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Research Article

Alternate Relationship between Single Fiber Properties and Both of Fiber Microscopic and Physical Properties

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Abstract

Current study was carried out in Cotton Research Institute, Agricultural Research Center, Egypt and Textechno company labs Monchengladbach, Germany during 2013 season. The materials used in this study comprised 16 different genotypes produced by cotton research institute. In addition to, two upland cotton varieties from Sudan. Aiming to study the effect of environmental conditions, genotypes and thier interaction on each characters under study beside studyig the relationship between single fiber prroperties and bundle properties. Giza 93 variety showed the lowest micronaire, fineness and area of cross section. On contrast, it showed the highest upper half mean. Giza 87 variety exhibited the highest bundle strength, the lowest reversals number per mm and the narrowest convolution angle. As for single fiber properties. Giza 45 variety followed by Giza 87 variety exhibited the lowest single fiber linear density readings. Single fiber strength is a little bit lower than bundle strength. Giza 87 variety surpassed the other genotypes on single fiber strength. Upland cotton varieties showed the worst bundle and single fiber properties. As maturity ratio increased bundle and single fiber properties improved and vice versa. According to, the relationship between single fiber prroperties and bundle properties, there was a nearly linear relation¬ship between fiber properties and single fiber properties. After excluding the weak correlated characters 3 linear multiple regression models for single fiber tenacity, single fiber linear density and single fiber elongation were produced. Fineness and degree of thickness were the predictor variables for single fiber strength parameters. However, fiber fineness per mtex and micronaire values were the most important factors for single fiber linear density, both of them proportionate directly with single fiber linear density. While, single fiber elongation contains 7 predictors i.e. Micronaire reading, UI, area of cross section, theta, fiber strength, fiber elongation and UHM characters. Nevertheless, it showed the weakest relation, UI, area of cross section, and fiber Strength proportionate inversely with single fiber elongation. The model is not reliable enough for single fiber elongation prediction.

Keywords: Cotton; Fiber; Single; Fineness; Strength; Elongation

Introduction

Quality is the ultimate goal of the cotton manufacturer because raw material costs are high up to50% of the total manufacturing costs at the spinning mill. These costs decrease or increase depending on the fiber quality of the raw material.

The quality is a set of attributes, some of them are related to the bundle physical and mechanical characters each measured with fast and easy instruments like AFIS , HVI and Fibrotest while, the others are time consuming attributes such as single fiber characters which need some complicated instruments like Image analyzer, Favimat and Robot tester. In fact, the qualities of single or bundle fiber characters is a result of some genetic factors like fiber perimeter or diameter ,cellulose deposition order, the angle of deposition [1] some others are associated with the growing conditions like the amount of cellulose deposited inside the fiber which represents the fiber body.

On the other hand, the single fiber characters are an indicator for the bundle physical and mechanical characters is that the bundle breaking and elongation were shown to increase as the single fiber breaking elongation increased [2] something like a building consisting of bricks, walls, and then the rooms.

From a commercial and industrial point of view, cotton faces great competition with the other natural and synthetic textile fibers. It should be strong enough to compete with other natural and synthetic textile fibers [3].

Hence it is important:

1. Studing how much each characters affected by the environmental conditions, genotypes and the interaction between them.
2. Understanding how some microscopic characters are associated with bundle and single fiber characters like fiber perimeter or diameter which describes the fiber intrinsic or biological fineness that is controlled by genetics. Intrinsic fineness is completely different from the fineness in millitex or linear density as weight of unit length. When we deal with weight, we do weight of cellulose where the maturity and the growing conditions affect. So, if there are two fibers equally in the intrinsic fineness (diameter or the perimeter) the higher in maturity ratio will give higher millitex reading (Figure 1).
3. Studying the effect of wall thickening (Figure 2) and the structural properties like convolution angle which refers to spiral angle (the angle formed between the fiber long axis and the cellulose layer the more acute angle the higher, fiber strength and reversals per unit length (the point which the cellulose layer changed the deposition direction from clock wise direction to anti clock wise direction and vice versa. This forms weak points during the tenacity test (Figure 3) [4].

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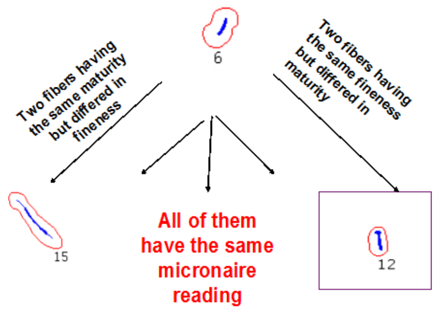

Figure 1: The Relationship between fineness and maturity.

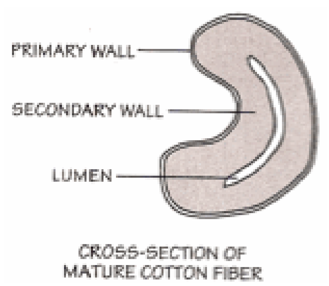

Figure 2: Cross Section of Mature Cotton Fiber.

Figure 3: Fiber Reversals.

4. The relationship between single fiber properties and bundle properties.

The investigation was conducted during 2013 season. The materials used in this study comprised 16 different genotypes (G) named (Giza 88, Giza 92, Giza 93, [G.84 (G.70xG.51b)] defined as C1, Giza 45, Giza 87, Giza 80, Giza 90, G90xAus. - defined as C2, [G.83(G75x5844)] G.80 defined as C3, 10229xG86 defined as C4, Giza 86, green cotton and brown cotton) produced by cotton research institute. In addition to, (upland Sudan fine, upland Sudan coarse). Aiming to study the effect of inherent fiber characters on the single fiber properties. Under all the genotypes we used two maturity ratio levels (L1, L2) within each genotype were used to study the effect of the fiber maturity on the single fiber properties. Beside, study the effect of some structural properties on the behavior of the single fiber during the mechanical tests.

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Studied characters

Microscopic characters

The cross sections and the Images 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 fiber cross section images to calculate fiber perimeter with [μ], fiber area of cross section (ASCW) in $[\mu]^2$ and degree of thickening (θ). Number of reversals per mm, number of Convolutions per mm, and ribbon width in micron were tested using (G208 projection microscope according to ASTM D: 2130-1986). Convolution angle was calculated according to [5], convolution angle=(π/2 X Average ribbon width /C) where, C=Convolutions pitch length divided by the number of convolutions.

Fiber physical characters

The Micromat instrument was used to determine micronaire reading, maturity ratio (MR), hair weight (fiber linear density (millitex)) (ASTM-D;2818-1986). Fiber upper half mean length UHM (mm), length uniformity index UI, short fiber content SFC, fiber strength (g/tex) and fiber elongation (%) were measured by Fibrotest instrument in Textechno company labs Monchengladbach, Germany.

Single fiber characters

Single fiber measurements and force/elongation curves were performed using Favimate + and Favigraph instruments in Textechno company labs Monchengladbach Germany.

Complete randomized design (two ways ANOVA) was used to analyze the data statistically. The treatment means were compared using. L.S.D. test at 0.05% Level. Simple and multiple regression model were performed between fiber properties (X) variables, single fiber properties (Y) according to the procedures outlined by [6].

Results and Discussions

Data presented in Table 1, explained the effect of the genotypes, maturity level and their interaction on fineness and maturity parameters measurements. As to the micronaire reading, Giza 93 showed the lowest micronaire reading (2.65) followed by Giza 87 (2.70) these reading were fitted to their fineness readings (103.61 and 103.25 mtex) ,respectively. Micronaire reading looks similar to fineness in mtex both could not be good indicator for fineness because it expresses both of fineness and maturity. They are referring to the fineness when the comparison is done between the genotypes of the same maturity or they are referring to the maturity degree when the comparison is done between the two maturity level inside the same genotype, the relation between fineness and maturity is not that easy it is complicated. Thus, determining fineness and maturity parameters using image analyzer as a reference method was very important to explain the results under this study. Giza 93 and Giza 87 exhibited the lowest two readings for the area of cross section (71.07 and 79.70$[\mu]^2$) respectively, which explained that the two pervious verities are the finest varieties comparing to the other genotypes. According to maturity ratio and theta values which, determine the amount of cellulose deposition or maturity degree. Giza 93 readings for maturity ratio and theta characters were (0.87 and 0.50), respectively.

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Sample	Micromat measurements			Image analyzer measurements	
	mic	MR	Fineness	θ	ASCW[μ]²
G 88 L1	2.90	0.90	111.62	0.53	73.01
G 88 L2	3.65	1.03	137.59	0.62	98.56
G88mean	3.28	0.97	124.61	0.58	85.79
G 92 L1	3.00	0.85	105.90	0.52	73.00
G 92 L2	4.00	1.05	148.89	0.63	109.62
G92mean	3.50	0.95	127.39	0.58	91.31
G 93 L1	2.15	0.82	93.00	0.45	58.28
G 93 L2	3.15	0.91	114.22	0.55	83.86
G93mean	2.65	0.87	103.61	0.50	71.07
c1 L1	3.30	0.87	127.74	0.49	88.14
c1 L2	4.20	0.95	160.57	0.57	116.21
c1mean	3.75	0.91	144.15	0.53	102.18
G 45 L1	2.60	0.87	99.32	0.51	77.35
G 45 L2	3.20	1.00	120.26	0.60	85.27
G45mean	2.90	0.94	109.79	0.56	81.31
G 87 L1	2.40	0.83	94.69	0.48	72.19
G 87 L2	3.00	1.02	103.25	0.61	79.70
87mean	2.70	1.02	103.25	0.61	79.70
G 80 L1	3.15	0.81	146.63	0.44	83.86
G 80 L2	4.35	0.91	173.72	0.54	121.30
G80mean	3.75	0.86	160.18	0.49	102.58
G 90 L1	3.20	0.81	127.17	0.43	85.27
G 90 L2	3.75	0.93	144.02	0.54	101.66
G90mean	3.48	0.87	135.60	0.49	93.47
c2 L1	4.60	0.84	178.21	0.44	128.33
c2 L2	5.00	0.91	199.19	0.45	144.65
c2mean	4.80	0.88	188.70	0.45	136.49
c3 L1	3.90	0.89	160.15	0.55	101.63
c3 L2	4.40	0.98	176.46	0.59	123.02
c3mean	4.15	0.94	168.30	0.57	112.33
G 86 L1	3.90	0.81	153.26	0.44	106.39
G 86 L2	4.50	0.99	169.50	0.50	126.49
G86mean	4.20	0.90	161.38	0.47	116.44
c4 L1	3.50	0.85	145.70	0.45	92.19
c4 L2	3.85	0.91	152.32	0.50	104.80
c4mean	3.68	0.88	149.01	0.48	98.50
green L1	2.50	0.60	139.70	0.38	80.00
green L2	3.00	0.67	157.13	0.40	87.20
gre.mean	2.75	0.64	148.41	0.39	83.60
brown L1	2.90	0.91	117.78	0.48	101.69
brown L2	3.70	0.76	134.38	0.47	130.10
bro.mean	2.90	0.91	117.78	0.48	101.69
upland L1	3.30	0.64	197.78	0.35	131.70
upland L2	5.10	0.60	231.74	0.39	150.92
up.mean	4.20	0.62	214.76	0.37	141.31
L1 mean	*3.15*	*0.82*	*133.24*	*0.46*	*90.20*
L2 mean	3.92	0.90	154.88	0.53	110.89
LSD 0.05G	0.07	0.00	2.37	0.00	1.44
LSD 0.05 L	0.04	0.01	1.92	0.00	1.21
LSD 0.05 LxG	0.10	0.01	3.23	0.01	2.20

Table 1: Effect of cotton genotype, maturity level and their interaction on fiber fineness and maturity parameters.

However Giza 87 Varity showed (1.02 and 0.61) for these two characters, respectively. These two varieties exhibited high maturity ratio. Upland cottons showed the lowest maturity ratio reading (0.62) and the lowest theta reading (0.37) followed by the green colored cotton then Giza 80. On the other hand, Giza 90xAus. C2, showed the highest micronaire reading (4.8). While, the upland cottons exhibited the highest fineness in mtex reading (214.76). Indicating that micronaire reading or fineness in mtex refers to the fineness, since it affected so much by maturity. So, their test should be accompanied by maturity test or image analyzer results.

Data of Fiber length and mechanical properties as affected by the genotype ,maturity level and their interaction are illustrated in Table 2, it is obvious from Table 2, that Giza 45 then Giza 93 varieties gave the highest upper half mean readings (35.28 and 35.248 mm), respectively.

Sample	Length parameters			Fiber mechanical characters	
	UHM(mm)	SFC	UI	strength(g/tex)	elongation%
G 88 L1	34.50	15.27	85.81	53.11	12.00
G 88 L2	35.76	10.77	85.95	58.54	13.82
G88mean	35.13	13.02	85.88	55.83	12.91
G 92 L1	30.32	16.46	82.01	50.19	11.31
G 92 L2	33.95	5.28	85.91	61.99	13.29
G92mean	32.14	10.87	83.96	56.09	12.30
G 93 L1	34.10	13.76	82.63	51.91	11.68
G 93 L2	36.38	11.26	86.06	55.81	12.68
G93mean	35.24	12.51	84.35	53.86	12.18
c1 L1	33.03	12.96	84.56	49.87	11.22
c1 L2	35.36	9.28	87.47	57.36	12.86
c1mean	34.20	11.12	86.02	53.62	12.04
G 45 L1	34.50	15.27	85.81	53.11	12.00
G 45 L2	36.05	20.39	87.51	55.84	12.93
G45mean	35.28	17.83	86.66	55.84	12.93
G 87 L1	33.59	9.36	81.84	54.85	11.11
G 87 L2	35.51	7.36	85.83	57.85	12.19
87mean	34.55	8.36	83.84	56.35	11.65
G 80 L1	29.02	18.33	81.68	35.96	11.74
G 80 L2	30.02	13.66	82.71	41.72	12.14
G80mean	29.52	16.00	82.20	38.84	11.94
G 90 L1	27.29	20.17	79.50	36.12	11.61
G 90 L2	30.46	15.63	80.73	35.9	11.25
G90mean	28.88	17.9	80.12	36.01	11.43
c2 L1	29.00	11.00	80.81	40.00	13.87
c2 L2	29.94	9.86	83.61	41.66	14.11
c2mean	29.47	10.43	82.21	40.83	13.99
c3 L1	30.00	12.14	81.84	33.00	12.17
c3 L2	30.31	11.81	82.25	36.24	12.56
c3mean	30.16	11.98	82.05	34.62	12.37
G 86 L1	30.42	6.51	84.96	50.1	13.77
G 86 L2	32.19	6.18	86.25	45.45	12.41
G86mean	31.31	6.35	85.61	47.78	13.09
c4 L1	31.31	11.21	83.65	46.00	12.31
c4 L2	32.26	10.13	85.62	47.18	12.48
c4 mean	31.79	10.67	84.64	46.59	12.4
green L1	29.14	13.12	81.32	33.14	10.00
green L2	29.37	10.71	83.17	35.20	10.30
gre.mean	29.26	11.92	82.25	34.17	10.15
brown L1	28.71	18.18	80.00	30.06	9.46
brown L2	29.97	18.96	81.45	35.01	9.83
bro. mean	29.34	18.57	80.73	32.54	9.65
upland L1	26.48	24.43	78.40	22.78	7.99
upland L2	27.69	11.21	81.83	25.22	8.52
up. mean	27.09	17.82	80.12	24.00	8.26
L1 mean	30.76	14.54	82.32	42.68	11.48
L2 mean	32.35	11.50	84.42	46.06	12.09
LSD 0.05 G	*0.24*	0.03	ns	0.44	0.02
LSD 0.05 L	*0.16*	0.01	ns	0.34	0.01
LSD 0.05 G.L	*0.26*	0.10	ns	n.s	0.04

Table 2: Effect of the genotype, maturity level and their interaction on fiber length and mechanical parameters as measured by Fibrotest instrument using HVI mode.

As for short fiber content, its worthy to mention that the SFC% measured by fibrotest instrument seems to be higher in content than those measured by the other instruments like fibrograph and sorters instruments. Data in Table 2, showed that the higher the maturity level the lower the short fiber content regardless the cotton genotype. (SFC %) being 11.50% for the higher level of maturity vs. 14.54% for the low maturity level. Immature fiber is easily to be broken during ginning resulting high SFC%. Regarding cotton genotype, Giza 86 variety showed the lower SFC% it is averaged 6.35%. While, the extra long cottons exhibited the higher SFC% it ranged from 8.36% in Giza 87 variety to 17.83% in Giza 45 variety and it ranged in upper Egyptian cottons from 10.43 % in c2 to 17.17.90% in Giza 90 variety. Colored cotton showed moderate SFC% but slightly higher than upper Egyptian varieties. Upland cotton showed the highest SFC% averaged 27.09%.

Sample	Convolutions no./mm	Reversals no./mm	Convolution angle
G 88 L1	3.61	1.41	13.00
G 88 L2	4.00	1.32	12.56
88mean	3.81	1.37	12.78
G 92 L1	3.52	1.41	15.38
G 92 L2	3.80	1.37	14.00
G92mean	3.66	1.39	14.69
G 93 L1	3.31	1.33	13.90
G 93 L2	3.42	1.27	13.80
G93mean	3.37	1.30	13.85
c1 L1	2.96	1.33	11.95
c1 L2	3.11	1.29	11.39
c1mean	3.04	1.31	11.67
G 45 L1	3.71	1.35	11.10
G 45 L2	3.98	1.32	10.58
G45mean	3. 85	1.32	10.58
G 87 L1	3.10	1.30	11.06
G 87 L2	3.79	1.30	9.32
87mean	3.45	1.30	10.22
G 80 L1	2.78	1.70	16.05
G 80 L2	3.32	1.50	15.03
G80mean	3.05	1.60	15.54
G 90 L1	3.45	2.10	15.57
G 90 L2	4.20	1.47	15.90
G90mean	3.75	1.79	15.73
c2 L1	3.21	1.71	16.30
c2 L2	3.55	1.66	15.70
c2mean	3.38	1.69	16.00
c3 L1	2.80	1.60	15.77
c3 L2	3.10	1.44	15.04
c3mean	2.95	1.52	15.41
G 86 L1	2.70	1.55	14.45
G 86 L2	3.60	1.53	13.68
G86mean	3.15	1.54	14.06
c4 L1	3.00	1.48	14.01
c4 L2	3.11	1.48	13.67
c4mean	3.06	1.48	13.84
green L1	2.70	1.90	17.01
green L2	2.81	1.70	16.66
gre.mean	2.76	1.80	16.84
brown L1	2.79	1.80	16.58
brown L2	3.00	1.70	16.36
bro.mean	2.90	1.75	16.47
UplandL1	2.54	2.11	17.06
upland L2	2.74	2.10	17.15
up.mean	2.64	2.10	17.11
L1 mean	3.08	1.61	14.61
L2 mean	3.44	1.50	14.06
LSD 0.05 G	0.13	0.02	0.03
LSD 0.05 L	0.15	0.01	0.01
LSD 0.05 GxL	ns	0.05	0.06

Table 3: Effect of the genotype, maturity level and their interaction on fiber microscopic characters.

Also, fiber strength could change the result in case of Giza 87 which gave the highest fiber strength and the lowest SFC (8.36) under the study. So, it is complex and its result affected by the inherent genes and the environmental conditions.

According to Uniformity index character, regardless it did show any significance due to the effect of the main factors or their interactions, but the extra long genotype surpassed the long ones. Therefore, upland and color cotton gave the lowest reading of fiber UI. Regarding to the fiber mechanical properties, 87 gave the highest fiber strength (56.35 g/tex) followed by Giza 92 which gave approximately the same reading (56.09 g/tex), while Giza 45 achieved the third level of the fiber strength (55.84 g/tex). Giza 92 is known as the strongest Egyptian variety, but this may be ascribed to that the result of each genotype under study didn't express the standard reading because it's a mean of low and high maturity levels. In addition to, the number of weak points and the convolution angle degree as going to discus later. Consequently the environmental condition expressed by maturity level could affect the strength readings. It could be recognized from the low and high maturity levels strength reading at the end of the table (42.68 vs. 46.06 g/tex), respectively. It's worthy to mention that the effect of the environmental condition on the fiber length has a limited range. Thus, usually the extra long cultivars are the strongest genotypes. On contrast, upland cotton gave the lowest strength value (24.00 g/tex).

According to the percentage of fiber elongation, genotype, maturity level and their interaction significantly affected the percentage of fiber elongation Giza90xAus. Gave the highest value of fiber elongation (13.99%). In contrast, the lowest value was (8.26%) for upland cotton. The percentage of fiber elongation value of the high maturity level (12.09%) exhibited the low maturity level (11.48%). The interaction between Giza90xAus and the high maturity level regard as the highest elongation value (11.44%).

Table 3 presented the effect of genotype, maturity level and their interaction on fiber microscopic characters. As regard to the number of convolutions per mm. it is well known that the Egyptian cotton have the higher convolutions number comparing to the upland cotton. That's clear from Table 3, Giza 45 verity exhibited the highest value of convolutions number per mm (3.85). On the other hand, the upland cotton gave the minimum reading of the number of convolutions per mm (2.64). The high maturity level exhibited the higher convolutions number per mm than low maturity level (3.44 vs. 3.08). As for the reversals number per mm, reversal considered as weak points along the fiber where the fiber exposed to breakage when force applied along. Because it the point where the cellulose deposition layer reversed the direction from clock wise to anti-clock wise Figure 3. It affected by both genetic and environmental conditions. Egyptian cotton contains the lowest reversals number comparing to the upland cotton. Giza 87 showed the lowest reversals number per mm (1.30). In contrast the upland cotton gave the maximum value of the reversals per number (2.10). Maturity level also, affected the weak points the highest in maturity ratio the lowest in reversals number per mm and vice versa as shown down in Table 3, accordingly, the interaction between the upland cotton and the low maturity ratio gave the highest value of reversals number per mm (2.11). According to the convolution angle, convolution angle refers to the spiral angle. The Egyptian cotton is characterized by narrow spiral and convolution angles, furthermore the extra-long genotypes has narrower angle of cellulose deposition along the fiber axis comparing to the long genotypes. Giza 87 cultivar gave the lowest value of convolution angle (10.22°) that reflected positively on its strength as mentioned before in Table 2. On the contrary, the upland cotton gave the widest convolution angle (17.11°).

Table 4, showed the effect of genotype, maturity level and their interaction on single fiber properties, it's clear from Table 4, that the effect of the main factors and their interaction were significant on all single fiber characters under the table. As to the single fiber linear density per mtex, its trend was as similar as bundle linear density. It

Sample	Linear density(mtex)	Single fiber tenacity(g/tex)	Single fiber elongation%
G 88 L1	115.00	49.20	11.44
G 88 L2	141.00	51.61	12.04
88mean	128.00	50.41	11.74
G 92 L1	127.00	46.73	10.55
G 92 L2	139.00	55.98	11.18
G92mean	133.00	51.36	10.87
G 93 L1	105.00	45.66	11.89
G 93 L2	119.00	48.35	10.61
G93mean	112.00	47.01	11.25
c1 L1	148.00	49.22	10.98
c1 L2	159.00	50.10	11.38
c1mean	154.00	49.66	11.18
G 45 L1	100.00	51.00	10.00
G 45 L2	105.00	51.28	10.49
G45mean	103.00	51.14	10.25
G 87 L1	103.00	50.09	10.10
G 87 L2	113.00	54.48	10.66
G87mean	108.00	52.29	10.38
G 80 L1	161.00	36.25	13.12
G 80 L2	165.00	41.93	13.77
G80mean	163.00	39.09	13.45
G 90 L1	122.00	42.60	13.12
G 90 L2	151.00	40.37	14.49
G90mean	136.50	41.49	13.81
c2 L1	187.00	33.12	12.27
c2 L2	204.00	35.60	13.45
c2mean	195.50	34.36	12.86
c3 L1	151.00	48.75	15.35
c3 L2	160.00	50.51	16.20
c3mean	155.50	49.63	15.78
G 86 L1	147.00	33.78	13.03
G 86 L2	186.00	35.76	9.76
G86mean	166.50	34.77	11.40
c4 L1	143 .00	35.11	11.01
c4 L2	154.00	36.78	11.76
c4mean	149.00	35.95	11.39
green L1	115.00	24.44	10.00
green L2	135.00	26.64	10.15
gre.mean	125.00	25.54	10.08
brown L1	129.00	40.76	10.92
brown L2	111.00	45.99	11.98
bro.mean	120.00	43.38	11.45
upland L1	191.00	29.62	9.60
upland L2	231.00	22.38	13.54
up. mean	211.00	26.00	11.57
L1 mean	135.80	41.52	11.60
L2 mean	151.60	43.18	12.10
LSD 0.05 G	3.10	0.28	0..13
LSD 0.05 L	2.40	0.19	0.11
LSD 0.05 GxL	3.90	0.33	0.16

Table 4: Effect of the genotype, maturity level and their interaction on single fiber properties.

could be arranged in ascending order according to the fineness mtex as follows: 1- the extra-long genotypes, i.e. Giza 45 (103 mtex) followed by Giza 87 (108 mtex) then Giza 93 (112 mtex), 2- The brown colored cotton (120 mtex), 3- the long Egyptian genotypes, i.e. Giza 90 (136.50 mtex) and 10229xG86 or C4 (149 mtex), 4- the upland cotton (211 mtex). This may be ascribed to that Giza 45, Giza93 and Giza87 which belong to extra-long extra fine fiber gave the lowest area of cross section whether in the lower or in the higher maturity level, while Giza 90 and C4 gave the lowest long fiber areas. On the contrary, the upland cotton exhibited the highest value of the area of cross section as explained before . The interaction between Giza 45 and the lowest maturity level gave the lowest fiber linear density (100 mtex). On the other hand, the highest fiber linear density was obtained from the interaction between the upland cotton and the high maturity level (231.00 mtex).

As regards to the single fiber strength it could be recognized from Table 4, that single fiber strength is a little bit lower than bundle strength. Giza 87 recorded (52.29 g/tex) and surpassed the other genotypes on this trait. This may due to that Giza gave highest theta, maturity readings and the lowest structure properties, i.e. convolution angle and number of reversals per mm. on the other hand the upland cotton gave the lowest single fiber strength (26.00 g/tex) according to the reasons discussed above. The higher maturity level surpassed the lower one in single fiber tenacity property, respectively (43.18 vs. 41.52 g/tex). The interaction between Giza 87 and the highest maturity level gave the highest single fiber tenacity. On the other hand, the lowest single fiber tenacity was obtained from the interaction between the upland cotton and the low maturity level.

Concerning the percentage of single fiber elongation, it's noticeable that single fiber elongation did not behave as bundle elongation, some readings were higher than those of the bundle elongation like, Giza 80, Giza 90, C 3, brown cotton and upland cotton. In contrast, the rest genotypes get lower readings than bundle elongation. In general the low maturity ratio gave low elongation % comparing to the high maturity level within the same genotype. This could be detected from the interaction means as well as the overall maturity level means.

The relationship between single fiber properties and bundle properties

Researchers usually use Regression analysis as a common statistical method for estimation of the relation between Y variable and the x variables. At first, the types of relationship between fiber properties (x variables) and single fiber properties (Y variable) were checked individually by using curve estimation and correlation analysis. Statistical analysis indicated that there was a nearly linear relationship between fiber properties and single fiber properties. After excluding the weak correlated characters 3 linear multiple regression equations were:

a. The relationship between single fiber tenacity and fiber properties.

b. The relationship between single fiber linear density and fiber properties.

c. The relationship between single fiber elongation and fiber properties.

The relationship between single fiber tenacity and fiber properties: It's clear from Table 5, and Figures 4 to 16 that there were excellent relationship between single fiber tenacity and bundle tenacity (R^2=0.8107, r=0.90). While, both of Theta and the reversals number per mm gave nearly the same relation level (r=0.87). Also, convolution angle character and maturity ratio gave good relationship with single fiber tenacity. On the other hand, the weakest relationship was between single fiber tenacity and short fiber content (R^2=0.0383, r=0.20). In addition, there were direct relationship between single fiber tenacity and all the studied characters except for, short fiber content, fiber finesses,

character	equation	R^2	r
UHM	Y=2.0813×-22.559	0.4916	0.70
SFC	Y= - 0.3465×+47.869	0.0383	-0.20
UI	Y=1.7412×-102.26	0.2562	0.51
Fiber strength(g)tex	Y=0.645×+14.404	0.8107	0.90
Fiber elongation	Y=3.2271×+5.4688	0.4221	0.65
Fiber finesses	Y= - 0.1538×+65.525	0.3409	-0.60
MIC	Y= - 1.9691×+51.604	0.0559	-0.24
Theta	Y=103.59x-9.495	0.7561	0.87
Area of cross section	Y= -0.1908×+62.872	0.3048	-0.55
Convolutions	Y=8.2849×+16.588	0.4093	0.64
Reversals	Y= - 26.573×+83.814	0.7443	-0.87
Convolution angle	Y= - 0.9718×+54.751	0.5855	-0.77
Maturity	Y=62.934×-11.932	0.7420	0.86

r= Correlation
R^2=Determining factor

Table 5: Simple linear regression between each fiber property and Single fiber tenacity.

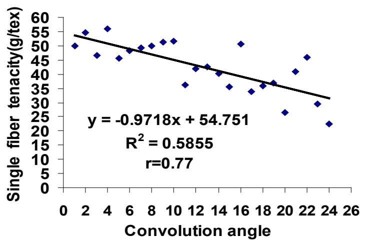

Figure 4: The relationship between single fiber tenacity and conv. angle.

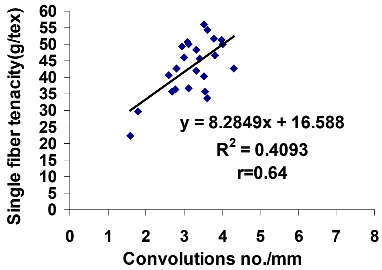

Figure 5: The relationship between single fiber tenacity and convolution no.

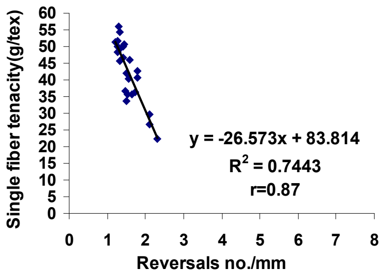

Figure 6: The relationship between single fiber tenacity and convolution no.

micronaire reading, area of cross section, reversals and convolution angle; where, there was a kind of negative relationship between each of them and single fiber tenacity.

Measuring the relations using the simple regression and correlation is not satisfactory. Also, partial correlation between more than character is very important incase if they used as indicator for building multiple regression models. According to the previous reasons stepwise analysis was used to form the best model for single fiber

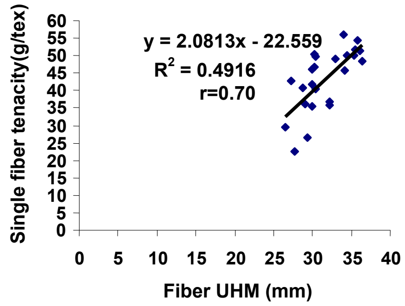

Figure 7: The relationship between single fiber tenacity and UHM.

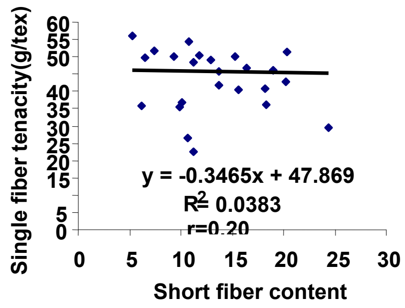

Figure 8: The relationship between single fiber tenacity and SFC.

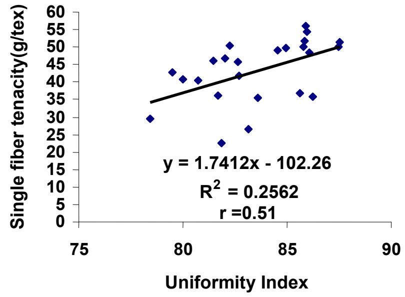

Figure 9: The relationship between single fiber tenacity and UI.

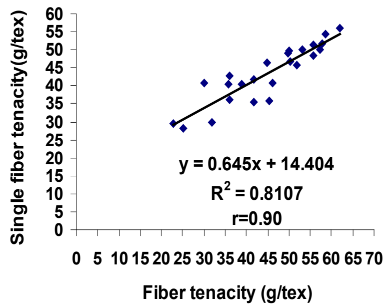

Figure 10: The relationship between single fiber tenacity and fiber strength.

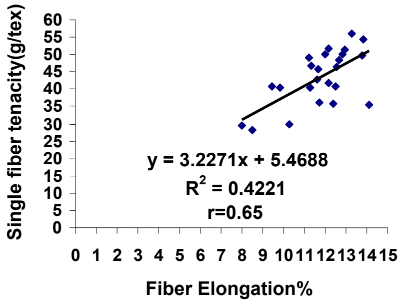

Figure 11: The relationship between single fiber tenacity and fiber elongation.

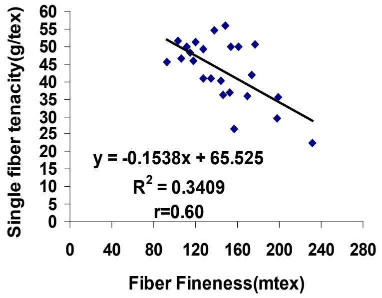

Figure 12: The relationship between single fiber tenacity and fiber fineness.

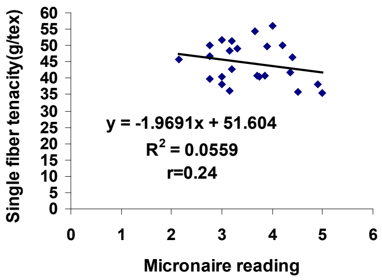

Figure 13: The relationship between single fiber tenacity and micronaire reading.

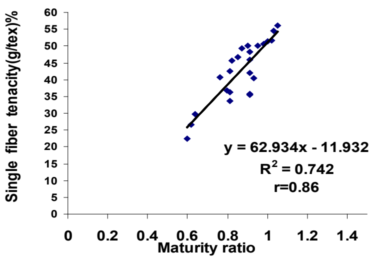

Figure 14: The relationship between single fiber tenacity and MR.

tenacity and the independent fiber characters. According to the result of the analysis, data in Table 6, indicated that microscopic characters, length and mechanical parameters were excluded from the model. In contrast, fineness and maturity parameters represented by theta and fineness with millitex were the predictors of the model. Table 7 and Figure 17, indicated the strong relationship between the single fiber and the independent variables in the model with correlation= 0.936 and determining factor= 0.874. Table 8, shows regression coefficients of variables, t-values and significance level of theta and fineness variables. Arrangement of variables in the table indicates their relative importance for the model. Signs (+ or -) of regression coefficients of variables indicate the direction of influence.

This means fine and mature fiber increased the single fiber strength character.

The relationship between single fiber linear density and fiber properties: It's clear from Table 9, and Figures 18 to 30 that there were excellent relationship between single fiber linear density and fiber fineness per mtex (R^2=0.8847, r=0.94). While, both of micronaire reading and area of cross section gave nearly the same relation level as follows, respectively (R^2=0.6622, r=0.81 and R^2=0.6779, r=0.82.). On the contrary, short fiber content gave the weakest relationship to single fiber linear density (R^2=0.0352, r=0.19), all the characters under study proportionate adversely with single fiber linear density except, fiber finesses, micronaire reading, area of cross section, reversals and convolution angle.

After Appling the stepwise analyses regression coefficients, t-values and the partial correlation determined the excluded character to build up the best model describes the relationship between single fiber linear density and all the studied fiber properties. Its clear from Table 10, that all the character were excluded from the model except the micronaire reading and the fiber fineness per mtex characters. Thus, the model showed strong correlation r=0.946 and high determining factor=0.894 Table 11 and Figure 31

Obviously, fiber fineness per mtex was the most important factor for single fiber linear density. Micronaire value as an indicator for the specific surface area of the fiber was another important fiber parameter

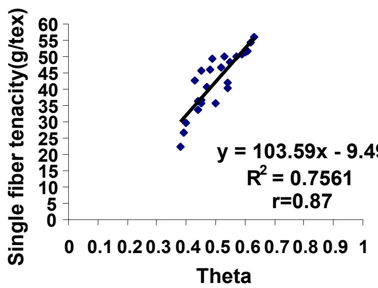

Figure 15: The relationship between single fiber tenacity and theta.

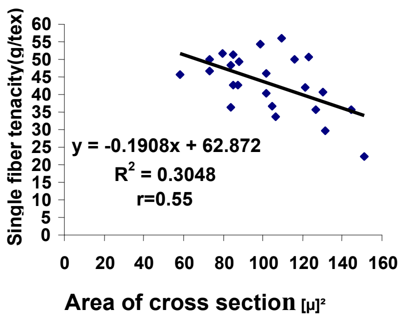

Figure 16: The relationship between single fiber tenacity and area of cross section.

Citation: Arafa AS (2014) Alternate Relationship between Single Fiber Properties and Both of Fiber Microscopic and Physical Properties. J Textile Sci Eng 4: 175. doi:10.4172/2165-8064.1000175

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	MIC	-.266a	-4.517	.000	-.563	1.000
	MR	.042a	.235	.815	.035	.161
	FI NN	-.335a	-5.802	.000	-.658	.859
	ASCW	-.251a	-4.050	.000	-.521	.961
	UHM	.213a	2.269	.028	.324	.512
	SF C	.159a	2.304	.026	.328	.945
	UI	-.038a	-.443	.660	-.067	.682
	STRENGTH	.201a	2.220	.032	.317	.554
	ELONGATI	-.037a	-.443	.660	-.067	.720
	CONV	.019a	.199	.843	.030	.567
	REVER	-.212a	-2.040	.047	-.294	.430
	CONVANGL	-.230a	-2.981	.005	-.410	.709
2	MIC	.104b	.795	.431	.120	.169
	MR	-.053b	-.388	.700	-.059	.159
	ASCW	.186b	1.497	.142	.223	.180
	UHM	-.017b	-.193	.848	-.029	.373
	SF C	.099b	1.804	.078	.265	.907
	UI	-.071b	-1.090	.282	-.164	.677
	STRENGTH	-.011b	-.126	.900	-.019	.415
	ELONGATI	-.005b	-.078	.938	-.012	.715
	CONV	-.080b	-1.092	.281	-.164	.537
	REVER	.023b	.240	.812	.037	.330
	CONVANGL	-.082b	-1.160	.253	-.174	.569

Table 6: Excluded varibles and predictors for single fiber tenacity.

Model	r	R square	Std. Error	Significant
1	0.936	0.874	0.868	0.000

r = Correlation
R^2=Determining factor

Table 7: Single fiber tenacity model summary.

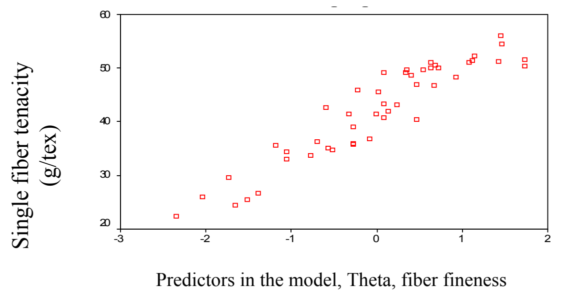

Figure 17: The best model for the relationship between Single fiber tenacity (g/tex)and fiber properties.

Statistical Parameter	Constant	theta	Fineness millitex
B*	8.165	95.22	-9.38E-02
Std. Error	5.016	7.277	0.016
T	1.628	13.085	-5.802
Significant	0.111	0.000	0.000

Table 8: Regression coefficients, t-values and significance level of the variables of the linear regression model for single fiber tenacity (g/tex).

for single fiber linear density, both of them proportionate directly with single fiber linear density, (Table 12).

character	equation	R^2	r
UHM	Y= - 5.2545x+312.78	0.2370	0.49-
SFC	Y= - 1.2075x+162.61	0.0352	0.19-
UI	Y= - 2.4339x+350.01	0.0379	0.19-
Fiber strength(g)tex	Y= - 1.4257x+210.21	0.2420	0.50-
Fiber elongation	Y= - 3.8406x +191.73	0.0357	0.19-
Fiber finesses	Y=0.8985x +15.396	0.8847	0.94
MIC	Y=36.6x +14.29	0.6622	0.81
Theta	Y= - 165.58x +229.86	0.1491	0.39-
Area of cross section	Y=1.1067x +32.929	0.6779	0.82
Convolutions	Y= - 38.582x +273.55	0.3563	0.60-
Reversals	Y=61.742x +50.833	0.3101	0.56
Convolution angle	Y=2.2722x +118.18	0.2470	0.50
Maturity	Y= - 97.747x +231.79	0.1323	0.36-

r= Correlation
R^2=Determining factor

Table 9: Simple linear regression between each fiber property and Single linear density.

The relationship between single fiber elongation and fiber properties: It's clear from Table 13, and Figures 32 to 44 that the relationship between single fiber elongation and fiber properties weren't strong enough the strongest relation was for UHM (R^2=0.3298, r=0.57). This may attributes to that the linear regression could not fit the relation it could be quadratic or any type other than linear type.

Citation: Arafa AS (2014) Alternate Relationship between Single Fiber Properties and Both of Fiber Microscopic and Physical Properties. J Textile Sci Eng 4: 175. doi:10.4172/2165-8064.1000175

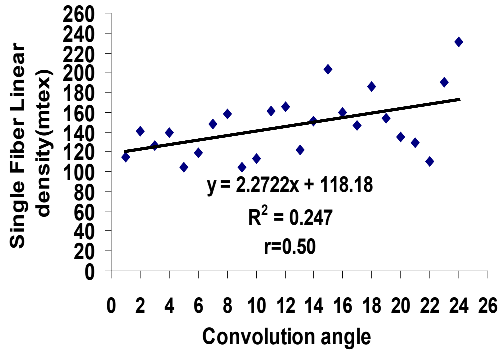

Figure 18: The relationship between single fiber linear density and conv. Angle.

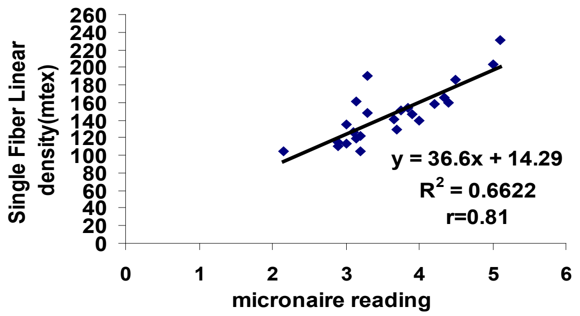

Figure 19: The relationship between single fiber linear density and micronaire reading.

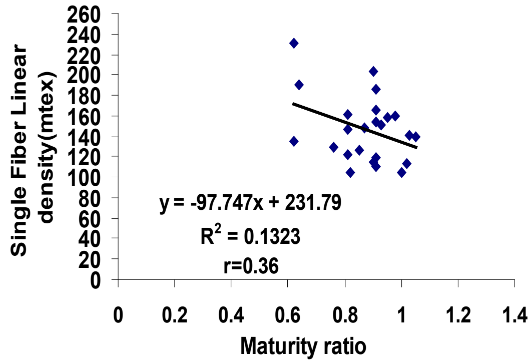

Figure 20: The relationship between single fiber linear density and MR.

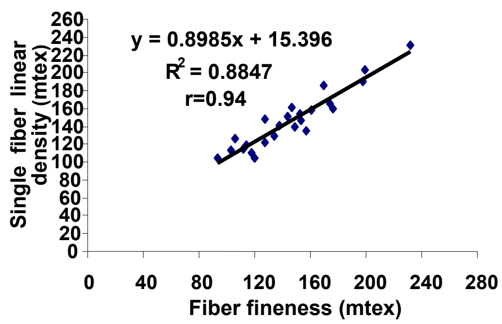

Figure 21: The relationship between single fiber linear density and fiber fineness.

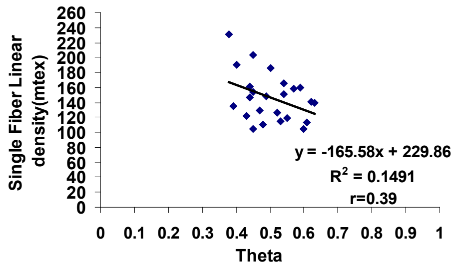

Figure 22: The relationship between single fiber linear density and theta.

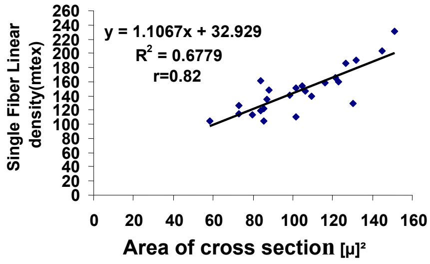

Figure 23: The relationship between single fiber linear density and area of cross section.

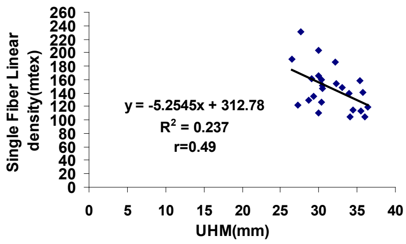

Figure 24: The relationship between single fiber linear density and UHM.

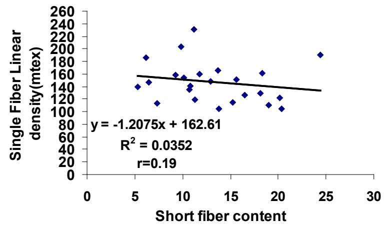

Figure 25: The relationship between single fiber linear density and SFC.

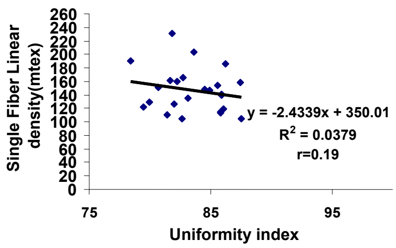

Figure 26: The relationship between single fiber linear density and UI.

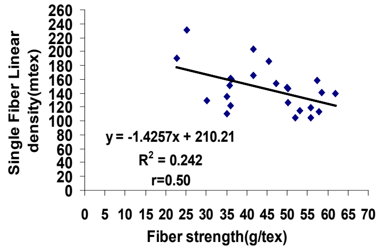

Figure 27: The relationship between single fiber linear density and fiber strength.

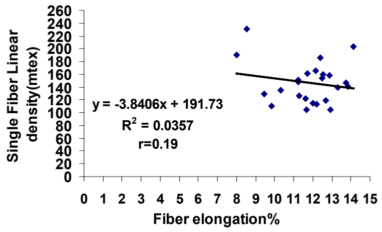

Figure 28: The relationship between single fiber linear density and Fiber elongation.

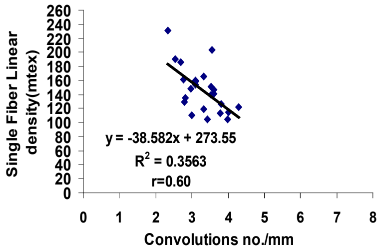

Figure 29: The relationship between single fiber linear density and convolution no.

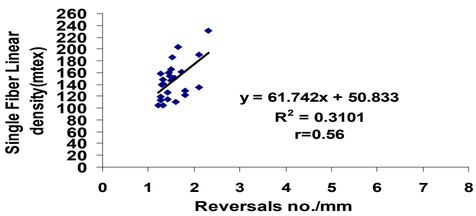

Figure 30: The relationship between single fiber linear density and reversals no.

All the characters under study proportionate directly with single fiber elongation except, short fiber content, UI, and fiber strength.

Table 14, represents the excluded varibles and predictors for single fiber elongation. This model surpassed the previous models on the number of the predictors variables, it contains 7 predictors. They are: Miconaire reading, UI, ASCW, theta, fiber strength, fiber elongation and UHM characters. Nevertheless, the model results and graph distribution illustrated in Table 15 and Figure 45, showed the lowest correlation value comparing to the others single characters (r=0.888 and determining factor=0.788) Mic, UI, ASCW were the most important factors for single fiber elongation. Theta values was other important fiber parameter for single fiber elongation, then fiber strength followed by fiber elongation finally UHM ranked the last important character in the model. Table 16, Indicated that UI, ASCW, and fiber Strength proportionate inversely with single fiber elongation. However, the rest fiber properties proportionate directly with single fiber elongation. In

Model	Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
					Tolerance
1 MIC	.213a	2.358	.023	.335	.294
MR	.095a	1.749	.087	.255	.849
THETA	.030a	.533	.597	.080	.859
ASCW	.106a	.922	.362	.138	.202
UHM	.048a	.740	.463	.111	.631
SF C	-.052a	-1.014	.316	-.151	.991
UI	.018a	.326	.746	.049	.923
STRENGTH	.097a	1.540	.131	.226	.644
ELONGATI	.060a	1.165	.250	.173	.983
CONV	.062a	1.109	.274	.165	.835
REVER	-.087a	-1.397	.169	-.206	.667
CONVANGL	-.074a	-1.214	.231	-.180	.698
2 MR	-.006b	-.065	.948	-.010	.334
THETA	-.089b	-1.290	.204	-.193	.495
ASCW	-.066b	-.491	.626	-.075	.134
UHM	-.021b	-.301	.765	-.046	.505
SF C	-.001b	-.019	.985	-.003	.796
UI	-.049b	-.851	.400	-.129	.722
STRENGTH	.022b	.286	.776	.044	.431
ELONGATI	-.047b	-.661	.512	-.100	.482
CONV	-.015b	-.232	.818	-.035	.560
REVER	-.003b	-.045	.965	-.007	.427
CONVANGL	-.028b	-.438	.663	-.067	.606

a. predictors in the model(constant), Fineness
b. predictors in the model(constant), Fineness, mic
c. Dependant variable: Single linear density

Table 10: Excluded varibles and predictors for single fiber linear density.

Model	r	R square	Std. Error	Significant
1	0.946	0.894	10.311	0.023

r= Correlation
R^2=Determining factor

Table 11: Single fiber linear density model summary.

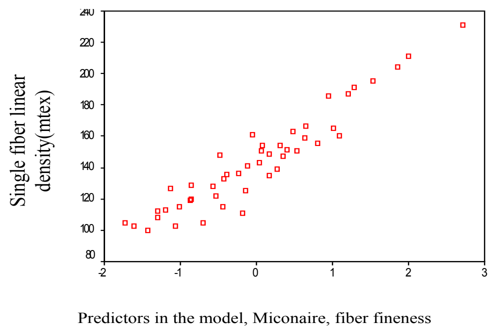

Figure 31: The best model for the relationship between single fiber linear density (mtex) and fiber properties.

mic	Fineness millitex	Constant	Statistical Parameter
9.382	.7400	4.198	**B***
3.979	.0880	7.807	**Std. Error**
2.358	8.402	.5380	**T**
.0230	0.000	.5930	**Significant**

Table 12: Regression coefficients, t-values and significance level of the variables of the linear regression model for single fiber linear density.

character	equation	R²	r
UHM	Y=0.1669x+3.374	0.3298	0.57
SFC	Y= - 0.0149x+12.119	0.0021	-0.05
UI	Y= - 0.1823x+27.159	0.0840	-0.29
Fiber strength(g)tex	Y= - 0.041x+13.75	0.0790	-0.28
Fiber elongation	Y=0.1942x+9.6383	0.0361	0.19
Fiber finesses	Y=0.0157x+9.6326	0.1064	0.33
MIC	Y=0.9563x+8.4645	0.1787	0.24
Theta	Y=0.2625x+11.789	0.0001	0.01
Area of cross section	Y=0.0179x+10.083	0.0701	0.27
Convolutions	Y=0.2747x+11.017	0.0071	0.08
Reversals	Y=0.4292x+11.256	0.0059	0.07
Convolution angle	Y=0.0941x+10.528	0.0393	0.20
Maturity	Y=1.5633x+10.559	0.0138	0.12

r= Correlation
R^2=Determining factor

Table 13: Simple linear regression between each fiber property and the percentage of single fiber elongation.

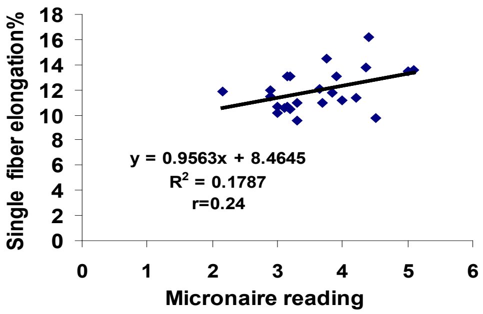

Figure 32: The relationship between single fiber elongation and micronaire reading.

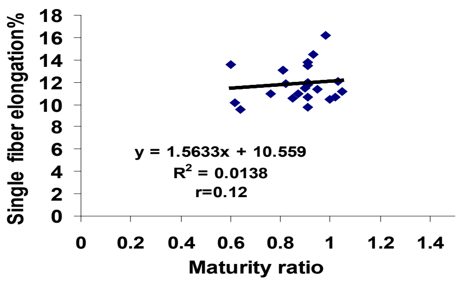

Figure 33: The relationship between single fiber elongation and MR.

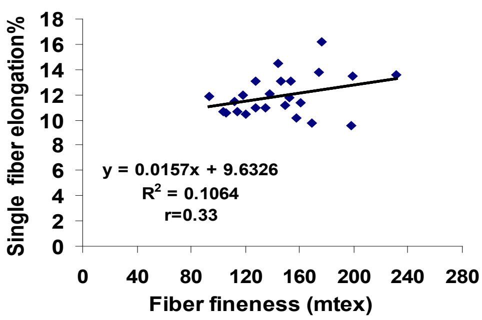

Figure 34: The relationship between single fiber elongation and fiber fineness.

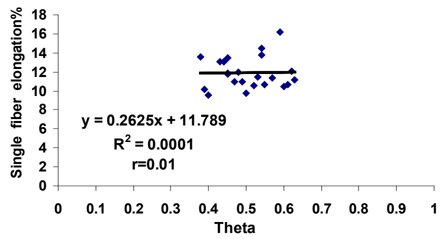

Figure 35: The relationship between single fiber elongation and theta.

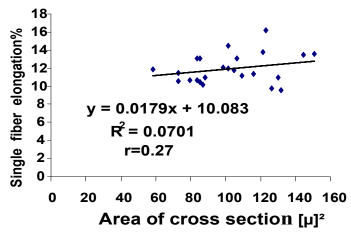

Figure 36: The relationship between single fiber elongation and area of cross section.

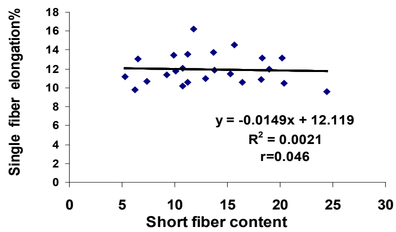

Figure 37: The relationship between single fiber elongation and SFC.

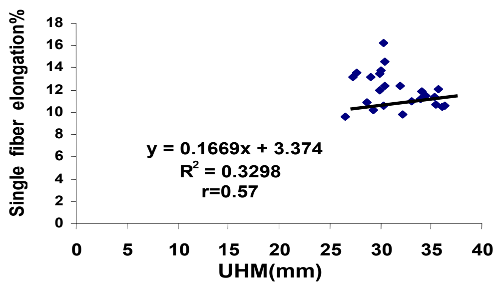

Figure 38: The relationship between single fiber elongation and UHM.

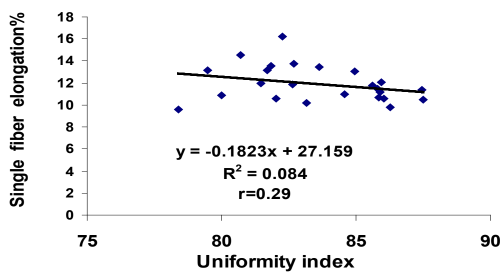

Figure 39: The relationship between single fiber elongation and UI.

Citation: Arafa AS (2014) Alternate Relationship between Single Fiber Properties and Both of Fiber Microscopic and Physical Properties. J Textile Sci Eng 4: 175. doi:10.4172/2165-8064.1000175

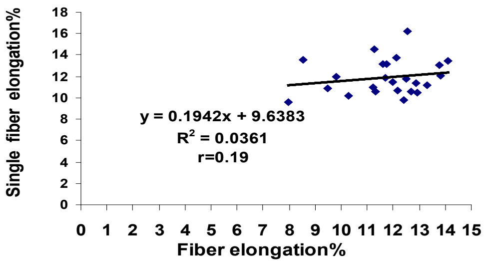

Figure 40: The relationship between single fiber elongation and fiber elongation.

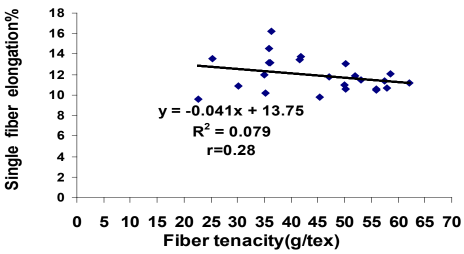

Figure 41: The relationship between single fiber elongation and strength.

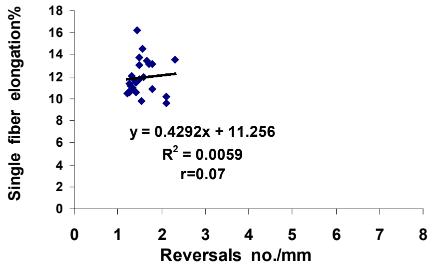

Figure 42: The relationship between single fiber elongation and reversals no.

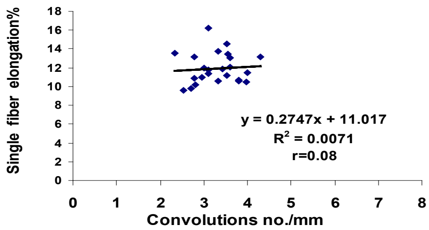

Figure 43: The relationship between single fiber elongation and convolution no.

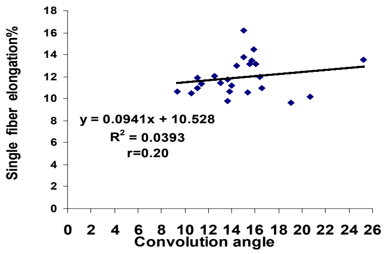

Figure 44: The relationship between single fiber elongation and conv. Angle.

Excluded Variables

Model	Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1MR	.119a	.943	.351	.141	.996
FINN	-.128a	-.547	.587	-.082	.294
THETA	.118a	.934	.356	.139	1.000
ASCW	-.504a	-1.854	.071	-.269	.203
UHM	-.200a	-1.531	.133	-.225	.899
SFC	.203a	1.550	.128	.228	.899
UI	-.320a	-2.716	.009	-.379	1.000
STRENGTH	-.241a	-1.910	.063	-.277	.937
ELONGATI	.070a	.527	.601	.079	.925
CONV	-.005a	-.043	.966	-.006	.997
REVER	.031a	.238	.813	.036	.952
CONVANGL	.157a	1.200	.237	.178	.911
2 MR	.423b	3.321	.002	.452	.695
FINN	-.608b	-2.517	.016	-.358	.212
THETA	.436b	3.412	.001	.462	.682
ASCW UHM	-1.179b	-4.719	.000	-.584	.150
SFC	.553b	1.992	.053	.291	.169
STRENGTH	.026b	.173	.863	.026	.630
ELONGATI	.153b	.648	.521	.098	.252
CONV	.469b	3.274	.002	.447	.553
REVER	.175b	1.335	.189	.199	.793
CONVANGL	-.602b	-3.416	.001	-.462	.360
	-.376b	-1.757	.086	-.259	.290
3 MR	.274c	2.341	.024	.340	.620
FINN	-.222c	-.953	.346	-.146	.173
THETA	.323c	2.900	.006	.408	.643
UHM	.417c	1.803	.079	.268	.166
SFC	.175c	1.409	.166	.212	.594
STRENGTH	-.256c	-1.225	.227	-.186	.211
ELONGATI	.144c	.869	.390	.133	.340
CONV	.006c	.053	.958	.008	.707
REVER	-.337c	-1.948	.058	-.288	.293
CONVANGL	-.261c	-1.454	.153	-.219	.284
4MR	-.058d	-.247	.806	-.039	.147
FINN	.179d	.689	.495	.107	.119
UHM	.013d	.046	.964	.007	9.712E-02
SFC	.124d	1.056	.297	.163	.578
STRENGT	-.633d	-3.227	.002	-.450	.169
HELONGATI	.060d	.381	.705	.059	.327
CONV	-.207d	-1.708	.095	-.258	.520
REVER	-.060d	-.280	.781	-.044	.177
CONVANGL	-.172d	-1.007	.320	-.155	.273
5 MR	.129e	.584	.563	.092	.137
FINN	-.181e	-.694	.492	-.109	9.704E-02
UHM	.547e	1.906	.064	.289	7.428E-02
SFC	.007e	.057	.955	.009	.510
ELONGATI	.345e	2.276	.028	.339	.257
CONV	-.124e	-1.077	.288	-.168	.487
REVER	-.352e	-1.733	.091	-.264	.151
CONVANGL	-.314e	-2.046	.047	-.308	.256
6 MR	-.237f	-.913	.367	-.145	8.832E-02
FINN	-.080f	-.317	.753	-.051	9.376E-02
UHM	.578f	2.136	.039	.324	7.412E-02
SFC	-.005f	-.049	.961	-.008	.508
CONV	-.154f	-1.408	.167	-.220	.481
REVER	-.305f	-1.557	.128	-.242	.149
CONVANGL	-.295f	-2.009	.051	-.306	.255
7 MR	-.199g	-.796	.431	-.128	8.784E-02
FINN	-.062g	-.253	.801	-.041	9.363E-02
SFC	-.004g	-.041	.967	-.007	.508
CONV	-.184g	-1.766	.085	-.275	.474
REVER	-.173g	-.831	.411	-.134	.127
CONVANGL	-.165g	-.879	.385	-.141	.156

a. predictors in the model (constant), Mic, b. predictors in the model (constant), Mic, UI , c. predictors in the model (constant), Mic, UI, area of cross section,
d. predictors in the model (constant), Mic, UI, area of cross section, Theta
e. predictors in the model (constant), Mic, UI, area of cross section, Theta, Strength
f. predictors in the model (constant), Mic, UI, area of cross section, Theta, Strength, Elongation
g. predictors in the model (constant), Mic, UI, area of cross section, Theta, Strength, Elongation, UHM
h. dependant variable: single fiber elongation

Table 14: Excluded varibles and predictors for single fiber elongation.

Model	r	R square	Std. Error	Significant
1	0.888	0.788	0.7979	0.039

r= Correlation
R^2=Determining factor

Table 15: single fiber elongation model summary.

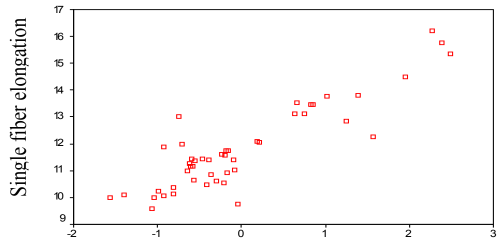

Figure 45: The best model for the relationship between percentage of single fiber elongation and fiber properties.

Statistical Parameter	Constant	Mic	UI	Area of cross section	Theta	Strength	Elongation	UHM
B*	31.127	2.930	-0.407	-7.72E-02	8.076	-0.166	0.3950	0.3400
Std. Error	8.000	0.6280	0.1310	0.018	2.719	.0350	0.160	0.159
T	3.891	4.667	-3.103	-4.274	2.970	-4.741	2.471	2.136
Significant	0.000	0.000	0.004	0.000	0.005	0.018	0.000	0.039

Table 16: Regression coefficients, t-values and significance level of the variables of the linear regression model for percentage of single fiber elongation.

general the results of the single fiber elongation are absurd and couldn't be helpful as prediction.

Acknowledgement

I would like to extend my appreciation to Dr. Guntram Kugler Ph.D., General Manager Laboratory Projects, and all the member of Textechno Herbert Stein GmbH & Co. KG, Monchengladbach, Germany for testing the samples in their labs.

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