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Evaluation of the Interrelationship among Fiber Properties and Yarn Strength of Egyptian Cotton

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Abstract: *The main subjective of this study to clarify the variation of yarn strength due to the interrelationship among cotton fiber properties. The materials were used four lint grades i.e. Fully Good (FG), Good (G), Fully Good Fair (FGF) and Good Fair (GF) for four Egyptian cotton verities, i., e. extra long staple (G 92 and G 93) and long staple (G 86 and G 95) at Cotton Research institute (CRI), Agricultural Research Center (ARC), Giza, Egypt. Results of ordinary correlation almost tends to misleading values of correlation coefficients due to the multicollinearity among large numbers of cotton fiber properties. Where the presence of large multidimensional, the confidence interval of the coefficients tends to become very wide and the statistics tend to be inaccurate. So using a dimensional reduction technique is to make better use of cotton fiber properties in data compared to most existing ordinary correlation matrices by improving the way of variables relation. Canonical correlation analysis (CCA) is one of the most powerful methods for extracting multidimensional correlation structure between two groups of variables, exploring the relationships among cotton fiber properties and yarn strength.*

Keywords: *Egyptian cotton; grades; technological properties; correlation; multicollinearity; canonical correlation.*

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I. Introduction

Cotton is the most widely used of all plant fibers which woven into soft, strong, absorbent fabrics to make clothing, bed sheets, carpeting, tablecloths, and other items. Other parts of plant provide raw materials for a wide variety of useful products (Chaudhry, Guitchounts 2003). The characteristics of the cotton fiber are not the same; they vary on climate, weather, cultivating system, harvesting system and others. The market value of cotton is determined by some critical factors, one of which is the grade given to a cotton bale. This grade is based on the appearance of the cotton fibers such as their color and trash. Exposure to various elements in the environment and contamination from harvesting and ginning techniques causes variations in the color and trash content of raw cotton (Cheng, Cheng 2003). Egypt is well known as a country that is growing up cotton varieties with very special, unique properties. Especially length, strength, fineness and also the color grades of Egyptian cotton cannot be found anywhere else in the world (Ebaido et al., 2017). Cotton fiber quality classification is done depending on physical characteristics such as length, strength, fineness, maturity and color. Cotton classing methodology is based on both grade and instrument standards used hand-in-hand with state of the art methods and equipment to provide the cotton industry with the best possible information on cotton quality for marketing and processing. (Cheng, Cheng 2003).

Traditional and modern devices are used to test and classify cotton samples. It is important to discover and quantify the degree to which variables in the studied data set are depended upon each other (Faulkner et al., 2012, Rypl et al., 2014, Yang, Gorden 2016). Length is one of the most important properties of cotton fibers. Longer fibers are generally finer and stronger than shorter ones. Yarn quality parameters such as evenness, strength, elongation and hairiness are correlated to the length of cotton fibers. Therefore it is very important for fiber producers and spinners to be able to measure the length distribution of cotton fibers (Braden 2005) and (Azzouz *et al.*, 2008). Fiber strength is generally considered to be one of the most rigorous properties of importance amongst fiber properties. It is obvious the importance of fiber elongation and strength and their contribution to yarn quality (Thibodeaux et al., 1998 ,Yang , Gordon 2016). In the textile industry throughout the world, visual assessment of color is the primary method of determining color accuracy. Several visual color sensation variables are important and must be considered to replace the subjective visual grade determined by cotton classer with objective instrumental measurement (Berns 2000, Shofner, Shofner 2002, Ebaido et al., 2017). Cotton yarn is processed by the yarn spinning process. Ring yarn is a quality yarn with a combination of functional and fashionable features. It can be successfully used to produce high count ranges of yarn with high quality (Sundaresan et al., 2017). This knowledge about variables can help for better prepare data to meet the expectations of machine learning algorithms, such as correlation whose performance will degrade with the presence of these interdependencies.

Multicollinearity is a state of very high intercorrelations or interassociations among the independent variables. It is therefore a type of disturbance in the data, and if present in the data the statistical inferences made about the data may not be reliable (Yoo et al., 2014). Canonical correlation analysis (CCA) is a useful and powerful technique for extracting multidimensional correlation structure between two groups of variables, exploring the relationships among multiple dependent and independent variables. The technique is primarily descriptive, although it may be used for predictive purpose. (Hardoon et al., 2004, Zhu et al., 2016, Cheveigne 2019 , Jansen et al., 2019).

The present study was conducted to provide information on interrelationships of cotton fiber properties and yarn strength for different lint grades using CCA.

II. Methods

The materials used in this study were six samples of four grades, i.e. Fully Good (FG), Good (G), Fully Good Fair (FGF) and Good Fair (GF). Four cotton varieties, i.e. G 92 and G 93 (belong to extra-long staple class) and G 86 and G 95 (belong to long staple category) were sourced from statistical database during 2018 crop season published by Egyptian & International Cotton Classification Center (EICCC), Cotton Research Institute (CRI), Agricultural Research Center (ARC).

All samples were conducted under standard testing conditions of 21 ± 2º C and 65 ± 2 % Rh. At the premises of Textile Testing Technology, the Fiber Classifying System (FCS) designed to measure all fiber properties which determine the quality and the spinnability of both, cotton and man-made fibers, used in production of spun yarns. This system can still be calibrated with calibration cotton to yield High Volume Instrument (HVI). FCS consists of several partitions as Fibrotest measures length and strength traits, Wira measures fineness and maturity, Optotest measures color and trash traits (Ebaido *et al.* 2017).

2.1. Fiber length characters.

1-Upper Half Mean (UHM) is the average length of the longest one-half of the fibers.

2- Mean Length (ML) is obtained by summing the product of fiber length and its weight, then dividing by the total weight of the fibers.

3- Uniformity Index (UI) is the ratio of the mean length divided by the upper half-mean length.

4- Short Fiber content (SFC) is the percent by weight of fibers of 12.7 mm or less.

5- Short Fiber Index (SFI) is percentage of fibers shorten than 1/2 inch or 12.7 mm.

2.2. Fiber strength characters.

1-Elongation (E_{max}) is an important cotton fiber property that directly affects yarn elongation and work-to-break values (Yang and Gordon 2016).

2-Strength (absolute) is indicated by the ability to resist being pulled or torn apart when subjected to stress or tension.

3- Rel-Strength is fiber bundle strength test of FCS relative to HVI strength.

2.3. Color traits characters.

1-a* is the redness/greenness degree.

2-Rd% is the percentage of reflectance.

3-+b is the degree of yellowness. (+b is the blueness/yellowness).

2.4. Micronaire characters.

1-Miconaire value is a measure of the air permeability of compressed cotton fibers. It is often used as an indicator of fiber fineness & maturity.

2-Maturity Ratio (MR) is the index of development of the fiber.

3-Linear Density (LD) is the number of skein material that weigh 1 pound (0.45 kg).

2.5. Yarn characters.

Yarn strength is the pound X count using the Good Brand Lea Tester.

The correlation coefficients among the studied traits were investigated. The correlation coefficient (r) tells the strength of the relationship among length, strength, color and fineness and yarn properties (Snedecor and Cochran 1980). Measure variance inflation factor (VIF) which assess how much the variance of an estimated regression coefficient increase when the predictors are correlated. A VIF between 5 and 10 indicates high correlation that may be problematic (Johnston 1972).

Using a Canonical Correlation Analysis (CCA) as a technique for determining if there is a relationship between two sets of variables (Hotelling 1936). In a multiple regression analysis a single variable Y is related to more than two variables X1, X2, ……, Xn to see how Y is related to the X variables. From this point of view, CCA is a generalization of multiple regressions in which Y variables are simultaneously related to several X variables (Janse *et al.* 2019).

Hypothesis of interest is change in predicted variables and yarn strength of 40s (YS-40s) and yarn strength of 60s (YS-60s) properties which are called (set 1) and four grades of cotton Fully Good (FG), Good (G), Fully Good Fair (FGF) and Good Fair (GF) which is called (set 2). The null hypothesis is equivalent to testing the hypothesis that all P canonical variate pairs are uncorrelated or the hypothesis of interest is: H_0: $\rho^*1=\rho^*2=\ldots=\rho^*P=0$; H_a: Not all P_i equal zero (Gu and Wu 2018).

SPSS syntax 21 software was used for all statistical analyses of this study (SPSS 2012).

III. Results

The summary of descriptive statistics for extra long staple cotton varieties (G 92 and G 93) and long varieties (G 86 and G 95) are reported in Table1 and Table 2. According to studying mean of fiber properties and yarn strength, there are gradually decreased from Fully Good (FG) lint grade to Good Fair (GF) through Good (G) and Fully Good Fair (FGF) for upper half mean length, mean length, uniformity index, strength, relative strength, YS-40s and YS-60s. On the contrary; short fiber content (SFC) and short fiber index (SFI) are increased gradually from FG to GF. There are some properties are not depending on grades such as color yellowness (+b), micronaire value (MIC), maturity ratio (M %), linear density (LD) and elongation (E %). A similar trend of results was detected by several authors (Liu *et. al* 2015 and Yang and Gorden 2016). In Tables (1 and 2) using standard deviation (SD) and coefficient of variation (CV) are rigorous for comparing any lint grade with others especially in the case of the same average (Nick 2007).

Any inappropriate results of coefficient of variation for Fully Good, Good, Fully Good Fair and Good Fair may be due to several reasons such as operators, not efficient sample sizes and devices.

According to measure variance inflation factor (VIF); the studied variables were more than limited values for VIF for the existence of multicollinearity. A VIF between 5 and 10 indicates high correlation that may be problematic. According to that multicollinearity is clarified by very high intercorrelations between variables where it is a type of disturbance in the data. If multicollinearity presents in the data; the statistical inference made the data may be not reliable as usual as it uses for (Kock and Lynn 2012). According to the existence of multicollinearity within data variables then using any dimension reduction techniques is powerful to study data without this problem such as canonical correlation analysis (CCA) (Merola and Abraham 2003).

Some statistical multivariate criteria and F approximation for multivariate test of dimension statistics are presented in Table (3). By far the most common method used is Wilks Lamda (λ) as it tends to have the most general applicability. The method was statistically significant for G86, G95, G92 and G93 varieties. On basis of this, rejecting the null hypothesis that there were no relationship between the variable sets and concluded that there probably were relationship using Wilks; $1-\lambda = r^2$, it was estimated nearly 0.99 for the four studied varieties.

Initially, it was tested that the hypothesis of independence was rejected. Then it can be obtained estimates of canonical correlation. In general, the number of canonical dimensions is equal to the number of variables in the smaller set. However, the number of significant dimensions may be even smaller. Herein Table (4) there is one canonical dimension which is significant with eigen value above one. According to the significant dimension; test indicates the significant of its contrast canonical correlation. For extra staple long varieties; G92 fiber and yarn properties explain 80.37% of total variance while grades explain 80.03%. Meanwhile in G 93 fiber and yarn properties demonstrated 86.46 % of total variance while grades explain 84.99%. Long staple varieties i.e. G86 and G95 elucidate total variance of (83.91 and 82.63 %) and (71.99 and 71.68%) for (fiber and yarn properties) and lint cotton grade, respectively. Results of Table (4) show that the canonical correlation is statistically significant with its significant dimension. The squared values of canonical variate pairs, found in the squared canonical correlation column, can be interpreted much in the same way as r^2 values are interpreted. The same trend was reported by (Hardoon et al. 2004).

Canonical coefficients are shown in Table (5). The raw canonical coefficients can be interpreted as same as to interpret regression coefficients. For instance, in the variable UHM; 1 unit increases in UHM leads to 1.88 percent increase in the canonical variate for G86 when all of the other variables are held constant meanwhile 1 unit increase for G93 leads to 0.864 decrease in the canonical variate. Similarly, high positive raw coefficient is observed for variable a* (5.48) for G95. The standardized coefficients allow for easier comparisons among the variables when all variables in the model have very different standard deviation. The standardized canonical coefficients are interpreted in a manner as same as to interpret standardized regression coefficients.

Below are correlations between observed variables and canonical variate which are known as the canonical loadings. Correlation between covariates and dependent variables with canonical variates are reported in Table (6). The canonical correlations between fiber properties and yarn strength of YS-40s and YS-60s with canonical variate are positive for all studied variables except for short fiber index and short fiber content in G86. Meanwhile in G 95 the canonical correlations between the studied variables are negative except for short fiber index and short fiber content. In extra long staple varieties (G 92 and G 93) canonical correlation between variables and canonical variate are negative except for short fiber content and short fiber index adding to elongation was positive for G 92.

According to the previous results, it was selected (YS-60s) where the YS-40 and YS-60 are in the same trend. The univariate regression analysis carried out to confirm the results from canonical correlation analysis (CCA) for YS-60 in Table (7) for cotton fiber properties. The value of standard error is obvious for each measurement in G 92, G 93, G 86 and G 95. Where the standard error measures the dispersion (how far is the studied data for each variable distanced from its mean?). Table (7) illustrated standard error for extra staple varieties; it ranged from 0.004 to 1.65 for G 92 variety in maturity ratio (MR %) and relative strength to HVI (Rel-Strength), respectively. Meanwhile in G 93 ranged from 0.009 to 0.422 for a* and linear density (LD), respectively. The lowest standard error for G 86 and G 95 were 0.008 and 0.011 for a* meanwhile the highest one was 3.73 for upper half mean (UHM) in

Table 1: Summary statistics of response and predicted variables with cotton grades for G 86 and G 95

Variable	Parameter	G 86				G 95			
		FG	G	FGF	GF	FG	G	FGF	GF
UHM mm	Mean	32.93	32.62	32.15	31.60	29.53	29.08	28.82	28.07
	S.D.	0.103	0.117	0.235	0.155	0.175	0.179	0.199	0.975
	C.V.	0.313	0.359	0.731	4.91	0.593	0.615	0.690	3.47
ML mm	Mean	28.38	27.85	27.00	26.25	24.47	23.78	23.38	22.18
	S.D.	0.101	0.105	0.385	0.442	0.234	0.343	0.399	1.67
	C.V.	0.356	0.377	1.43	1.68	0.956	1.44	1.71	7.53
UI%	Mean	86.68	85.53	84.10	83.07	83.00	82.03	81.13	78.77
	S.D.	0.371	0.423	0.465	0.848	0.509	0.568	0.367	3.29
	C.V.	0.428	0.494	0.553	1.02	0.613	0.692	0.452	4.18
SFC%	Mean	2.06	3.24	5.67	7.68	3.42	4.92	6.23	8.42
	S.D.	0.330	0.713	1.16	2.00	0.100	0.117	0.375	0.579
	C.V.	16.02	22.01	20.46	26.04	2.92	3.59	6.01	6.88
SFI%	Mean	2.26	2.80	3.62	4.56	8.51	9.36	9.92	11.66
	S.D.	0.066	0.093	0.327	0.439	0.207	0.261	0.742	2.00
	C.V.	2.92	3.32	9.03	9.63	2.43	2.79	7.48	17.15
E %	Mean	7.88	8.20	7.90	8.60	9.50	9.02	8.52	7.5
	S.D.	0.367	0.175	0.367	0.175	0.322	0.343	0.293	0.329
	C.V.	4.66	2.13	4.65	2.03	3.39	3.80	3.44	4.39
Strength CN	Mean	21.12	20.93	18.67	16.08	19.11	17.45	14.31	12.10
	S.D.	0.874	0.979	0.792	1.71	0.012	0.046	1.54	2.15
	C.V.	4.14	4.68	4.24	10.63	0.063	0.264	10.76	17.77
Rel-Strength g/tex	Mean	46.35	43.50	41.58	39.38	36.04	35.2	33.56	32.73
	S.D.	2.55	0.486	0.937	2.18	0.096	0.647	0.887	2.65
	C.V.	0.55	1.12	2.25	5.54	0.266	1.84	2.64	8.09
a*	Mean	0.175	0.262	0.330	0.992	1.61	1.78	1.87	1.98
	S.D.	0.007	0.018	0.029	0.020	0.068	0.052	0.037	0.077
	C.V.	4.00	6.87	8.79	2.02	4.22	2.92	1.98	3.89
Rd%	Mean	77.47	76.23	74.13	72.47	69.30	67.33	65.17	63.13
	S.D.	0.151	0.166	0.374	0.871	0.335	0.742	0.301	0.654
	C.V.	0.195	0.218	0.505	1.20	0.483	1.10	0.462	1.04
+b	Mean	8.53	8.87	9.17	9.40	12.33	12.17	12.08	11.68
	S.D.	0.413	0.137	0.121	0.126	0.082	0.082	0.041	0.240
	C.V.	4.84	1.54	1.32	1.34	0.665	0.674	0.339	2.05
MIC	Mean	4.66	4.06	3.71	3.56	4.23	4.09	3.97	3.82
	S.D.	0.096	0.165	0.184	0.289	0.009	0.070	0.299	0.468
	C.V.	2.06	4.06	4.96	8.12	0.213	1.71	7.53	12.25
MR %	Mean	0.878	0.861	0.854	0.833	0.856	0.832	0.813	0.775
	S.D.	0.029	0.111	0.155	0.199	0.012	0.262	0.088	0.099
	C.V.	3.30	12.89	18.15	23.89	1.40	3.15	10.82	12.77
LD	Mean	174.83	163.50	157.67	142.00	167.50	165.67	150.33	141.67
	S.D.	3.71	3.94	7.15	10.09	4.04	4.50	5.80	7.63
	C.V.	2.12	2.41	4.53	7.11	2.41	2.72	3.86	5.39
YS-40s	Mean	2903	2856	2770	2690	2530	2476	2416	2355
	S.D.	26.58	28.75	44.09	45.29	15.46	20.33	41.31	49.45
	C.V.	0.916	1.01	1.59	1.68	0.611	0.821	1.71	2.09
YS-60s	Mean	2888	2821	2747	2671	2463	2361	2220	2152

	S.D.	14.38	25.63	47.09	31.25	25.03	35.45	91.43	105.31
	C.V.	0.498	0.908	1.71	1.17	1.02	1.50	4.12	4.89

Table 2: Summary statistics of response and predicted variables with cotton grades for G 92 and G 93

Variable	Parameter	G 92				G 93			
		FG	G	FGF	GF	FG	G	FGF	GF
UHM mm	Mean	33.98	33.27	32.58	31.70	34.03	33.40	32.63	31.55
	S.D.	0.065	0.367	0.354	0.815	0.009	0.167	0.341	0.568
	C.V.	0.191	1.10	1.09	2.57	0.026	0.500	1.05	1.80
ML mm	Mean	29.60	28.07	26.57	25.05	29.94	29.28	28.28	27.05
	S.D.	0.222	0.528	0.565	1.03	0.111	0.256	0.392	0.758
	C.V.	0.750	1.88	2.13	4.11	0.371	0.874	1.39	2.80
UI%	Mean	87.1	84.38	81.55	79.02	87.98	87.66	86.67	85.74
	S.D.	0.674	0.903	2.99	4.89	0.739	0.582	0.573	1.37
	C.V.	0.774	1.07	3.67	6.19	0.839	0.664	0.661	1.59
SFC%	Mean	3.67	4.89	6.38	8.92	4.97	5.99	6.99	8.36
	S.D.	0.555	0.779	0.735	1.77	0.495	0.277	0.406	1.58
	C.V.	15.12	15.93	11.52	19.84	9.96	4.62	5.81	18.89
SFI%	Mean	3.74	4.87	6.05	7.37	1.81	2.79	3.92	5.75
	S.D.	0.372	0.585	0.300	1.23	0.191	0.320	0.493	1.11
	C.V.	9.95	12.01	4.96	16.69	10.55	11.47	12.58	19.30
E %	Mean	6.77	6.37	7.15	7.60	9.40	9.50	9.60	9.33
	S.D.	0.333	0.446	0.625	0.888	0.352	0.400	0.534	0.680
	C.V.	4.92	7.00	8.74	11.68	3.75	4.21	5.56	7.29
Strength CN	Mean	27.83	25.82	24.35	22.60	28.12	27.25	25.42	23.37
	S.D.	0.321	0.343	0.838	1.59	0.231	0.418	0.634	1.17
	C.V.	1.15	1.33	3.44	7.04	0.821	1.54	2.49	5.00
Rel-Strength g/tex	Mean	47.45	46.12	44.08	42.31	49.33	47.33	45.65	42.68
	S.D.	0.579	0.978	1.55	2.65	0.444	0.599	0.927	1.72
	C.V.	1.22	2.12	3.52	6.26	0.900	1.27	2.03	4.03
a*	Mean	0.258	0.437	0.607	0.918	2.65	2.78	2.86	3.07
	S.D.	0.010	0.039	0.091	0.157	0.022	0.026	0.032	0.039
	C.V.	3.88	8.92	14.99	17.10	0.830	0.935	1.19	1.27
Rd%	Mean	74.34	72.91	72.03	71.43	65.03	64.37	63.43	62.07
	S.D.	1.49	1.89	0.627	2.48	0.207	0.207	0.484	0.408
	C.V.	2.00	2.59	0.870	3.47	0.318	0.322	0.763	0.657
+b	Mean	8.36	8.52	9.20	9.85	12.50	11.97	11.68	11.37
	S.D.	0.194	0.212	0.126	0.251	0.141	0.163	0.166	0.151
	C.V.	2.32	2.49	1.37	2.54	1.23	1.36	1.42	1.33
MIC	Mean	3.99	3.45	3.30	3.23	3.52	3.39	3.28	3.13
	S.D.	0.016	0.106	0.256	0.366	0.005	0.025	0.321	0.444
	C.V.	0.401	3.07	7.76	11.33	0.142	0.737	9.78	14.19
M %	Mean	0.880	0.863	0.849	0.832	0.869	0.833	0.811	0.775
	S.D.	0.015	0.021	0.010	0.023	0.021	0.05	0.111	0.122
	C.V.	1.70	2.43	1.18	2.76	2.41	6.00	13.69	15.74
LD	Mean	155.00	143.50	137.50	130.3	149.83	142.50	138.17	133.67
	S.D.	1.67	4.51	5.81	7.63	3.87	4.38	5.00	0.599
	C.V.	1.08	3.14	4.23	5.86	2.58	3.07	4.14	4.48
YS-40s	Mean	3398	3370	3258	3178	3539	3401	3314	3240
	S.D.	4.08	5.55	10.20	20.15	22.45	80.35	88.12	85.85
	C.V.	0.120	0.165	0.313	0.634	0.634	2.36	2.66	3.05
YS-60s	Mean	3346	3316	3239	3097	3475	3350	3261	3187
	S.D.	10.33	8.16	20.00	372.04	27.39	34.64	44.90	80.81
	C.V.	0.309	0.246	0.617	12.01	0.788	1.03	1.38	2.54

Table 3: Hotellings and Wilks multivariate statistics and F approximation

Varieties	Statistics	value	F-value	Num DF	Den DF	Significance
G 92	Hotellings	233.59	82.45	17	6	**
	Wilks	0.004				
G 93	Hotellings	57.53	20.30			
	Wilks	0.017				
G 86	Hotellings	64.61	22.80			
	Wilks	0.015				
G 95	Hotellings	231.25	81.62			
	Wilks	0.004				

Table 4: Eigen value, canonical correlation and variance in variables explained by canonical correlation

Varieties	Dimensions	Eigen value	Canonical correlation	Square canonical correlation	Technological and yarn properties variance	Grade Variance
G92	1	233.59	0.998	0.996	80.37	80.03
G93	1	57.53	0.991	0.983	86.46	84.99
G86	1	285.54	0.998	0.997	83.91	82.63
G95	1	231.25	0.998	0.996	71.99	71.68

Table 5: Raw and standardized Canonical coefficient for technological and yarn variables

Covariate	G92		G93		G86		G95	
	CV1	CV1	CV1	CV1	CV1	CV1	CV1	CV1
	Raw	Standarized	Raw	Standarized	Raw	Standarized	Raw	Standarized
UHM	-0.217	-0.217	-0.864	-0.669	1.88	1.00	2.44	1.76
ML	0.335	0.335	-1.03	-1.34	0.025	-1.59	-3.03	-3.86
UI	0.161	0.161	0.283	0.627	-1.32	-0.379	2.15	4.84
SFC	-0.007	-0.007	0.107	0.145	-0.295	0.157	0.794	0.412
SFI	-0.676	-0.676	-0.345	-0.558	-0.253	-1.22	0.451	0.782
E%	0.137	0.189	-0.021	-0.028	-1.81	-0.689	0.909	0.740
Strength	0.059	0.240	2.45	6.04	-0.693	0.493	-0.448	-1.64
Rel-Strength	-0.021	-0.379	-1.59	-5.73	0.222	-0.354	0.454	2.44
a*	-1.25	-0.334	-4.69	-0.751	-0.119	-0.119	5.48	0.825
Rd%	-0.155	-0.972	-0.219	-0.260	-1.301	1.39	0.528	0.690
+b	0.121	0.117	2.78	1.24	1.56	-0.684	-4.21	-1.16
MIC	-0.535	-0.166	8.81	1.13	-1.72	1.02	-8.35	1.14
M %	9.55	0.610	-0.257	-1.03	2.29	0.293	0.173	0.576
LD	0.021	0.199	-0.126	-0.810	0.033	0.486	-0.047	-0.476
YS-40s	-0.007	-0.583	-0.001	-0.125	-0.001	-0.109	-0.020	-1.45
YS-60s	-0.001	-0.245	-0.005	-0.456	-0.003	-0.227	-0.003	-0.380

Table 6: Correlations between variables and canonical variate

Variable	G 92	G 93	G 86	G 95
Covariate	CV1	CV1	CV1	CV1
UHM	-0.929	-0.938	0.964	-0.743
ML	-0.924	-0.937	0.946	-0.709
UI	-0.936	-0.929	0.943	-0.691
SFC	0.800	0.949	-0.860	0.834
SFI	0.899	0.920	-0.956	0.660
E%	0.775	-0.940	0.926	-0.914
Strength	-0.903	-0.920	0.890	-0.867
Rel-Strength	-0.876	-0.920	0.884	-0.887
a*	-0.922	-0.954	0.899	-0.922
Rd%	-0.961	-0.958	0.856	-0.935
+b	-0.957	-0.953	0.839	-0.848
MIC	-0.899	-0.849	0.942	-0.907
M %	-0.946	-0.886	0.890	-0.897
LD	-0.951	-0.945	0.934	-0.946
YS-40s	-0.967	-0.939	0.942	-0.944
YS-60s	-0.560	-0.941	0.948	-0.927

Table 7: Regression and adjusted coefficient of determination (R^2adj.) estimates for G 92, G 93, G 86 and G 95 in YS-60

Variable	Extra long staple varieties						Long staple varieties					
	G 92			G 93			G 86			G 95		
	Standardized coefficient Beta	Std. Error	R^2adj.	Standardized coefficient Beta	Std.Error	R^2adj	Standardized coefficient Beta	Std.Error	R^2adj	Standardized coefficient Beta	Std.Error	R^2adj.
UHM	-0.928	0.102	0.854	-0.930	0.053	0.859	-212.37	3.73	0.911	-0.741	0.090	0.529
ML	0.922	0.135	0.843	-0.929	0.089	0.857	-111.94	2.51	0.876	-0.708	0.063	0.479
UI	-0.934	0.158	0.866	-0.922	0.160	0.843	-12.38	0.35	0.870	-0.689	0.305	0.451
SFC	0.798	0.409	0.621	0.941	0.086	0.879	5.55	0.242	0.716	0.832	0.054	0.679
SFI	0.898	0.126	0.797	0.912	0.123	0.825	8.02	0.147	0.896	0.659	0.243	0.408
E%	0.773	0.163	0.579	-0.933	0.089	0.864	0.670	0.011	0.837	-0.912	0.063	0.823
Strength	-0.901	0.324	0.804	-0.913	0.188	0.826	-0.883	0.194	0.770	-0.866	0.342	0.738
Rel-Strength	-0.875	1.65	0.754	-0.913	0.273	0.825	-0.877	0.266	0.759	-0.885	0.468	0.773
a*	-0.919	0.019	0.839	-0.945	0.009	0.889	-0.893	0.008	0.788	-0.920	0.011	0.840
Rd%	-0.959	0.331	0.917	-0.949	0.069	0.897	-0.849	0.088	0.709	-0.933	0.088	0.864
+b	-0.955	0.054	0.907	-0.945	0.027	0.888	-0.833	0.088	0.679	-0.846	0.027	0.703
MIC	-0.899	0.025	0.797	-0.842	0.013	0.696	-0.935	0.029	0.868	-0.905	0.014	0.810
M %	-0.944	0.004	0.887	-0.878	0.356	0.761	-0.883	2.98	0.770	-0.895	0.278	0.792
LD	-0.949	0.564	0.897	-0.936	0.422	0.871	-0.926	1.02	0.852	-0.944	0.623	0.887

G 86 and 0.623 for linear density (LD) in G 95. Table (7) showed also how this model could explain coefficient determination for each variable when all of the other variables are held constant and that after analyzing canonical correlation analysis (CCA).

IV. Conclusion

Canonical correlation analysis (CCA) is one of the powerful tool for analysis of a multivariate analysis of correlation. It explores the relationships between two multivariate sets of variables (vectors), all measured on the same individual which describes the relationship between the first set of variables and the second set of variables without thinking of one set of variables as independent and the other as dependent. Then studying the interrelations among cotton fiber properties and yarn strength of 40s and 60s as one set are more rigorous than studying individual traits as studying only one predicted variable versus several predictors. Therefore, using CCA is one of the several methods to study associations among different cotton properties to final cotton product.

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