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The Relationship Between Non-cellulosic Content with Fiber and Yarn Properties

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Abstract: This investigation was carried out at Cotton Res. Inst., Agric. Res-Center, Giza, Egypt to evaluate the relationship between non-cellulosic content to fiber and yarn properties for some Egyptian cotton cultivars i.e., Giza 45, Giza 70, Giza 86 and 80. Four lint grades i.e., fully good (FG), good (G), fully good fair (FGF) and good fair to fully good fair (GF/FGF) were used. Physical and chemical fiber properties were estimated as well as yarn properties. For determining the relations between the above properties, simple correlation, as well as the regression equations was established. The results showed that there were a highly negative correlation between micronaire value, fibers strength (g/tex), maturity ratio, lea product and single yarn strength (cN/tex) with non-cellulosic content (%). Whereas, the correlation between yellowness degree (+b) and yarn evenness CV % with non-cellulosic were a positive direction. The fiber maturity (%), miconaire reading, fineness (millitex), strength (g/tex), upper half mean (UHM), uniformity index (UI), (Rd %), cellulosic content (%), lea product and single yarn strength (cN/tex) were increased as the lint grade increased to fully good, (FG). While, yellowness degree, (+b) and yarn evenness CV % were decreased by increasing the lint grade.

Key words: Cellulosic and Non-cellulosic content, Fiber, Yarn, Relationship and Prediction Model.

INTRODUCTION

Non-cellulosic content can lead to extreme disturbances during processing. Variation in non-cellulosic content is largely influenced by first the environmental conditions then the genotypes. Also, factors affecting maturity play the main role in increasing or decreasing non-cellulosic constituent. Some of them having some benefits, i.e., wax presents on the surface of the fiber play very important role as they act as lubricants facility slippage of fibers during drafting (Price 2002), but for the same effect reducing slightly yarn strength (Abd Elsalam 1999). However some have no effect, i.e., peptic substance are removed during scoring and their removal haven't affected fiber strength. Gamble (2003) demonstrated that concomitant decreases in non-cellulosic content, i.e., wax sugar s alts with increasing fiber maturity micronaire and fineness. However, the same researcher (2004) added that, increasing the speed of cotton yarns in the textile mills have made it necessary to develop the complementary methods to traditional measurements of physical fiber properties such as length and strength as predictors of yarn spinning efficiency that research attempted to quantify the pectin, wax sugars and other non-cellulosic content and the results are negatively correlated with micronaire and fiber friction. Yarn yellowness (+b) was highly related to metal content. Process carding wastes correlated with increased raw fiber ash residues, potassium content, and the fiber-to-fiber friction measurement. Also, yarn break factors and single yarn strengths were found to increase and evenness thick and thin places were found to decrease, as levels of ethyl alcohol extractions, the metals potassium and magnesium, and rotor ring friction increased. Yarn strength decreased and thick and thin places increased in ring spinning as levels of the metal calcium increased. Ring yarn neps increased and rotor yarn neps decreased as alcohol extractions, wax levels, potassium and magnesium content, and fiber to metal friction increased, (Brushwood 2004 a & b). In addition, Brushwood (2005) found that increases in yarn strength correlate with increasing levels of total fiber alcohol surface extractable, wax, and potassium content. Processing ends down increases in ring and open-end spinning and decreases in vortex spinning as fiber alcohol surface extractable wax, and light metal content increase.

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Ends down decreasing in ring and open-end spinning and increase in vortex spinning as the HVI trash measurement increases. Uster yarn evenness, neps, thick and thin places decrease in ring and open-end and increased in vortex yarns as alcohol surface extractable increase. Fiber yellowness and grayness increase as concentrations of the metals potassium, magnesium, and iron increase. Brushwood (2003) reported that increases in HVI and stelometer fiber strength and rotor ring fiber-to-fiber friction and decreases in Sutter Webb short fiber content are highly related to increases in alcohol extractable materials, fiber ash residues, and total light metal contents. Conversely, increases in the metal calcium correlate with decreases in both fiber strength and fiber-to-fiber friction and increases in short fiber content. Increases in (Rd %) and (+b) color measurements correlate positively with increasing levels of the metals potassium and magnesium.

MATERIALS AND METHODS

This study was carried out at Cotton Research Institute, Agricultural Research Center, Giza, Egypt, using four commercial cultivars season 2010 representing two categories of Egyptian cotton, namely: extra long staple (over 35 mm) i.e., Giza 45 and Giza 70 and long staple (from 32 to ‹ 35 mm) i.e., Giza 80 and Giza 86 each cultivar including four lint grades as follows: fully good (FG), good (G), fully good fair (FGF) and good fair to fully good fair (GF/FGF). The regression analysis method was selected for establishing the relationships between non-cellulosic content and both of fiber and yarn properties. At the beginning, the types of relationship between non-cellulosic content [independent variables, (X)] fiber and yarn properties [dependent variables, (Y)] were checked individually by using curve estimation and correlation analysis. Hence, the linear regression analysis method was chosen for this study. Statistical analyses were performed using SPSS 9.0 software.

Studied Characteristics:

A. ***Fiber Physical Properties:***

1. Upper Half Mean (UHM) mm
2. Micronaire value
3. Fiber bundle strength (g/tex)
4. Fiber maturity ratio
5. Fiber yellowness degree (+ b)

Micronaire value, fiber fineness (millitex) and fiber maturity ratio was determined using Micromate instrument according to (ASTM: D-3818-1986). While, Spain Lab 900B HVI instrument system was used to determine fiber upper half mean (UHM), uniformity index (UI), reflectance percentage (Rd %), yellowness degree (+b), strength and fiber elongation (%) according to (ASTM: D-4605- 1986).

The determined fiber physical properties of cotton cultivars and lint grades were shown in Table (1).

B. ***Fiber Chemical Properties:***

1. ***Fiber Cellulosic Materials Content:***

Cellulosic materials % in cotton fiber was determined according to the methods described by Jenkis (1930).

2. ***Fiber Reducing Sugar Content:***

Reducing sugar content in cotton fiber was determined by using soxhlet extraction according to the methods of Smith (1956).

3. ***Total Wax Content of Fiber:***

Total wax content was determined according to the methods described by Conrad (1944).

4. ***Non-cellulosic Content %:***

Non-cellulosic content in cotton fiber was determined according to the methods described by Hebeish *et al*. (1971) and Al-Ashwat (1974).

The fiber chemical properties of cultivars and lint grades were determined and shown in Table (2).

C. ***Yarn Properties:***

Ring spun carded yarn of 60s and 3.6 twist factor were produced by the standard 60 grams micro-spinning technique used in Spinning Research Department, Agricultural Research Center, Giza, Egypt, and yarn properties were measured as follows:

1. Lea product
2. Single yarn strength (cN/tex)
3. Yarn evenness (C V %)
4. Single yarn elongation (%)

Yarn strength expressed in terms of lea count strength product was measured by using the good-brand lea tester according to (ASTM: D-1578- 1967). The single yarn strength and breaking extension were determined on zwick 1511 automatic tensile tester according to (ASTM: D-2256 - 1984) and yarn evenness (C.V %) was measured on the uster tester III according to (ASTM: D-1425- 1984).

Table 1: Mean values of the fiber physical properties for cotton cultivars and lint grades, used in the prediction models.

Treatments	Maturity ratio	Miconaire reading	Fineness (millitex)	Strength (g/tex)	Elongation (%)	UHM (mm)	UI (%)	Rd (%)	+b
					Giza 45				
FG	1.01	3.40	130.00	45.70	6.90	36.10	88.10	72.90	8.20
G	0.96	3.20	125.00	45.50	6.90	35.70	87.90	73.40	8.90
FGF	0.92	2.90	122.00	44.70	6.70	35.70	87.80	74.80	8.90
GF/FGF	0.91	2.70	118.00	44.30	6.40	35.10	85.20	75.20	8.90
Mean	0.95	3.05	123.75	45.05	6.73	35.65	87.25	74.08	8.73
				Giza 70					
FG	0.99	4.20	144.70	41.30	6.90	36.20	88.70	71.50	9.30
G	0.96	4.10	144.00	41.00	6.90	36.00	88.30	70.20	9.70
FGF	0.93	3.90	137.00	40.30	6.40	36.10	87.00	67.10	10.00
GF/FGF	0.89	3.70	132.00	39.20	6.40	35.50	86.00	67.00	10.70
Mean	0.94	3.98	139.43	40.45	6.65	35.95	87.50	68.95	9.93
				Giza 89					
FG	1.01	4.30	159.00	41.50	7.30	33.00	88.20	72.50	8.10
G	0.98	4.30	158.00	41.00	7.10	32.50	87.30	72.10	8.32
FGF	0.95	4.10	151.00	39.30	6.90	31.70	87.10	70.00	8.50
GF/FGF	0.93	3.90	139.00	37.78	6.70	31.70	87.00	69.50	8.89
Mean	0.97	4.15	151.75	39.90	7.00	32.23	87.40	71.03	8.45
				Giza 80					
FG	0.97	4.40	167.00	38.30	7.70	31.50	87.00	66.00	11.70
G	0.96	4.40	163.00	37.50	7.40	30.50	86.30	62.10	12.74
FGF	0.92	4.20	154.00	35.70	6.70	30.00	85.00	60.90	13.01
GF/FGF	0.87	3.90	144.00	35.80	6.50	29.70	85.00	60.00	13.53
Mean	0.93	4.23	157.00	36.83	7.08	30.43	85.83	62.25	12.75

FG= Fully Good, G= Good, FGF= Fully Good Fair and GF= Good Fair

Table 2: Percentage of cellulosic, wax, sugar, others and non-cellulosic content for cotton cultivars and lint grades, used in the prediction models.

Treatments	Cellulosic content (%)	Wax (%)	Sugar (%)	Others (%)	Non cellulosic content (%)
			Giza 45		
FG	95.17	0.35	0.11	4.37	4.83
G	94.41	0.29	0.12	5.18	5.59
FGF	92.20	1.13	0.14	6.53	7.80
GF/FGF	91.70	1.14	0.16	7.00	8.30
Mean	93.37	0.73	0.13	5.77	6.63
			Giza 70		
FG	94.77	0.53	0.11	4.59	5.23
G	93.53	0.66	0.13	5.68	6.47
FGF	92.21	0.88	0.16	6.75	7.79
GF/FGF	91.03	0.98	0.17	7.82	8.97
Mean	92.89	0.76	0.14	6.21	7.12
			Giza 89		
FG	94.20	0.64	0.12	5.04	5.80
G	93.09	0.73	0.15	6.03	6.91
FGF	91.49	0.80	0.18	7.53	8.51
GF/FGF	90.00	0.83	0.19	8.98	10.00
Mean	92.20	0.75	0.16	6.90	7.81
			Giza 80		
FG	92.88	1.10	0.10	5.92	7.12
G	92.08	1.20	0.14	6.58	7.92
FGF	90.01	1.40	0.14	8.45	9.99
GF/FGF	89.81	1.60	0.18	8.41	10.19
Mean	91.20	1.33	0.14	7.34	8.81

Table 3: Mean values of lea product, single yarn strength, yarn elongation % and yarn CV % for cotton cultivars and lint grades used in prediction model

Treatments	Lea product	Single yarn strength (cN/tex)	Yarn elongation (%)	Yarn evenness CV (%)
		Giza 45		
FG	3865.00	25.25	5.30	14.31
G	3805.00	25.22	5.30	14.35
FGF	3725.00	25.00	5.30	15.72
GF/FGF	3655.00	24.70	5.00	15.81
Mean	3762.50	25.04	5.23	15.05
		Giza 70		
FG	2845.00	18.80	4.20	17.10
G	2705.50	18.50	4.20	17.80
FGF	2655.50	17.30	4.10	18.10
GF/FGF	2550.00	16.20	4.10	18.84
Mean	2689.00	17.70	4.15	17.96
		Giza 89		
FG	2460.70	16.53	5.30	19.70
G	2425.70	16.12	5.10	20.12
FGF	2215.70	14.10	5.10	20.90
GF/FGF	2015.50	14.10	5.10	21.22
Mean	2279.40	15.21	5.15	20.49
		Giza 80		
FG	1955.00	16.25	5.50	19.30
G	1925.50	16.03	5.50	20.10
FGF	1855.00	15.72	5.20	20.40
GF/FGF	1800.50	15.21	5.10	21.60
Mean	1884.00	15.80	5.33	20.35

All tests were performed at the laboratories of Cotton Research institute, Agricultural Research Center, under standard conditions of temperature 20 + 1 0c and 65% + 2% of relative humidity. The yarn properties of cotton cultivars and lint grades were determined and shown in Table (3).

RESULTS AND DISCUSSION

The results and discussion could be divided into three main categories as follows:

1. Cultivar and lint grade interaction effect on cellulosic and non-cellulosic content of cotton fibers.
2. The relationship and prediction model of the most important fiber properties using non-cellulosic materials.
3. The relationship and prediction model of the most important yarn properties using non-cellulosic materials.

1. *Cultivar and Lint Grade Interaction Effect for Cellulosic and Non-cellulosic Content of Cotton Fiber:*

Mean values of cellulosic and non- cellulosic content are shown in Table 2. Data cleared that the cellulosic content was decreased as the lint grade decreased. On the other side, the non-cellulosic materials were increased when lint grade decreased.

The highest mean value of cellulosic content (95.17 %) was detected from the highest lint grade, fully good (FG) for Giza 45 cotton variety. Meanwhile, the lowest mean value for the same character (89.81 %) was recorded from the lowest lint grade, good fair to fully good fair (GF/FGF) for Giza 80.

Concerning, the highest mean value of non-cellulosic content (10.19 %) was reached from the lowest lint grade, good fair to fully good fair for Giza 80. While, the lowest mean value for the same trait (4.83 %) were attained from the highest lint grade, fully good (FG) for Giza 45 variety.

Generally, it could be concluded that, cellulosic material content was increased and non- cellulosic materials (%) was decreased by increasing lint grade.

These results could be explained on the bases that, when the lint grade increase, the degree of maturity was also increased, which lead to increased deposition of cellulose within the secondary wall and thus increasing the percentage of cellulosic materials and vise versa for non-cellulosic content.

2. *The Relationship and Prediction Model of the Most Important Fiber Properties Using Non-cellulosic Materials:*

2.1. Upper Half Mean Length (mm):

Indicated to the results of R2 and regression equations of non-cellulosic content in cotton fibers affecting and contributing to fiber upper half mean. Analysis results of Fig. 1 could be concluded as follows.

A negative relationship between non-cellulosic and fiber upper half mean. Pretty good correlation -r = 0.73 while, R2 = 0.54 was weak so, could not predict of fiber upper half mean length using non-cellulosic content.

2.2. *Micronaire Reading:*

Data in Fig.2 get across the results of R2 and regression equations for micronaire reading affecting and contributing to fiber non-cellulosic content. It was apparent that -r = 0.95, R2 ? 0.91, the prediction equation was Y = -0.0757x + 4.5778, that mean the relationship between non-cellulosic content and micronaire reading was very strong. In spite of, it had a negative direction. This could be attributed the fact that micronaire values incorporates both intrinsic fineness and maturity. Finesse is a varietal character, so its effect is limited, thus the maturity ratio playing the main role in this relationship.

2.3. *Fiber Bundle Strength (G/tex):*

Data of this analysis in Fig. 3 could be explained as follows: -r = 0.94, while, R2 = 0.90 indicated that fiber strength at 1/8 inch was effective variable contributing to yarn strength. The negative meaning referred to that as non-cellulosic content increased in the fiber, the fiber strength decreased. Because of the highest non-cellulosic materials found in the large lumen at less matured fiber as mentioned above accompanied with less cellulose deposition layers in the secondary cell wall which representing the body of the fiber so the fiber becomes weak and easy to rupture.

2.4. *Maturity Ratio:*

It obvious from Fig. 4 that there were negative relationship and excellent correlation between non-cellulosic content and maturity ratio, -r = 0.96. Also, the highly R2= 0.92 representing good predictor to micronaire value using non-cellulosic content. The prediction model was Y = -0.019x + 1.0904. This may be due to that this may be a result of increase in primary wall thickness and lumen size of immature fibers which contain non-cellulosic materials and vise versa.

2.5. *Yellowness Degree (+b):*

Concerning Fig. 5, could be noticed that a positive relationship between fiber +b and non-cellulosic content this mean that as fiber +b increased the non-cellulosic content increased the values of r = 0.96 R2? 0.93 and indicating excellent correlation and good prediction model for fiber +b (Y = 0.4755x + 6.1203).

The non-cellulosic materials is usually known with (colored materials)which usually associated with the large volume of lumens, vacuoles and primary cell wall which are large in immature fiber so it contain large amount of non-cellulosic (colored materials).

3. *The Relationship and Prediction Model of the Most Important Yarn Properties Using Non-cellulosic Materials:*

3.1. *Lea Product:*

Looking forward to the Fig. 6, indirect highly correlation -r = 0.92 and good determining factor R2 = 0.84, relationship between non-cellulosic content and lea product could be noticed. It is worthy to mention that when non-cellulosic content increased the yarn lea product decreased. These results may be due to increase non-cellulosic content inner fiber, reduce the yarn strength via lea product, Price (2002) and Abd Elsalam (1999).

3.2. Single Yarn Strength (cN/tex):

Highly correlation coefficient (0.95), highly determining factor R2 =0.91 and indirect relationship between non-cellulosic content and single yarn strength was recorded, Fig. 7. This is mean that when non- cellulosic content increased the single yarn strength decreased, high matured fiber which usually contain low amount of non-cellulosic materials could bear mechanical properties and get high yarn strength, Price (2002) and Abd Elsalam (1999).

3.3. *Yarn Elongation (%):*

Fig. 8 showed low correlation coefficient -r = 0.024, weak determining factor R2= 0.0006 and negative relationship. According to the previous predict yarn elongation values using non-cellulosic content are not adequate.

3.4. *Yarn Evenness Cv %:*

Looking forward to Fig. 9, it could be noticed that there was a moderate correlation r = 0.82, and determining factor R2 = 0.66 between non-cellulosic content and yarn evenness CV %, the model did not fit prediction of yarn evenness CV % using non-cellulosic content. The relationship was positive, when non-cellulosic content increased the yarn evenness CV % was also increased and vise versa. Generally, the yarn evenness CV % profile revealed that when the lint grad decreased, the yarn evenness CV % increased, are shown in Table (3). This result maybe due to the high lint grade contains the high percentage of mature fiber and vise versa.

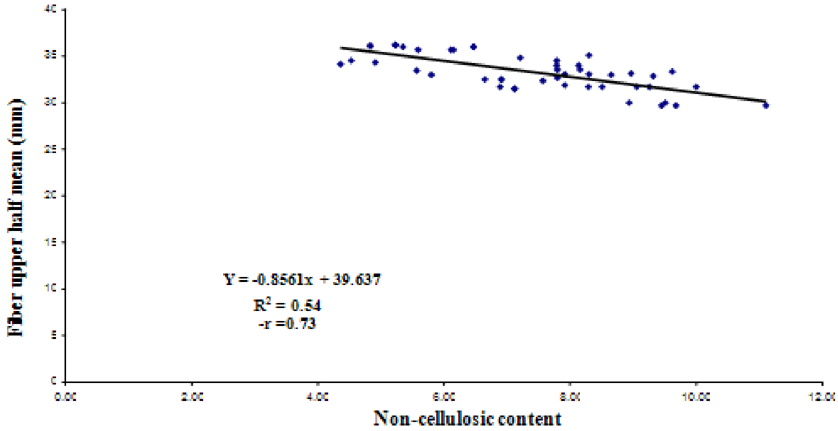

Fig. 1: Relationship between non-cellulosic content and fiber upper half mean (mm).

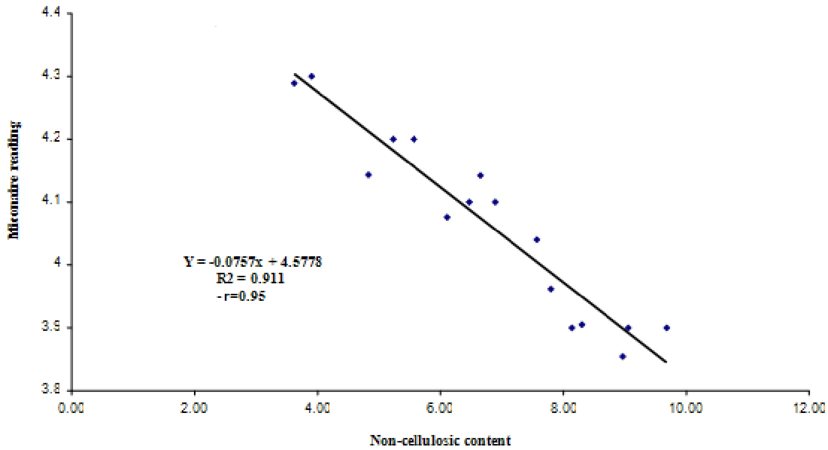

Fig. 2: Relationship between non-cellulosic content and Miconaire reading.

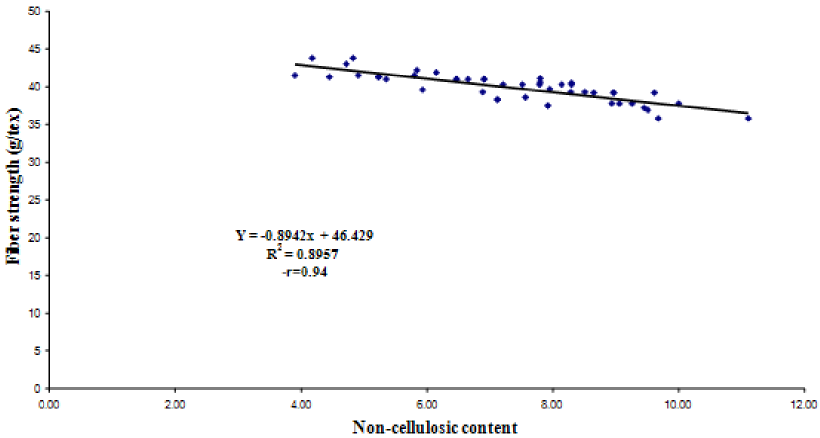

Fig. 3: Relationship between non-cellulosic content and fiber strength (g/tex).

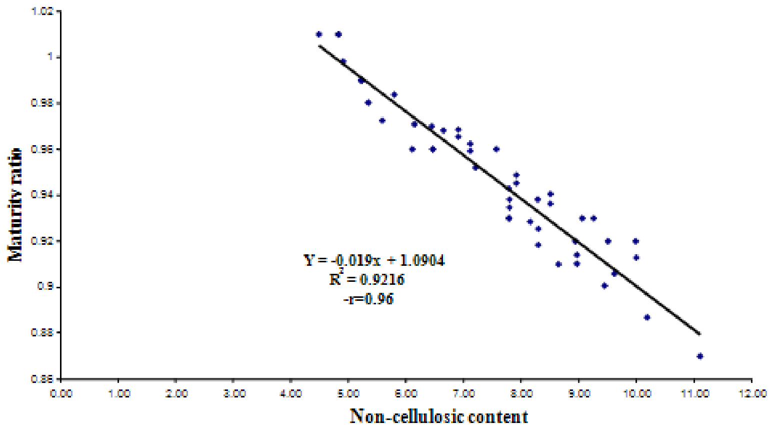

Fig. 4: Relationship between non-cellulosic content and maturity ratio.

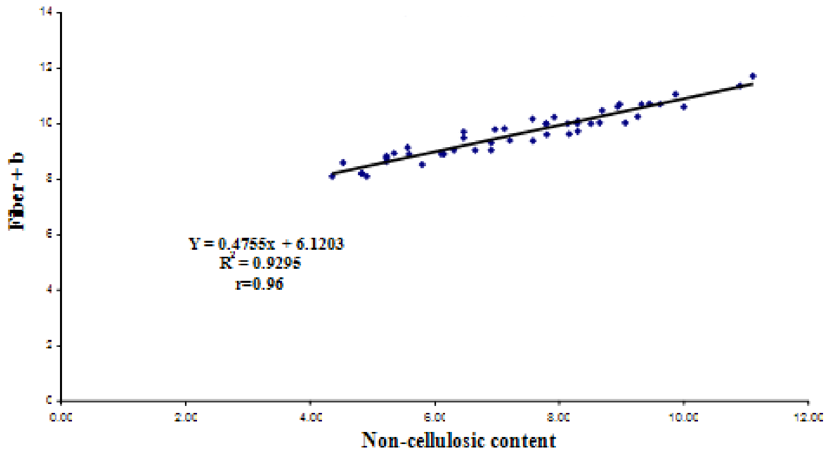

Fig. 5: Relationship between non-cellulosic content and fiber +b.

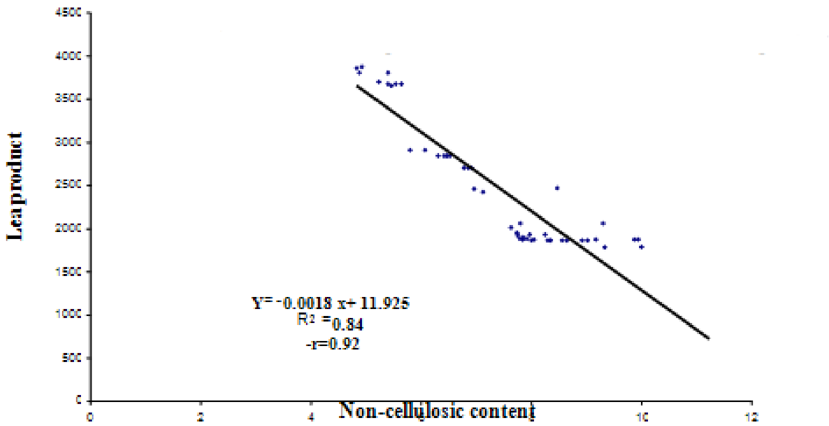

Fig. 6: Relationship between non-cellulosic content and Lea product.

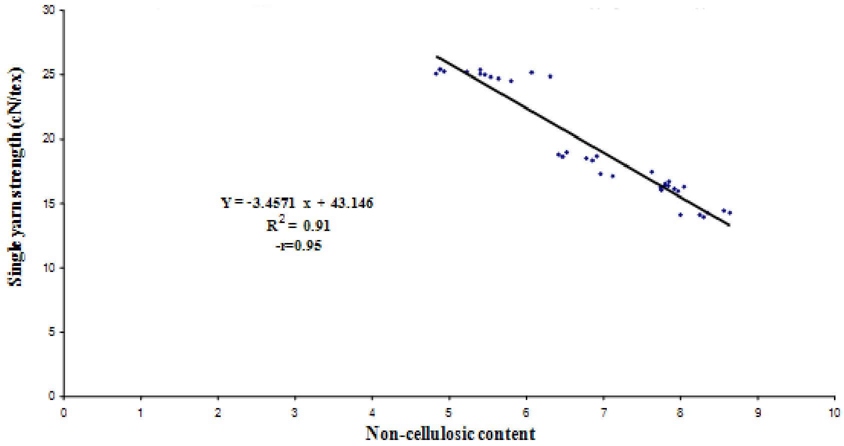

Fig. 7: Relationship between non-cellulosic content and single yarn strength.

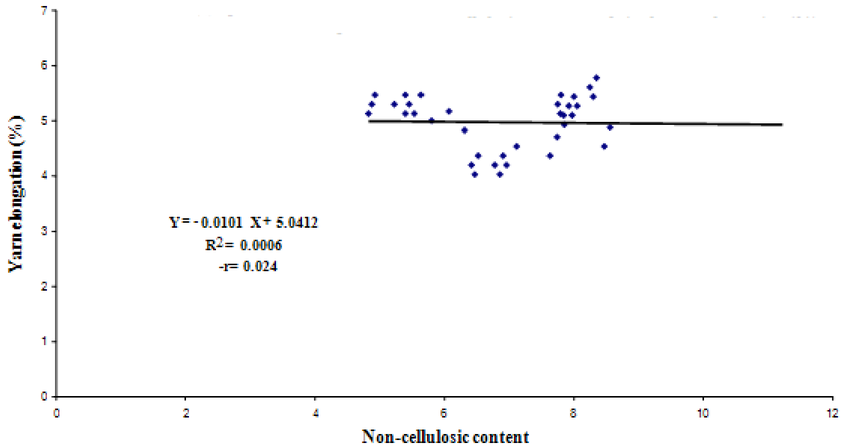

Fig. 8: Relationship between non-cellulosic content and single yarn elongation (%).

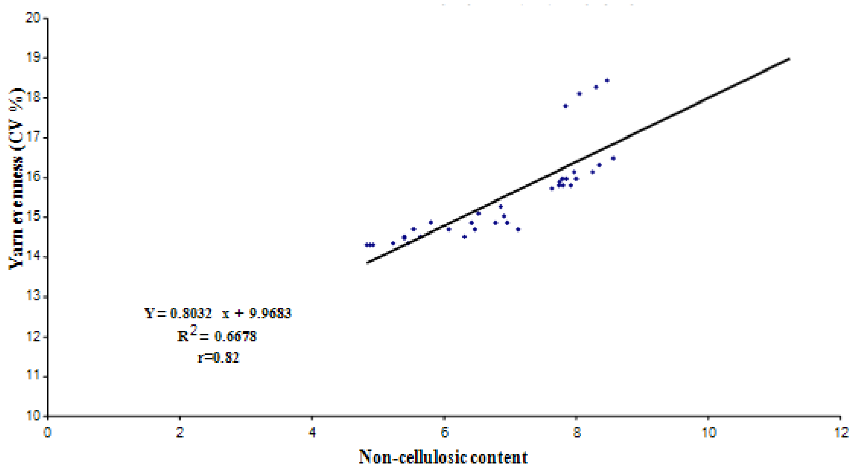

Fig. 9: Relationship between non-cellulosic content and single yarn evenness (CV %).

Conclusion:

A highly negative correlation between micronaire value, fibers strength (g/tex), maturity ratio, lea product and single yarn strength (cN/tex) with non-cellulosic content (%). Whereas, the correlation between yellowness degree (+b) and yarn evenness CV % with non-cellulosic were a positive direction. The fiber maturity (%), miconaire reading, fineness (millitex), strength (g/tex), upper half mean (UHM), uniformity index (UI), (Rd %), cellulosic content (%), lea product and single yarn strength (cN/tex) were increased as the lint grade increased. While, yellowness degree, (+b) and yarn evenness CV % were decreased by increasing the lint grade.

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