Cotton Counc. Am., Memphis, TN.

5. Heap, S.A.(2000) the meaning of micronaire p. 97-113. In proc. Int cotton conf. Bremen, Germany.

6. Hequet, E. and Wyatt B. (2001). Relationship among image analysis on cotton fiber cross sections, AFIS measurements and yarn quality. Proceedings of the Beltwide Cotton Conference vol. 2:1294-1298.

7. Hequet, E. F.; Wyatt B.; Abidi N. and Thibodeaux D.P. (2006). Creation of a set of reference material for cotton fiber maturity measurements. Text. Res. J. 76:576-586.

8. ITMF Standard Procedures for HVI Calibration and Operation for Testing Cotton (2001). http://www.itmf.org.

9. Little, T.M. and Hills F.J. (1978). Agricultural Experimentation Design and Analysis. John Wiley and Sons. New York.

10. Lord.E.(1956).J.text.inst.,4747.T 16.

11. Lord, E., and S.A. Heap. 1988. The origin and assessment of cotton fibre maturity. Int. Institute for Cotton, Technical Research Division, Manchester, England.

12. Montalvo Jr.(2005) relation ship between micronaire fineness and maturity past I. fundamentals. The journal of cotton science.

13. Montalvo, J.G., Jr., and R. Grimball, 1994. SRRC maturityand fineness equations, version 1.0 software.

14. Montalvo, J. G., Jr., and Von Hoven, T. M., (2003).Improved FMT Precision with New Sample Insertion Technique, in Proceedings of the Beltwide Cotton Conference, 2003, National Cotton Council of America, Memphis, USA, pp. 1961–1966.

15. Montalvo, J.G., T.M. Von Hoven, S. S. Reed, D.L. Francois, and S. Faught. (2001). Organizational and instructional manual for the Micromat Tester. USDA, ARS, Southern Regional Research Center, New Orleans, LA.

16. Peirce, F.T. and Lord E. (1939). The fineness and maturity of cotton. J. Text. Inst. 30:T173-T210.

17. Ramey, H.H., Jr. 1982. The meaning and assessment of cotton fibre fineness. Int. Institute for Cotton, Technical Research Division, Manchester, England.

18. SDL 089 Micromat Tester Instruction Manual. 1994. Shirley Developments Limited, Stockport, England.

19. Thibodeaux D.,Rajasekaran K.montalvo J., von hovent. (2000) the status of cotton maturity measurements in new millennium. Proceeding International cotton conference Bremen: 115-128.

20. Von Hoven, T. M., Montalvo, J. G., Jr., Reed, S., Francois, D.,Buco, S., and Faught, S., (2001) Calibration of Upgraded FMTs, in Proceedings of

the Beltwide Cotton Conference, 2001,National Cotton Council of America, Memphis, USA, pp.1307–1309.

21. Xu, B. and Y. Huang 2004. Image Analysis for Cotton Fibers Part II: Cross-Sectional Measurements. Textile Research Journal 2004: 74: 409-416.

Table 1, mean reading of Fiber fineness and maturity parameters measured by Micromat and Image analyzer measurements

Sample	Micromat measurement			Image analyzer measurement		
	mic	MR	Fineness	θ	ASCW[μ]²	P [μ]
G88 low maturity	2.8	0.79	111.62	0.47	73.01	49.01
G 88 normal	3.7	0.95	137.59	0.58	98.56	49.45
G92 low maturity	2.8	0.87	105.90	0.53	73.00	47.30
G 92 normal	4.0	0.99	148.89	0.60	109.62	49.32
G 93 low maturity	2.2	0.75	93.00	0.45	58.28	43.00
G 93 normal	3.2	0.95	114.22	0.57	83.86	44.55
c 1 normal	4.2	0.98	160.57	0.57	116.21	51.05
c1 low maturity	3.3	0.90	127.74	0.53	88.14	49.11
G 45	3.2	0.92	120.26	0.53	85.27	43.12
G 87	3.0	0.99	103.25	0.58	79.70	42.00
G 80 low	3.2	0.74	146.63	0.44	83.86	56.00
G 80 normal	4.4	0.95	173.72	0.56	121.30	57.00
G 90 low	3.2	0.87	127.17	0.49	85.27	54.00
G 90 normal	3.8	0.94	144.02	0.54	101.66	55.05
c 2	5.0	0.92	217.72	0.54	144.65	56.94
c3	4.4	0.95	176.46	0.55	123.02	56.02
G 86 low maturity	3.9	0.93	153.26	0.55	106.39	52.00
G 86	4.5	1.02	169.50	0.59	126.49	52.70
c4	3.9	0.92	152.32	0.54	104.80	52.41
green	2.8	0.86	107.13	0.50	73.01	49.50
Dark brown	3.7	0.99	134.38	0.58	100.10	49.19
light brown	3.0	0.80	127.78	0.47	79.69	48.00
upland Sudan fine	3.0	0.80	127.78	0.47	79.70	55.03
upland Sudan coarse	4.9	0.84	231.74	0.48	140.92	67.20

P =perimeter, express the inherent fineness
(ASCW) =area of secondary cell wall and (Theta-θ) =degree of thickening

Table 2, comparison between fineness and maturity readings obtained from image analyzer instrument and their corresponding reading calculated using HVI instrument .

Sample	θ (Image)	θ (HVI)	ASCW[μ]² (Image)	ASCW[μ]² (HVI)	P [μ] (Image)	P [μ] (HVI)
G88 low maturity	0.47	0.46	73.01	71.21	49.01	45.91
G 88 normal	0.58	0.55	98.56	96.36	49.45	46.40
G92 low maturity	0.53	0.50	73.00	71.50	47.30	45.00
G 92 normal	0.60	0.57	109.62	106.62	49.32	46.19
G 93 low maturity	0.45	0.43	58.28	56.28	43.00	40.54
G 93 normal	0.57	0.55	83.86	81.36	44.55	42.45
c1 normal	0.57	0.57	116.21	114.51	51.05	49.97
c1 low maturity	0.53	0.52	88.14	86.44	49.11	46.78
G 45	0.53	0.53	85.27	83.25	43.12	41.51
G 87	0.58	0.57	79.70	87.50	42.00	39.86
G 80 low	0.44	0.43	83.86	81.36	56.00	53.86
G 80 normal	0.56	0.55	121.30	119.37	57.00	55.89
G 90 low	0.49	0.50	85.27	83.77	54.00	52.67
G 90 normal	0.54	0.54	101.66	99.66	55.05	52.43
c2	0.54	0.53	142.65	138.95	56.94	54.85
c3	0.55	0.55	123.02	121.42	56.02	53.28
G 86 low maturity	0.55	0.54	106.39	99.79	52.00	49.86
G 86	0.59	0.59	126.49	124.41	52.70	50.29
c4	0.54	0.53	104.80	98.10	52.41	49.72
green	0.50	0.50	73.01	71.01	49.50	46.18
Dark brown	0.58	0.57	100.10	98.19	49.19	47.88
light brown	0.47	0.46	79.69	77.88	48.00	45.79
upland Sudan fine	0.47	0.46	79.70	77.78	55.03	54.79
upland Sudan coarse	0.48	0.48	140.92	138.62	67.20	65.62

t :not significant t: not significant t: not significant

Fig.3 comparison between degree of thickness readings obtained from image analyzer instrument and their corresponding readings calculated using HVI instrument .

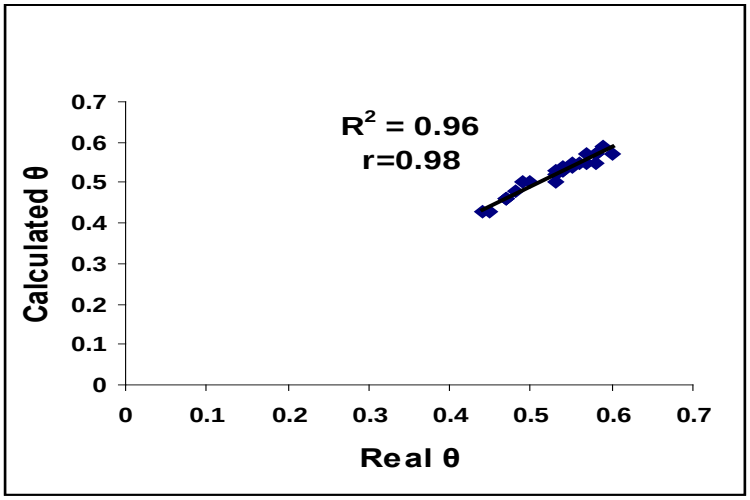

Fig.4 comparison between area of secondary cell wall readings obtained from image analyzer instrument and their corresponding readings calculated using HVI instrument .

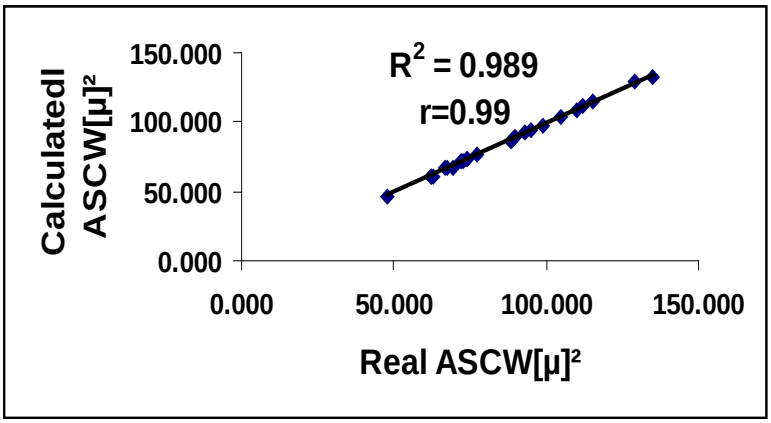

Fig.5 comparison between perimeter readings obtained from image analyzer instrument and their corresponding readings calculated using HVI instrument