COMPARISON BETWEEN AMERICAN AND EGYPTIAN EQUIPMENT FOR TESTING FIBER PROPERTIES OF EGYPTIAN COTTON

by

Mohsin Abbas Al Didi

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SIGNED:

Mohsin Al Didi

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INTRODUCTION

Significant advances have been made recently in developing instruments and applying techniques for measuring the properties of cotton fibers. Many workers have contributed to these advances which are important to cotton breeders who are striving to develop better cottons, and to others whose interest is to utilize more effective combinations of cotton fiber properties. These new instruments and techniques, being accurate and rapid, have largely replaced the former ones which are laborious, slow, and expensive for routine tests.

Moreover, it has been known for a long time that the spinning performance of cotton depends upon certain fiber properties such as length, strength, structure, and fineness. Within the past few years a great deal has been discovered about their properties and their inter-relationship effect upon yarn and fiber quality. For cotton breeders it is a matter of great importance to predict, as early as possible, the spinning value of their selections from fiber tests carried out on small samples to avoid working on selections which may prove unsatisfactory at a later stage. Consumers and manufacturers are interested in this problem, too.

These recent advances in instruments and techniques are the result of research carried out on American cottons which differ from the Egyptian cottons in fiber properties. The exceptionally long staple Egyptian varieties, i.e., Karnak (Giza 29), Menoufi (Giza 36), Amon (Giza 39), and Giza 45, have no major counterpart in the United States; and the shorter staple varieties, i.e., Ashmouni and Zagora, are comparable only to the long staple Mississippi Delta varieties. (49) The Egyptian cottons today have a deservedly good reputation among spinners all over the world. This reputation has been maintained by the efforts of many workers in agriculture, plant breeding (13) and related fields. The fiber property determinations used in developing these Egyptian varieties were much different than those currently employed by American cotton breeders.

The spinning tests of the established Egyptian cotton varieties, new varieties, and selections under test are reported from the Spinning Test Mill at Giza, which was established in 1935 and attached to the Plant Breeding Section of the Egyptian Ministry of Agriculture. Spinning tests there are conducted by the use of standard industrial machinery to obtain the most accurate and dependable results.

Therefore, it was considered of interest to test the Egyptian cottons by these American instruments for determining fiber properties, and to determine their accuracy for testing extra long staple cottons. For this purpose, the Egyptian commercial cotton varieties were tested first in Egypt to determine accurately their fiber properties. These samples were then sent to the author at the University of Arizona and retested for the same fiber properties on American instruments, i.e., the Fibrograph, the Micronaire, and the Pressley Fiber Strength Tester. A comparison was made between the fiber properties of these cottons as determined by Egyptian "standards" and by American "standards."

To study the above instruments more fully, a comparison was made between different predictions of spinning performance as determined from different fiber properties, and the best prediction was established.

The significance of these results and their importance to Egyptian cotton breeders and to American cotton breeders who are working on long staple cottons are discussed.

REVIEW OF LITERATURE

The important researches which have been carried out on the determination of cotton fiber properties are briefly summarized here.

Staple Length of Cotton Fibers

The importance of the mean fiber length of any cotton sample is well known, since it serves as a major criterion for the judgment of its quality. Other things being equal, finer yarns can generally be produced from the longer cotton; and in any one count, the longer cottons lead to greater strength than shorter cottons. (44)

A correct estimation of this character, however, has always been difficult in view of the fact that lint, even from a single seed, is made up of innumerable fibers of different lengths. (43, 47)

Although a number of methods possessing varying degrees of accuracy are known for determining the mean fiber length of any sample (2, 5, 7, 40, 51, 56, 57, 70), the "sorters" developed by Balls, Baer, and Webb are considered to be the most reliable and have been adopted as standard. These "sorters," however, have been found to be laborious and time consuming. The Balls sorter requires about two hours and the Baer sorter one and one-half hours for a single determination. (51).

In Balls' method (7, 8, 33) the fibers of various group lengths are sorted out at intervals of 1/8 inch, weighed, and mean fiber length determination is made on the assumption that the cumulative length of all fibers of each group length is proportional to the weight of the section; it is accordingly calculated on the basis of the formula

$$\frac{\Sigma (WL)}{8(\Sigma W)}$$

where $\Sigma (WL)$ is the summation of all the products of sectional weights and the group length, (ΣW) the total weight of the fibers of the groups. From a diagram showing the percentage by weight of various group lengths, a quantity named the "half-fall" is measured off which agrees closely with staple length as estimated by graders. (33)

In Baer's method (5) a diagram is formed by arranging the fibers in order of their length, side by side, on a common base to form a pattern of uniform density as determined by the eyes of the operator. The pattern so formed has a minimum base length of 4 inches. The area of the whole pattern is derived by dividing the base into units of 0.5 inch, and adding up the areas in 1/8 inch squares covered by the fibers from longest to shortest, standing on successive units of the base. The whole area is computed from a minimum of 8 sections ranging from the longest to the shortest fibers in the pattern. The total area of the pattern in square inches divided by the base in inches gives the mean fiber length.

Another measurement, "effective length," is derived from the Baer Sorter Diagram. This quantity, within limits, has been found to be fairly typical for a given variety of cotton. (44) The "half-fall" derived from Balls Sorter Diagram is found to agree closely with the "effective length" derived from the Baer Sorter Diagram in Egyptian cottons. (20)

More recently the Fibrograph machine test has made inroads on the "sorters" test because of the high speed with which the newer test can be made. At least ten fibrograph tests can be made while making one sorter test, "Suter Webb test." (29)

The Fibrograph (36, 37) is a photoelectric instrument employing light sensitive cells for scanning samples of parallel cotton fibers and simultaneously tracing a special light-frequency curve known as a "Fibrogram." The geometrical properties of the resulting curve make it possible to quickly obtain various average length intervals, mean length and upper half mean, and coefficient of variation.

For some types of investigations the sorter test is preferred because it gives precise information on the percentage of fibers of different lengths in a sample, in addition to a value for upper quartile length, mean length, and length variability. (29)

The important thing about the mean fiber length is that it should ideally represent the mean length of all fibers included in a representative sample of lint. The various methods adopted for the purpose are the nearest approximation to it by indirect estimation.

Additional methods have been suggested for determination of the variability of fiber lengths estimated by the previous methods. These are:

1. The "dispersion percentage" of Clegg (20)
2. The "irregularity percentage" of Ahmed and Navkal (3)
3. The "length uniformity index" of Hertel. (36)

Each of these measures is based on the use of a different instrument for determining the mean fiber length. Thus Clegg derives the "dispersion percentage" from a geometrical construction superimposed on a Baer diagram. Ahmed and Navkal use the Balls sorter and find the ratio of the weight of the fibers which are less than three-fourths of the modal length to the total weight of fibers to obtain the "irregularity percentage" of fiber length. Hertel derives his "length uniformity index" from the curve traced by the Fibrograph by dividing the upper half mean length into the mean length.

Fineness of Cotton Fibers

Although the term "fiber fineness" has come into general use and is well established in cotton literature as applied to hair weight measurements, it is not a very good description. In this connection, the term must be taken to mean "fineness by weight for equal length." More precisely, fineness implies two properties: small diameter, which is largely an inherited character; and thin fiber wall, which is dependent on both genetic and environmental influences. These two properties are not exactly correlated. The two Egyptian varieties, Maarad and Giza 7, for example, are found to be nearly identical in fineness by diameter, but Maarad is appreciably finer according to weight. (77)

The accepted method of determining the "fineness" of cotton is to divide the weight of a counted number of fibers by the product of the number of fibers times the mean length to obtain the average weight per unit length of the individual cotton hairs.

The importance of this method as a measure of fineness in cotton has come to be realized since Balls (6) first introduced it, as it is required in assessing the spinning value of a cotton, the number of fibers per seed, surface area of fibers in a known weight of lint, standard fiber weight, and the number of fibers in the cross-section of a yarn. The earlier methods used by Balls, Burd (16) and Morton (48) are open to two objections. First, the sampling is biased because fiber lengths less than the cut lengths are ignored; and, second, the cut portions are necessarily the middle portions and as such are expected to give a higher value of fiber weight per unit length than that averaged over the whole fiber. The work of Iyengar and Turner (39) has shown that the first objection does not materially affect the value of fiber weight per unit length. The effect of the second objection has been studied frequently. O'Neill (52) found that the breaks occurred near the ends of a cotton fiber, and that each successive test gave a higher value. He attributed this behavior to the fiber diameter in cross-sectional area being greater in the middle portion. Turner (67) found that in some cases the weight of individual fibers decreases very considerably from the middle of the fiber to the apex. Further, the recent studies of Pearson (53) showed that the location of the maximum perimeter near the middle of the fibers appears to be the most common condition. Goldthwait, Smith and Barnett (30) developed a differential dyeing technique for cotton fibers which showed probable variations of wall thickness along a fiber length. Both base and tip dye green (thin-walled), whereas the middle of the fiber dyes red (thick-walled).

Therefore, the determination of "fineness" by the cut fiber method obviously would be higher than the actual mean, because the middle portions of the fibers are selected, which are found to be heavier than the end portions. Moreover, sorting and counting is a tedious, time-consuming process. Hence there has recently been much interest in the use of air flow methods in the measurement of cotton "fineness."

Back in 1888, Greenhill (32) propounded and proved a theorem of hydrodynamics which has recently been put to very good use in measuring the total surface area of small particles when held in the form of porous plugs. Wiggins (74) and Hertel (26, 64, 65) and their collaborators saw in this a means of measuring the surface area or the diameter of textile fibers. Hertel proposed that the surface area per gram of cotton fibers, determined by the porous plug method, should be used as a measure of fineness in cotton. The method seemed practical on several kinds of fibers. Cassie (18) extended this method to the measurement of wool fiber diameter by air permeability.

Since then several workers have devised different methods of applying the general principle, all of which depend upon the resistance to the flow of air through a known mass of fibers which is compressed to constant density in the form of a porous plug. At least four types of instruments using this principle have been developed. (29) They are:

1. The Schiefer-Frazier Fabric Permeability Tester, as adapted by Pfeiffenberger (54) for cotton fineness testing and given the name "Permeameter" by him. It uses a low rate of flow through a low density plug.

2. The Kendall Mills Porosity Meter developed by Elting and associates. (25) This instrument uses a much denser plug and a high rate of flow.

3. The "Arealometer." (64, 65)

4. The "Micronaire Fiber Fineness Tester" developed jointly by a commercial textile firm and an instrument manufacturer. (63) This instrument uses a fairly high plug density. By means of reducing valves, air pressure is stabilized at a fixed level, and the rate of flow of air through the plug is measured by a visible flowmeter of the rotameter type. The scale on the instrument is graduated in micrograms per inch.

Cottons with large mean fiber weight have a small specific surface (the surface area per unit mass of the material) and so offer small resistance to the flow of air. Cottons with low mean fiber weight have a large specific surface, and so offer a large resistance to the flow of air.

Recently, Brown and Graham (14), working on the measurement of fineness of cotton by air-flow methods, came to the conclusion that all the previous instruments are excellent devices, giving valid, reproducible results. Although the general problem of air flow through porous media is quite complex, the air-flow method applied to measuring cotton fibers fortunately is much simplified over the usual situation for the following reasons:

1. The volume of the plug is constant.
2. The mass of the fiber in the plug is constant.
3. The density of all cottons is nearly constant.
4. From reasons 1, 2, and 3 it follows that the channel around the fibers in the plug is constant.

The scale of the Micronaire was based on the linear relationship which was observed between air permeability and actual weight per inch of fiber of cotton of all types within the range of normal fiber maturity. The studies carried on by the Cotton Branch of the Production and Marketing Administration, U.S.D.A., showed that the relationship between the Micronaire values and the weight-per-inch method values is of a curvilinear nature (21), and the new revised scale is now used for testing American Upland cottons. It was shown, however, that neither the original linear scale nor the revised scale for Upland cottons gave satisfactory results in relation to actual weight-per-inch values for American Egyptian and other extra long staple cottons. (22) As a result of further studies, a special direct reading Micronaire scale is now used with American Egyptian and similar cottons.

Strength of Cotton Fibers

Since fibers are very long in relation to their thickness and since they are used mainly in the form of fabrics or laminar structures that are thin compared with their area, the forces to which they are subjected in manufacture and use nearly always cause the fibers to stretch. Such forces are known as tensile forces. The tensile strength is commonly used as an index of quality. The maximum resistance to stretching forces developed in a tensile test in which the sample is broken is called the "breaking load"; it is measured, for example, in grams or pounds.

The Chandler bundle method (59) using the pendulum type Scott tester was the most widely used procedure for testing fiber strength for many years. In operation, a bundle of fibers about a millimeter in diameter is used as the sample. The fibers are combed to remove trash and drawn out parallel. The bundle is then wrapped with thread of known size and length so the cross-sectional area can be calculated from measurement of the circumference. The wrapped bundle, held with specially devised clamps, is placed in the test jaws of the breaker where the weight required for breaking is determined. The tensile strength of the sample is calculated as pounds per square inch of cross-sectional area.

To obviate difficulties inherent in the wrapped bundle method of testing, Crowley (23) proposed a flat bundle test for fibers, which was adapted by Bellinson (11) for cotton and other similar fibers.

Pressley (58) has developed an instrument for testing fibers by the flat bundle method which is relatively inexpensive and is both fast and simple in operation. The fiber bundle is formed for testing in removable jaws which are inserted into the machine. A sliding weight moves down an incline until the fiber bundle breaks, where the weight automatically locks in position. The broken bundle is then weighed. The quotient obtained by dividing the breaking load in pounds by the weight in milligrams of the bundle is the strength index. Because of the more general understanding of fiber strength when expressed in terms of tensile strength, the index is converted into 1000 pounds per square inch by applying the following formula:

$$\text{Tensile strength} = (10.8116 \times \text{strength index}) - 0.12$$

Since its development in 1942, the Pressley Fiber Strength Tester has largely replaced the laborious Chandler Bundle Test as a method of evaluating the relative fiber strengths of various cottons.

The Pressley Fiber Strength Tester was studied by Shepherd (62), who found evidence of variations between operators and between instruments which he could not fully explain. Williams and Painter (75) observed variations which could be assigned to the type of instrument used or to the person making the test. Other factors which are seen to influence results were ribbon width, jaw pressure, bundle alignment, and the mechanical condition of the instrument. They indicated, too, an increase in strength of bundles with increase in length of fiber, but offered no interpretation.

Grant and Morlier (31) compared two methods of determining fiber strength: the individual fiber test and the Pressley Fiber Strength Tester. They found that because of the combing action in bundle preparation, cotton fibers broken in the flat bundle test represent the longer fibers found in a sample of cotton. These fibers are not representative of the length of the original samples, and since fiber specific strength increases with fiber length, neither are they representative of the strength of the original sample.

Older researches, too, have shown the pronounced effect of test specimen length on tensile strength of single cotton fibers (19) and cotton yarns. (15, 55)

This increase in breaking load with length found by Williams and Painter, Grant and Morlier, and others does not bear out the findings of Nanjundayya and Ahmed (50) who reported the reverse to be true.

The most accurate method of determining the strength of cotton is yarn strength testing, which is presented as the product of lea strength x counts, commonly known as the "lea product." In this test, cotton lint is spun and results of actual spinning tests are determined.

The amount of cotton required for a quality test is often an important matter to cotton breeders, especially with varieties at an early stage of development. Several attempts were made to obtain spinning tests from micro-samples of cotton. Hancock (34) was able to develop a technique for spinning 60-gram samples on standard cotton machinery. Now these micro-spinnings are carried out on all F_3 families and families of subsequent generations at the Plant Breeding Section, Egyptian Ministry of Agriculture.

Prediction of Spinning Properties from Fiber Properties

It is well known that one of the most important factors in determining the quality of cotton is the spinning performance of its lint, which is correctly estimated only by carrying out spinning tests under controlled conditions and expert supervision. Such tests, however, are both expensive and time consuming.

So far as cotton breeders are concerned, it is a matter of utmost importance to know the probable spinning performances of their selections, as early as possible, from fiber tests carried out on small samples so that they may confine their attention to desirable strains only. This would save a large amount of labor, money, and time that may be spent on such strains as would prove unsatisfactory from the spinning point of view at a later stage.

Apart from cotton breeders, consumers and manufacturers are also deeply interested in this problem. Until recently fiber length in combination with grade was the only criterion for purchasing cotton. Length has long been recognized as the individual fiber property most highly correlated with yarn strength. Two other important properties, fiber fineness and strength, have been proposed successively as criteria by several researches using statistical methods. (27)

On account of the importance of this problem, i.e., forecasting yarn strength from measured lint characters, research workers for many years have attempted to determine the contributing factors in this problem.

Balls (8) postulated that the effect of length is largely exaggerated, and that long fibered cotton can be spun into fine yarn numbers not because of its length, but because of its fineness. Turner (66) stated that fiber strength has little value in predicting the skein strength of singles yarn because too little of the fiber strength is utilized in the yarn. Kohler (42) reviewed the early work on spinning and stated that only 10 to 20 per cent of the fiber strength is evident in the yarn strength. Turner and Venkataraman (68) correlated certain fiber properties with yarn strength and concluded that fiber length is most closely associated with the highest standard warp count and that fiber weight per inch is next in order. Kapadia (41) concluded that fiber strength is an important factor of yarn strength, and that fiber fineness is more important than fiber length. Underwood (69) found that spinning quality is related to a greater effective length, percentage of normal (thick-walled) hairs, and a lower mean hair weight per centimeter, in the order given. In this study where Egyptian cottons were examined alone, however, length was not significantly correlated with spinning quality.

Hutchinson and Govande (38) obtained, by separating varietal and environmental factors, relatively high r values for variety effects and low r values for environmental effects when they correlated mean fiber length and fineness with spinning value of Indian cottons. Richardson (60) found that greater fiber length, lighter unit weight (greater fineness), and higher intrinsic fiber strength singly and collectively lead to a greater elasticity and strength in yarns; he suggested that more uniformity in all properties would lead to better cottons. Carter (17) recently found that mean fiber strength has the most consistent effect on yarn strength in American cottons.

Webb and Richardson (71, 72) made a general or over-all correlation of six fiber properties and skein strength. They found in the first study that in terms of skein strength of 22's and 60's carded yarn, fiber strength was the most important of the six fiber properties considered, i.e., upper quartile fiber length, Chandler bundle strengths, weight fineness, grade of cottons, length uniformity, and per cent of thick-walled fibers. In the second study there were slight changes in the order of significance for 22's, but fiber strength remained the most important fiber property.

Berkley, Woodyard, Barker, Kerr and Kings (12) observed that the importance of the various fiber properties changed when going from 22's to 60's yarn. Fiber strength appeared to be more important in 22's, whereas length, and particularly fineness, gained in importance at the expense of fiber strength at the higher counts.

Still other researches (9, 10) have presented the significant fiber properties in a different order of importance.

Fiori and Brown (27) came to the conclusion that "This lack of agreement is not unexpected since the cottons used for these investigations differed widely in their characteristics, and the different laboratories conducting the experiments used widely different processing techniques." They studied fiber fineness while maintaining other important properties approximately constant, and found that a relationship exists between fiber fineness and turns per inch required in a single yarn to obtain optimum yarn strength.

In India, cotton research workers have tried to develop formulas for the prediction of the spinning value of Indian cottons from their fiber properties. The first prediction formula was given by Turner and Venkataraman (68) as a result of their studies on the fiber properties of 95 samples of standard Indian cottons. It was as follows:

$$X_1 = 75.4\ X_2 - 79.5\ X_3 - 22.8$$

where X_1 = highest standard warp counts, X_2 = mean fiber length, and X_3 = fiber weight per inch (10^{-6} oz.).

As a result of studies on 153 samples, Ahmed (1) evolved the following formula for predicting the spinning performance of Indian cottons on the basis of the above-mentioned two major fiber properties:

$$X_1 = 78.9\ X_2 - 79.2\ X_3 - 24.8$$

He divided the Indian cottons into four major groups, and separate prediction formulas have been worked out for each group on the basis of their fiber properties, which give much better agreement with actual tests. Gadkari and Ahmed (28) working on Gaorani (Bani) cottons gave another formula:

$$X_1 = 65.37\ X_2 - 251.98\ X_3 + 19.18$$

In Egypt, extensive work has been carried out in the Giza Spinning Test Mill of the Egyptian Ministry of Agriculture to correlate measureable lint characters with yarn strength in the hope of solving the problem of forecasting yarn strength from the hair properties. (76, 77). A good forecast of yarn strength has been found possible from the ratio of staple length (half-fall) to hair weight, the correlation coefficient between actual and forecasted yarn strength being about 0.93. The deviations from the normal as detected from the correlation diagram are expressed either by anomalously strong cottons, which give higher yarn strength than expected from their hair measurements, or anomalously weak ones, which give lower yarn strength than expected. In other words, the former cottons are of higher intrinsic strength, while the latter are of lower intrinsic strength. The Egyptian cottons were found to be of a higher intrinsic fiber strength than the majority of foreign cottons.

There is something important to be borne in mind about these prediction formulas which are based on fiber properties. The cotton fibers pass through fairly elaborate opening, cleaning, and preparatory processes before they are formed into a roving ready for spinning. During these processes the fibers are pretty harshly beaten, teased, pulled, bent, twisted by the action of the spikes and beaters, card wire points, drafting rollers, etc. The effect of this severe treatment on the physical properties of the fiber was studied to assess the extent of such effects and to enable any possible changes to be made in the processing details. Further, it would enable the experimenters to see if the prediction formulas, based on fiber properties, require any modification.

Balls (8) states on page 112: "It was noticed after carding some cotton that the hair weight of the sliver was a little less than that of the strippings from flats and cylinder. These strippings were returned to the card, and again the hair weight of the new strippings was raised about 2% above that of the new sliver, making a total shift of 4% above that of the original cotton. Now although the experiment was incidental and the actual shift very small, it is a result of some importance in that it proves the possibility of sifting out coarse hairs from fine ones. It may be that serious study of the card will accidentally provide a clue to the method by which this may be done."

Turner and Venkataraman (68) state on page 27: "Fourthly, the cotton fibers of the yarn are not exactly those that comprised the raw cotton, as in various preparatory processes of spinning some lint is removed as waste, having a rather shorter mean length than the raw cotton, and other fiber properties also are slightly different. Yet the raw cotton must be used in determination of fiber properties when these are required for the prediction of spinning value. However, tests on this point have shown that the differences in fiber properties between the yarn and the raw cotton are not serious, so that they may be regarded as merged in errors of experiment and sampling."

Webb and Richardson (73) made corresponding measurements by the same test methods and procedures on the fiber properties in both the raw cottons and the second drawing slivers. The findings reported give good evidence that the testing of raw cotton is a comparatively reliable method of approach for evaluating the relative fiber quality of a cotton, and that it is capable of providing a reasonably trustworthy basis for estimating or predicting the relative spinning quality of different cottons.

EXPERIMENTAL PROCEDURE

Six samples, representing the purest types of the Egyptian commercial varieties of cotton grown in 1952, were sent from Egypt after being tested by the Spinning Test Mill of the Egyptian Ministry of Agriculture for three important fiber properties: length, fineness, and strength.

The commercial varieties of cotton grown now in Egypt are described here briefly. (24, 35, 45, 46) The cottons are listed in ascending order of spinning quality:

1. Giza 19, "Ashmouni, Zagora" (introduced 1868)

These are the "bread and butter" cottons of Egypt. Zagora was originally a separate variety introduced about 1917, but Ashmouni and Zagora are now from identical Ashmouni seed grown respectively in Upper Egypt and the Delta, the difference between the cottons arising solely from the conditions of growth. Ashmouni is stronger and finer in staple than Zagora and therefore spins stronger yarns. Both cottons spin clean, strong yarns free from nep; Ashmouni is suitable for warps up to 80's combed, while Zagora is more usually recommended for weft. Ashmouni only was tested in this research.

2. Giza 30 (introduced 1945)

This is a medium stapled cotton, soft in character, and unusually white and showy for Egyptian. It is a hybrid from Giza 7 and Sakha 11. The variety has high yield and ginning out turn, and the crop runs at high grade. On account of its whiteness, Giza 30 is probably the most suitable Egyptian cotton for knitting trades.

3. Giza 29, "Karnak" (introduced 1939)

This is a long staple type derived from a cross between Maarad and Sakha 3. The crop runs at high grade and is longer in staple and distinctly better in spinning quality than the former Sakel. The variety is remarkably uniform in quality wherever it is grown.

4. Giza 36, "Menoufi" (introduced 1942)

This is a general purpose cotton and the highest yielding variety commercially grown. The variety is a hybrid derived from the cross Giza 12 and Sakha 3. A new improved Menoufi type has been developed and is now being propagated to displace the original seed supply. "Improved" Menoufi is approaching Karnak in fiber properties, although slightly longer.

5. Giza 39, "Amoun" (introduced 1945)

This is the best spinning Egyptian quality. Although fully 1/8 inch shorter in staple, Amoun gives stronger yarn than Montserrat Sea Island in all counts and is a white and showy cotton to a degree unusual in Egyptian. It is suitable for the highest quality embroidery threads and fine sewing, also for parachute or balloon fabrics or for any purpose where exceptional strength is required. The variety is a cross between Giza 26 and Sakha 4.

6. Giza 45 (on trial)

This is a super quality cotton suitable for the same purposes as Amoun but of a higher yield. It is derived from the cross Giza 7 x Giza 28.

A new variety, Giza 31 (Dandara), is now grown in the south of Upper Egypt, which is the most suitable zone for its growth. It is prolific and earlier than Ashmouni, also of a higher ginning out turn and yield. No samples were available from this variety; therefore, it was excluded from the research.

Measurements of staple length, hair weight, along with the yarn test for these varieties are shown in Table I as reported from the Spinning Test Mill at Giza, Egypt. The methods used in Egypt are given here.

Mean length and half-fall (7, 8):

Mean length is measured by the Balls sorter. The sorter mechanism consists of a pair of delivery rollers which deliver cotton through their nip, at which time they are being translated bodily in relation to a collecting device such as a strip of plush. The rollers are fed with hairs which have previously been laid parallel in a sliver, always a third drawframe sliver. The feed is intermittent in a series of cycles, and for any one cycle the sliver is fed forward about a millimeter by the feed rollers which support it. It is then brought up to the nip of the delivery rollers and held there while they are turning through the feed distance. Thus the delivery

Table I

Spinning-test Report on Egyptian Cotton Varieties, 1952

Variety	Yarn strength 60's carded	Mean length	Half-fall*	Hair weight per cm.
		inches	1/32"	10^{-8} gms.
Giza 19	1740	0.98	42	186
Giza 30	2100	0.94	42	158
Giza 29	2765	1.03	48	146
Giza 36	2840	1.07	48	135
Giza 39	2985	1.04	49	116
Giza 45	3140	1.03	50	118

*Half-fall is actually designated as "staple length" in the Egyptian literature on cotton (33)

rollers take hold of the front ends of a number of hairs. The sliver is then withdrawn quickly to its former position about 1/8 inch away from the delivery roller nip, so that the particular hairs which had been gripped are partly dragged out from the body of the sliver. The delivery rollers continue to turn uninterruptedly. These partially freed hairs with their front ends still even continue to be dragged out and are passed forward to the other side of the delivery roller nip until all of them have been set free from the rollers and gathered up by the collector. Since the front ends are in alignment, it follows that the first hair to be released on the other side of the delivery rollers will be that hair which is shortest. The longest hair will be the last set free. Thus the mixture of hair lengths in the original sliver is "sorted" out into regular sequence of lengths, usually at stages of 1/8 inch. Then the fibers of various group lengths are weighed, and the mean length is determined by the formula

$$\frac{\Sigma\ (WL)}{8\ x\ (\Sigma W)}$$

where Σ(WL) is the summation of all the products of the sectional weights and the group length, and (ΣW) is the total weight of all the fibers of the groups.

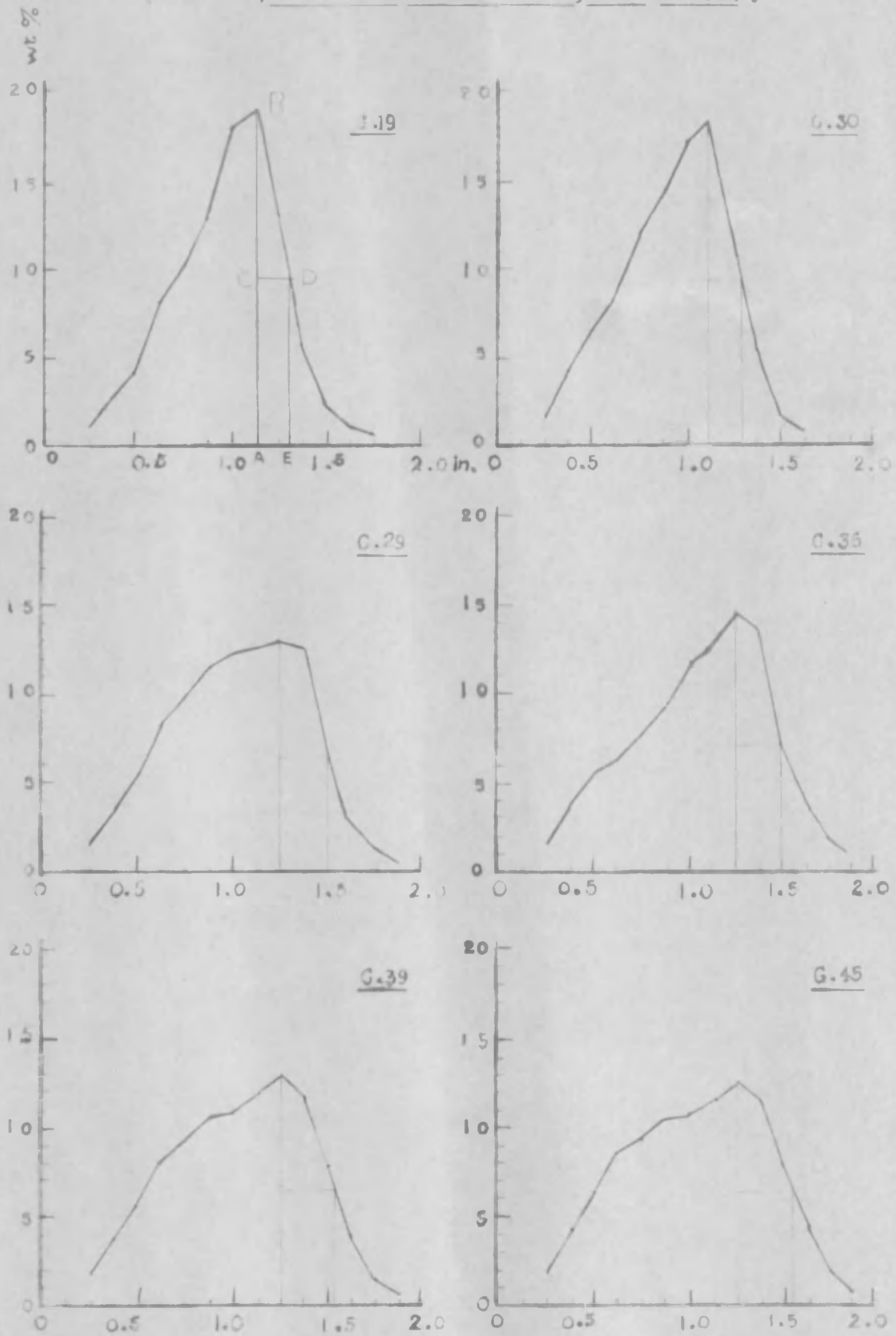
To estimate the half-fall (33), the Balls sorter data are used to construct a diagram showing the proportion of cotton in each class by weight (Plate 1).

A perpendicular line is dropped from the sorter peak B to A (Plate 1, G.19); a horizontal line is drawn through C (AC = 1/2 AB) intersecting the curve at D; a perpendicular line is then dropped from D to E, and the length (O-E) is defined as "half-fall." The half-fall is expressed in 32nds of an inch as being more suitable for rapid comparisons, and agrees closely with staple length as estimated by graders.

<u>Hair weight</u>:

Although the term "hair weight" is used for convenience, it should be repeated that the term applies to "fineness by weight" for equal length. The purpose of this measurement is to obtain a figure for the weight of 1 centimeter of the

(PLATE I.) "HALF-FALL" DETERMINATION, BALLS SORTER.



average hair. (8)

A number of hairs are withdrawn from a prepared sliver so that these hairs can be separated and ready for easy counting instead of being tangled. The hairs are laid out on a slide and counted under a microscope with a moderately powerful objective, thereby avoiding eye strain. After they have been counted, the assembled bundle is cut to a known length (14.7 millimeters) and weighed on an Oertling Assay balance, which is sensitive to hundredths of a milligram.

The total length of hairs in the bundle is then computed and recorded. The hairs are weighed, and the hair weight per centimeter is computed. The value is expressed as a three-figure number, the omission of .00 mgm./cm. being understood.

Four determinations were made from every sample.

<u>Yarn strength</u>:

The yarn strength quoted is the product of lea strength in pounds times the yarn counts product (or shortly, the lea product) of 60's carded ring twist yarn, twist factor being 3.6.

Testing Egyptian Cottons on the American Equipment

In obtaining reliable fiber test results it is very essential to provide uniform and adequate test conditions, and to use a dependable sampling procedure. Test conditions and sampling procedures as adopted by the American Society for Testing Materials and used for this research are widely used in fiber laboratories in the United States of America and are the result of intensive research work on the part of many scientists. (4)

All tests and essential operations involved are carried out in a standard atmosphere having a relative humidity of 65 per cent at 70° F. (21° C.). A tolerance of plus or minus 2° F. in temperature during the conditioning of the samples for at least 4 hours prior to testing is permitted.

The sample is spread into a thin, uniform layer, and a laboratory test sample is taken by selecting 48 pinches each weighing approximately 25 milligrams. These pinches are continued and the process repeated, but with a decrease in number and an increase in weight of pinches. This is continued until the laboratory sample consists of 3 pinches of 400 milligrams each.

One of these 3 pinches is further homogenized by mixing and lapping, and is divided into 3 sub-samples for determining length and other fiber properties such as fineness, maturity, and cross-section. The Fibrograph test specimen is taken directly from the laboratory sample. A second pinch, after being homogenized, is divided into 3-5 sub-samples for determining strength. The third of the 400-milligram pinches is kept for extra test specimens, if needed.

In the present study the Egyptian cottons, after being tested in Egypt for fiber properties (length, fineness, and strength) were sent to the writer at the University of Arizona and were re-tested for the same fiber properties. The fiber length was measured by the Fibrograph, fiber fineness by the Micronaire, and fiber strength by the Pressley Fiber Strength Tester.

Fiber length determined by the Fibrograph:

A Fibrograph test specimen was made from 3 or more pinches, each taken from a different portion of the laboratory sample (approximately 425 mg.). The specimen was divided into 2 parts of about equal size. The broken parts were then placed one on the other so that broken ends coincided. With the Fibrograph comb in one hand and the sample in the other, fibers were collected from the broken surface of the sample, using 10-15 strokes. With an empty comb and the comb containing the fiber for the test specimen, the cotton was combed until half of the fibers were embedded in each comb; approximately 20 strokes were required for the first combing. The fibers were then transferred from one comb to the other so that all the fibers were on one comb, and re-combed as in the first combing with the exception that approximately 10 strokes were necessary instead of 20. A final transfer and combing were made, requiring not more than 10 strokes, after which the combs contained equal quantities of parallel fibers caught at random in their teeth.

The combs were placed in the Fibrograph machine for scanning the fiber surface. The resulting curve traced by the Fibrograph pen on the "fibrogram" represented the relative number of fibers at each position along the sample. Tangents drawn to the resulting curve gave two fiber length measurements: (a) the mean length of all fibers in the sample, (b) upper half mean, the average length of the longer half of the fiber population which compares roughly with staple length as judged by commercial classers.

The length uniformity index for a sample was obtained by multiplying the ratio of mean length to the upper half mean length by 100.

Five test specimens and five fibrograms were made from each sample.

The instrument used was Fibrograph Model 800-F Series.

<u>Fiber fineness determined by the Micronaire</u>:

A Micronaire test specimen consisted of 5 or 6 pinches taken at random with a total weight of 50 grains (3.240 grams). Each specimen was placed in the compression cylinder, and the compression plunger was put in place and secured by turning clockwise. The foot pedal was pressed, and a reading of the float position on the scale was recorded. The Micronaire is calibrated in terms of weight per inch for the convenience of those familiar with hair weight.

Fiber determinations with the Micronaire involved making 2 readings on 2 representative specimens from the original sample.

The scale installed on the Micronaire used for this research was the original linear scale, which is not suitable for testing extra long, fine-fibered cottons such as American-Egyptian, Egyptian, and Sea Island. Therefore, the readings for the Egyptian cottons were taken on the linear scale and then the true fiber fineness for these cottons was computed from this equation used originally for American-Egyptian cottons (22):

$$Y_1 = 1.514 + .0413\ x + .101\ X^2$$

where Y_1 = American-Egyptian (or Egyptian) fiber fineness (micrograms per inch) and X = Micronaire linear-scale fineness units.

<u>Fiber strength determined by the Pressley Fiber Strength Tester:</u>

A test specimen was prepared by extracting pinches from several places in the bulk laboratory sample and placing the pinches one on top of the other. The tuft thus formed was held near its middle point in one hand between the thumb and forefinger, and combed with a special, coarse hand comb by taking about 15 strokes to each end of the sample.

The pair of fiber clamps was inserted in the vise, locked in place, and the top sections of the clamps were raised. A small portion was taken from the prepared tuft and pulled through the fine comb attached to the vise. The flat bundle (approximately 1/4 inch wide) was placed in the clamps and tightened to keep the fiber from slipping. The clamps were removed from the vise, and the protruding ends of the ribbon were sheared off with a special knife. The loaded clamps were placed in the machine, and the rolling weight was released.

When the weight stopped rolling, the beam reading was recorded. If the break was ragged or less than 10 pounds, the test was discarded and another test specimen used.

The clamps were removed from the machine, placed in the vise and opened. The broken ribbon was weighed on a Roller-Smith Precision Balance with a range of 0-5 milligrams. Six breaks were made from each sample of test cotton.

The number of pounds read from the beam divided by the weight of broken fibers in milligrams gave the strength index, or the number of pounds required to break a milligram of cotton of a standard length of .464 inches, which is the width of the clamps.

The difference between each break should not be greater than .80 pounds in the strength index.

The strength index was converted into 1000 pounds per square inch by applying the following formula:

Tensile strength = (10.8116 x strength index) - 0.12.

EXPERIMENTAL RESULTS

As previously stated, 6 of the cultivated Egyptian varieties were tested in the Cotton Spinning Mill, Giza, for length, fineness, and strength of fiber. It was necessary to do this testing in Egypt since the type of testing equipment used in that country is not available at the University of Arizona. The results of these tests were brought to Arizona to be used in evaluating the results of tests of the same fiber properties as determined on American equipment.

Determination of Fiber Length

The weight and percentage of fibers in each of the length classes, and mean length as determined by the Balls sorter, are shown in Table II. The half-fall for each variety is shown in Plate I (page 27).

The values for these samples derived from the Fibrograph are shown in Table III with the figures for the mean length, half-fall, irregularity percentage, and uniformity ratio as determined by the Balls sorter.

The coefficient of correlation between mean length as determined by the Fibrograph and mean length as determined by the Balls sorter was .946, which is significant above the 1 per cent level of probability.

Table II

Mean Length of Egyptian Cotton Varieties as Determined by the Balls Sorter

Length (L)	G. 19 Weight of strip (W)	G. 19 %	G. 30 Weight of strip (W)	G. 30 %	G. 29 Weight of strip (W)	G. 29 %
1/8"	mgm.		mgm.		mgm.	
2	0.7	1.04	0.6	1.52	0.6	1.42
3	1.8	2.68	1.6	4.06	1.4	3.31
4	2.9	4.31	2.4	6.08	2.2	5.20
5	5.5	8.18	3.2	8.14	3.4	8.04
6	7.0	10.42	4.6	11.67	4.2	9.93
7	9.0	13.39	5.6	14.21	4.8	11.35
8	12.1	18.00	6.6	16.76	5.1	12.06
9	12.8	19.05	7.1	18.04	5.3	12.53
10	8.8	13.10	4.5	11.42	5.4	12.76
11	3.8	5.66	2.2	5.58	5.3	12.53
12	1.7	2.53	0.7	1.78	2.7	6.38
13	0.7	1.04	0.3	0.76	1.2	2.83
14	0.4	0.59	-	-	0.5	1.18
15	-	-	-	-	0.2	0.47
16	-	-	-	-	-	-
Total	67.2		39.4		42.3	

G. 19:

$$\bar{x} = \frac{\Sigma (L) \times (W)}{8 \times \Sigma (W)} = \frac{527.8}{8 \times 67.2} = \frac{527.8}{537.6} = 0.98 \text{ inch}$$

G. 30:

$$\bar{x} = \frac{\Sigma (L) \times (W)}{8 \times \Sigma (W)} = \frac{296.6}{8 \times 39.4} = \frac{296.6}{315.2} = 0.94 \text{ inch}$$

G. 29:

$$\bar{x} = \frac{\Sigma (L) \times (W)}{8 \times \Sigma (W)} = \frac{348.8}{8 \times 42.3} = \frac{348.8}{338.4} = 1.03 \text{ inch}$$

Table II (cont.)

Length (L)	G. 36 Weight of strip (W)	G. 36 %	G. 39 Weight of strip (W)	G. 39 %	G. 45 Weight of strip (W)	G. 45 %
1/8"	mgm.		mgm.		mgm.	
2	0.7	1.47	0.8	1.74	0.8	1.78
3	1.8	3.77	1.7	3.70	1.8	4.01
4	2.6	5.45	2.6	5.65	2.7	6.01
5	3.0	6.29	3.7	8.04	3.8	8.47
6	3.6	7.55	4.2	9.13	4.2	9.35
7	4.4	9.22	4.8	10.44	4.6	10.25
8	5.5	11.54	5.0	10.87	4.9	10.91
9	6.1	12.80	5.5	11.96	5.1	11.36
10	7.0	14.67	6.0	13.04	5.6	12.47
11	6.5	13.63	5.4	11.74	5.1	11.36
12	3.4	7.13	3.5	7.61	3.4	7.58
13	1.9	3.98	1.8	3.91	1.8	4.01
14	0.9	1.88	0.7	1.52	0.8	1.78
15	0.3	0.63	0.3	0.65	0.3	0.67
16	-	-	-	-	-	-
Total	47.7		46.0		44.9	

G. 36:

$$\bar{x} = \frac{\Sigma (L) \times (W)}{8 \times \Sigma (W)} = \frac{407.6}{8 \times 47.7} = \frac{407.6}{381.6} = 1.07 \text{ inch}$$

G. 39:

$$\bar{x} = \frac{\Sigma (L) \times (W)}{8 \times \Sigma (W)} = \frac{383.0}{8 \times 46.0} = \frac{383.0}{368.0} = 1.04 \text{ inch}$$

G. 45:

$$\bar{x} = \frac{\Sigma (L) \times (W)}{8 \times \Sigma (W)} = \frac{371.3}{8 \times 44.9} = \frac{371.3}{359.7} = 1.03 \text{ inch}$$

Table III

Fiber Length Determinations of Egyptian Cotton Varieties by the Fibrograph and Balls Sorter

	FIBROGRAPH		
Variety	Mean Length	Upper Half Mean	Uniformity Index*
	inches	inches	
G. 19	0.92	1.06	86.79
G. 30	0.90	1.06	84.91
G. 29	1.09	1.30	83.85
G. 36	1.11	1.30	85.38
G. 39	1.10	1.32	83.33
G. 45	1.09	1.33	81.95

		BALLS SORTER		
Variety	Mean Length	Half-fall	Irregularity Percentage**	Uniformity Ratio***
	inches	1/32"		
G. 19	0.98	42	26.64	74.7
G. 30	0.94	42	31.47	71.6
G. 29	1.03	48	39.24	68.7
G. 36	1.07	48	33.75	71.3
G. 39	1.04	49	38.70	67.9
G. 45	1.03	50	39.87	65.9

*Length uniformity index (Fibrograph)

$$= \frac{\text{mean length}}{\text{upper half mean}} \times 100$$

**Irregularity percentage

$$= \frac{\text{per cent of fibers less than 3/4 modal length}}{\text{total weight of fibers}} \times 100$$

***Uniformity ratio (Balls sorter)

$$= \frac{\text{mean length}}{\text{half-fall}} \times 100$$

The coefficient of correlation between the upper half mean derived from the Fibrogram and the half-fall derived from the Balls Sorter Diagram was .992.

The coefficient of correlation between the length uniformity index of the Fibrograph and the irregularity percentage of Ahmed and Navkal was -.877. This is significant at about the 2 per cent level.

Since there was a highly significant correlation between the mean lengths as determined by the Fibrograph and the Balls sorter, these data show that it was possible to determine with comparable accuracy the mean fiber length of a cotton by the Fibrograph and in much less time.

The regression equation was calculated for changing the mean length by the Fibrograph (x) into the mean length by the Balls sorter (y) and is given thus:

$$y = .5434 + .4557x$$

The regression equation for changing upper half mean (x) to half-fall (y) is:

$$y = 12.3202 + 27.0128x$$

Tables IV and V were set up for changing the mean and upper half mean of the Fibrograph into the mean and half-fall of the Balls sorter without further calculations.

The irregularity of a cotton sample tested by the Balls sorter was calculated by the method adopted by Ahmed and Navkal.(3) The correlation coefficient between the length uniformity index and the irregularity percentage was found to

Table IV

Values for Conversion of Mean Length as Determined by the Fibrograph to Estimate Mean Length for the Balls Sorter

Mean length		Mean length	
Fibrograph	Balls sorter	Fibrograph	Balls sorter
inches	inches	inches	inches
.85	.93	1.03	1.01
.86	.94	1.04	1.02
.87	.94	1.05	1.02
.88	.94	1.06	1.03
.89	.95	1.07	1.03
.90	.95	1.08	1.04
.91	.96	1.09	1.04
.92	.96	1.10	1.04
.93	.97	1.11	1.05
.94	.97	1.12	1.05
.95	.98	1.13	1.06
.96	.98	1.14	1.06
.97	.99	1.15	1.07
.98	.99	1.16	1.07
.99	.99	1.17	1.08
1.00	1.00	1.18	1.08
1.01	1.00	1.19	1.09
1.02	1.01	1.20	1.09

Table V

Values for Conversion of Upper Half Mean Fiber Length as Determined by the Fibrograph to Estimate Half-fall for the Balls Sorter

Fibrograph upper half mean	Balls sorter half-fall	Fibrograph upper half mean	Balls sorter half-fall
inches	1/32"	inches	1/32"
1.05	42	1.22	46
1.06	42	1.23	47
1.07	42	1.24	47
1.08	42	1.25	47
1.09	43	1.26	47
1.10	43	1.27	48
1.11	43	1.28	48
1.12	44	1.29	48
1.13	44	1.30	48
1.14	44	1.31	49
1.15	44	1.32	49
1.16	45	1.33	49
1.17	45	1.34	50
1.18	45	1.35	50
1.19	45	1.36	50
1.20	46	1.37	50
1.21	46		

be -.877.

From the results showing the high correlation between the Fibrograph mean length and the Balls sorter mean length and the similar correlation between the Fibrograph upper half mean and the Balls sorter half-fall, it is suggested that a new uniformity ratio be adopted by users of the Balls sorter, i.e.

$$\frac{\text{Mean length (Balls sorter)}}{\text{Half-fall (Balls sorter)}} \times 100$$

The correlation between the Fibrograph length uniformity index and the new uniformity ratio suggested was found to be .990. This nearly perfect r value lends strong support for the use of the new uniformity ratio.

Determination of Fiber Fineness

The fiber fineness of the Egyptian cottons as determined by the cut fiber method (1 cm. long) and the Micronaire is shown in Table VI with the coefficient of correlation. From this table it is shown that there was a high correlation between the "hair weight" of these cottons as determined by the cut fiber method and the "fiber fineness" as determined by the Micronaire.

This result was expected because of the relationship between air permeability and actual weight per unit of fiber within the range of normal fiber maturity. In the Micronaire the resistance of air offered by a given mass of cotton under the standard condition previously mentioned depends mainly

Table VI

Fiber Fineness of Egyptian Cotton Varieties as Determined by the Micronaire and the Cut Fiber Method

Variety	Micronaire American-Egyptian scale (a)	Hair weight (b)
	u gram/inch	hundredth mgm./cm.
G. 19	4.27	186
G. 30	3.91	158
G. 29	3.05	146
G. 36	2.82	135
G. 39	2.26	116
G. 45	2.29	118

*Correlation between (a) and (b), r = 0.976

on the surface area of fibers in this mass. The specific surface (surface area per unit mass of fibers) depends on the number of fibers in the mass and the mean fiber diameter. The number of fibers again depends on mean fiber weight per unit length and mean fiber length. Then the resistance offered by a given mass of cotton to the flow of air under the standard conditions varies with fiber diameter, fiber weight, and fiber length.

Mean fiber diameter and fiber maturity (development of secondary cellulose deposit within fiber walls) contribute to the mean fiber weight of a sample. Therefore, in normally mature cotton, the mean fiber weight per unit length is a measure of the fiber diameter and hence of the specific surface. A cotton with a heavy mean fiber weight has a small specific surface and so offers small resistance to the air flow, whereas a small volume of air passes through the mass of cotton with a low mean fiber weight under standard conditions.

The linear regression of hair weight measurement (y) on the Micronaire reading "American-Egyptian scale" (x) was computed, and the coefficient of regression of y on x found to be:

$$y = 47.081 + 30.995x$$

For convenience, Table VII was made to give with fair accuracy the hair weight measurements from the Micronaire readings on the American-Egyptian scale.

It was thought desirable to design a direct reading hair weight scale for use in testing Egyptian cottons based upon the previous results. This scale can be installed in the Micronaire and reads immediately the hair weight of one centimeter in .00 milligram. The new scale, the linear scale formerly used, the curvilinear scale for testing American Upland cottons, and the curvilinear scale for testing American-Egyptian cottons are illustrated in Plate II.

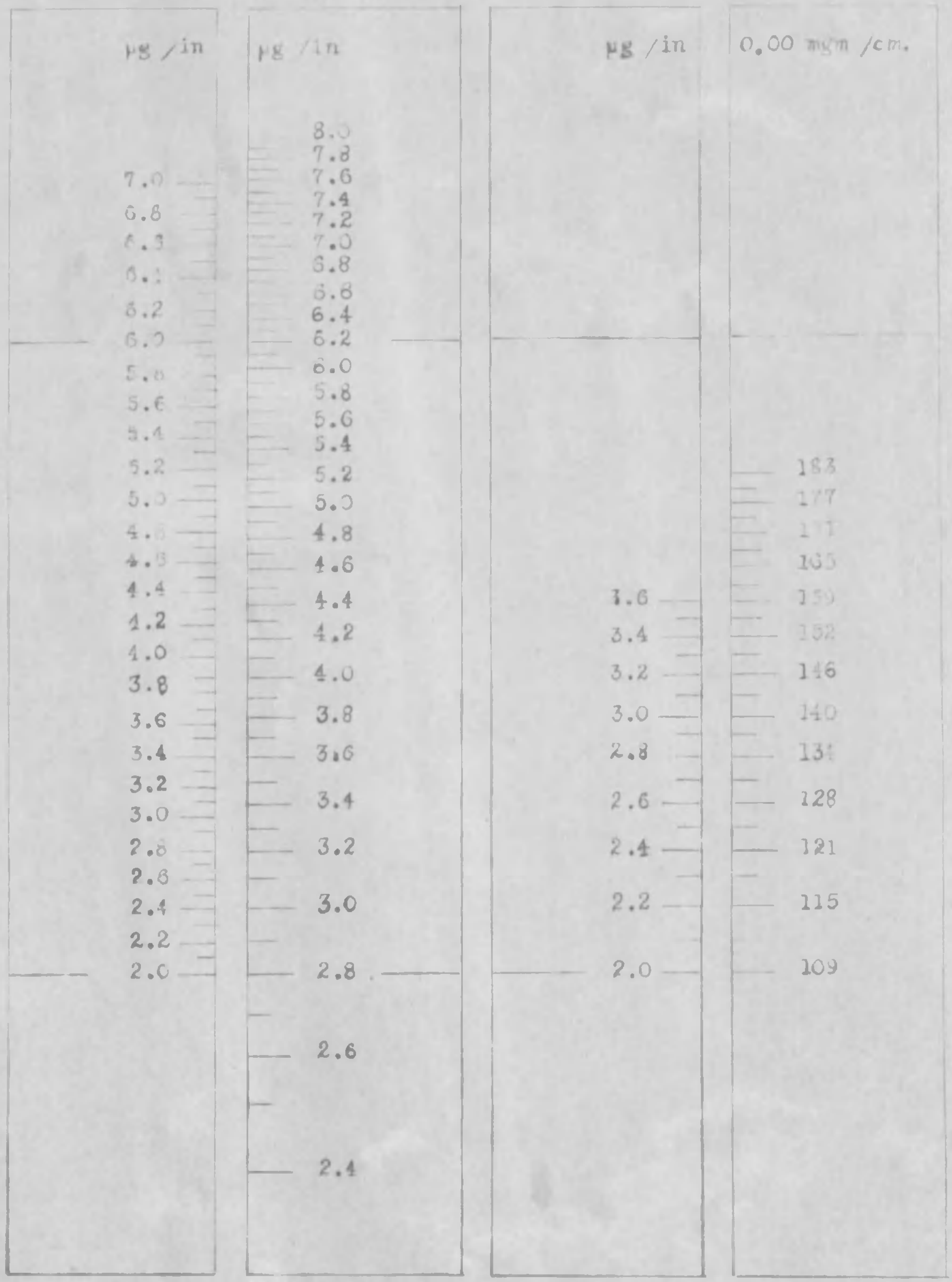
The Micronaire cannot give reliable figures for anomalous cottons. Two cottons having the same fiber weight can differ

Table VII

Values for Conversion of Fineness as Determined by the Micronaire (American-Egyptian Scale) to Estimate Hair Weight for the Cut Fiber Method

Micronaire (American-Egyptian scale)	Hair weight	Micronaire (American-Egyptian scale)	Hair weight
grams	hundredth milligram	grams	hundredth milligram
2.0	109	3.3	149
2.1	112	3.4	152
2.2	115	3.5	156
2.3	118	3.6	159
2.4	121	3.7	162
2.5	124	3.8	165
2.6	128	3.9	168
2.7	131	4.0	171
2.8	134	4.1	174
2.9	137	4.2	177
3.0	140	4.3	180
3.1	143	4.4	183
3.2	146	4.5	187

(PLATE II.) MICRONAIRE FIBER- FINENESS SCALES



Linear Scale

Amer.- Upland Scale

Amer.- Egypt. Scale

Egyptian Scale

in their specific surface areas because of a difference in the mean fiber diameters of the two cottons. The differences in fiber maturity are responsible for the same mean fiber weight. The cotton with the smaller fiber diameter is more mature than the cotton with the larger fiber diameter. The fiber weight therefore remains the same. The cotton with the larger fiber diameter will have a smaller specific surface area and will offer less resistance to the flow of air than the cotton with the larger fiber diameter, the density of packing remaining the same. Thus, two cottons with the same mean fiber weight may still give two different air permeameter readings.

Two cottons with different fiber weights may also give rise to the same air permeameter reading under the following conditions: If the cotton with the larger fiber weight was more mature and the cotton with the lesser fiber weight was more immature, it is possible that the fiber diameter of both cottons may be the same. In such a case, the resistance to the flow of air offered by both the cottons will be the same.

As long as the determination of the hair weight by the cut fiber method is probably higher than it should be because the determination is made on the middle portions of the fibers, which are heavier than the end portions, the air permeameter method can be used to give reliable values for mean fiber weight per unit length in comparison with the cut fiber method.

Determination of Fiber Strength

The strength of Egyptian cottons, as determined by the Pressley Fiber Strength Tester and the Lea Test, is shown in Table VIII with coefficient of correlation between tensile strength and lea product.

Table VIII

Pressley Index, Tensile Strength, and Lea Product of Egyptian Cotton Varieties

Variety	Pressley index	Tensile strength (a)	Lea product (b)
	lbs./mgm.	1000 lbs./sq.in.	60's
G. 19	8.4	90.697	1740
G. 30	9.3	100.428	2100
G. 29	10.7	115.564	2765
G. 36	10.9	117.726	2840
G. 39	11.2	120.970	2985
G. 45	11.4	123.132	3140

Correlation between (a) and (b), $r = 0.999$

This table shows clearly the high correlation between the tensile strength as determined on the Pressley Fiber Strength Tester and the lea product.

The regression of the lea product (y) on tensile strength (x) is found to be

$$y = 42.5049x - 2140.8747$$

For convenience Table IX was made to give the estimated lea product from the Pressley index or tensile strength.

Table IX

Values for Conversion of Strength as Determined by the Pressley Fiber Strength Tester to Estimate the Lea Product

Pressley index	Tensile strength	Lea product
lbs./mgm.	1000 lbs./sq.in.	60's
8.0	86.373	1530
8.1	87.454	1576
8.2	88.535	1622
8.3	89.616	1668
8.4	90.697	1714
8.5	91.779	1760
8.6	92.860	1806
8.7	93.941	1852
8.8	95.022	1898
8.9	96.103	1944
9.0	97.184	1990
9.1	98.266	2036
9.2	99.347	2082
9.3	100.428	2128
9.4	101.509	2174
9.5	102.590	2220
9.6	103.671	2266
9.7	104.753	2312
9.8	105.834	2358
9.9	106.915	2404
10.0	107.996	2449
10.1	109.077	2495
10.2	110.158	2541
10.3	111.239	2587
10.4	112.321	2633
10.5	113.402	2679
10.6	114.483	2725

Table IX (cont.)

Pressley index	Tensile strength	Lea product
lbs./mgm.	1000 lbs./sq.in.	60's
10.7	115.564	2771
10.8	116.645	2817
10.9	117.726	2863
11.0	118.808	2909
11.1	119.889	2955
11.2	120.970	3001
11.3	122.051	3047
11.4	123.132	3093
11.5	124.213	3139
11.6	125.294	3185
11.7	126.376	3231
11.8	127.457	3277
11.9	128.538	3323

The previous regression equation is important in predicting the "anomaly" of the Egyptian cottons. If the calculated strength by this equation is more than the actual strength, then the cotton is considered anomalously weak; whereas if the actual strength exceeds the calculated strength, then the cotton is considered anomalously strong. If both the calculated and actual strength are the same, the cotton is normal.

Table X shows the actual and the calculated strength of the Egyptian varieties and the amount of deviation of the actual strength from the calculated strength. This table shows the anomaly of G. 19 and G. 45 toward strength, and the anomaly of G. 30, G. 36 and G. 39 toward weakness, while G. 29

Table X

Actual and Calculated Strength (Lea Product) of Egyptian Cotton Varieties

Variety	Strength (lea product) Calculated A	Actual B	Deviation (A-B)
G. 19	1714	1740	-26
G. 30	2128	2100	+28
G. 29	2771	2765	+ 6
G. 36	2863	2840	+23
G. 39	3001	2985	+16
G. 45	3093	3140	-47

is nearly normal.

The tensile strength, as determined by the Pressley Fiber Strength Tester, is a good forecast of the actual lea product of cotton, despite the disagreement between some research workers as to whether or not the flat bundle test is representative of the strength of the original sample. The main claim, as was mentioned before, is that the portion of the flat bundle between where the break occurs is short (.464 inch), and since breaking load increases with fiber length, the bundle is not representative of the actual strength. There is inadequate control, too, over the speed at which the breaking load is applied.

In Table VIII it is found that the Pressley Index of G. 19 is 8.4, while that of G. 45 is 11.4. The conclusion might therefore be drawn that G. 45 fibers are generally stronger than G. 19 fibers. But G. 19 fibers are coarser than G. 45 fibers so that a bundle of given weight, e.g., one milligram, would contain fewer G. 19 fibers than G. 45 fibers. Accordingly, in order to compare the strength of different cottons, it is necessary to eliminate the effect of the hair weight on the breaking load. This can be done by multiplying the Pressley index by the hair weight (milligram per .464 inch) by .0464 as long as the length of the bundle cut in the Pressley Fiber Strength Tester is .464 inch. The quantity given by this modified equation is the "hair strength" after eliminating the effect of the hair weight. In other words, the hair strength is the breaking load divided by the number of the fibers in the bundle instead of the weight of the bundle itself.

Number of hairs in the bundle (.464 inch)

$$= \frac{\text{Weight of the bundle (.464 inch) in milligrams}}{\text{Weight of one hair (.464 inch) in milligrams}}$$

$$= \frac{\text{Weight of the bundle (.464 inch) in milligrams}}{\text{Hair weight by the Micronaire (u gram/in.) x .464/10}}$$

$$= \frac{\text{Weight of the bundle (.464 inch) in milligrams}}{\text{Hair weight by the Micronaire x .0464}}$$

Breaking load for one hair (.464 inch) in pounds "hair strength"

$$= \frac{\text{Breaking load of the bundle (.464") in lbs.}}{\text{Number of hairs in the bundle (.464")}}$$

$$= \frac{\text{Breaking load of the bundle (.464") in lbs.}}{\text{Weight of the bundle (.464")/hair weight x .0464}}$$

$$= \frac{\text{Breaking load of the bundle (.464") in lbs.}}{\text{Weight of the bundle (.464")}} \text{ x hair weight x .0464}$$

= Pressley index x hair weight x .0464

The values of the hair strength of the Egyptian cottons were calculated as given in Table XI with the Pressley index and the coefficient of correlation.

Table XI

Hair Strength, Pressley Index of Egyptian Cotton Varieties

Variety	(a) Pressley index lbs./mgm.	(b) Hair strength lbs./hair
G. 19	8.4	1.66
G. 30	9.3	1.69
G. 29	10.7	1.51
G. 36	10.9	1.43
G. 39	11.2	1.17
G. 45	11.4	1.21

Correlation between (a) and (b), r = -.869

The remarkable thing about this table is that G. 19, which gives the lowest Pressley index, has the highest hair strength. The reason is that there was a high correlation between hair strength and hair weight reaching .953, as shown in Table XII.

Table XII

Hair Strength and Hair Weight of
Egyptian Cotton Varieties

Variety	Hair weight (a)	Hair strength (b)
	u gram/in.	lbs./hair
G. 19	4.27	1.66
G. 30	3.91	1.69
G. 29	3.05	1.51
G. 36	2.82	1.43
G. 39	2.26	1.17
G. 45	2.29	1.21

Correlation between (a) and (b), $r = .953$

Cottons with high hair strength have high hair weight and consequently fewer hairs are found in one milligram of the bundle to be cut on the Pressley breaker, which gives a low index. On the other hand, cottons with low hair strength have low hair weight, and many hairs are found in one milligram of the bundle. This results in a high index. G. 30 and G. 19 have nearly the same hair strength, but because G. 19 is much coarser the Pressley index is higher for G. 30.

The regression equation for hair strength (y) on hair weight (x) was found to be

$$y = .6650 - .2516x$$

Prediction of Yarn Strength from Different Fiber Properties

Coefficients of correlation between the lea product and different hair properties were calculated and are given in the table below.

Table XIII

Coefficients of Correlation between Lea Product and Different Hair Properties of Egyptian Cotton Varieties

	Coefficient of correlation
1. Lea product and $\frac{\text{Mean length (Fibrograph)}}{\text{Hair weight (Micronaire)}}$	+.958
2. Lea product and tensile strength	+.999
3. Lea product and $\frac{\text{Mean length}}{\text{Hair weight}}$ x tensile strength	+.967

From the values of coefficients of correlation, it is apparent that the correlation between the lea product and the tensile strength is the highest (.999). Hence tensile strength can be used as a good forecast of lea product.

This high correlation which exists between tensile strength and lea product is important to cotton breeders who always find it difficult to secure enough lint from single plants in early generations for strength testing. The minimum quantity of lint which can be spun is 60 grams (34), and single plants normally do not yield this amount.

The regression equation for the lea product (y) on tensile strength (x), as previously mentioned, was

$$y = 42.5049x - 2140.8747$$

The correlation of the ratio (mean length/hair weight) with the lea product was also high, being .958. Extra fiber length gives a better overlapping of fibers on each other in the final yarn; moreover, the surface friction or "drag" increases with longer fibers, resulting in better yarn strength. Hair weight, too, influences the yarn strength because yarns are spun to different counts, i.e., number of 840-yard hanks per pound of cotton.

SUMMARY AND CONCLUSIONS

During the past few years, significant advances have been made in instruments and techniques for testing cotton fiber properties. These new instruments and techniques have largely replaced the former ones which are tedious, slow, and time consuming.

One of the major problems in plant-breeding programs is to detect as early as possible the spinning value of the plants selected, to avoid working on selections which may prove unsatisfactory in late generations. Thus an intensive study of the fiber properties and their relation to the spinning performance has been carried on by many workers in cotton-growing countries to reach the best prediction of yarn strength from fiber properties.

The recent advances in American instruments and techniques for testing cotton have been attained while working with American cottons which differ from the Egyptian cottons in quality. Therefore it was thought desirable to test Egyptian cottons on these instruments to determine their accuracy for testing such extra long cottons. "Pure" samples from the Egyptian commercial varieties were tested first in Egypt to determine accurately their fiber properties. Then these samples were sent to the writer at the University of Arizona and re-tested for the same fiber properties on the American instruments, i.e., the Fibrograph for determining fiber length, the Micronaire for determining fiber fineness, and the Pressley Fiber Strength Tester for determining fiber strength.

The results showed that these instruments are successful in determining accurately the fiber properties of Egyptian cottons in considerably shorter time.

The prediction of spinning properties from fiber properties was considered in this research. It was found that tensile strength determined by the Pressley Fiber Strength Tester gives a good forecast for the lea product.

A new procedure for determining hair strength using the Pressley Fiber Strength Tester is explained.

These results are important to cotton breeders working on extra long cottons who find difficulty in determining the spinning properties of their selections in early generations because of the lack of lint on the single plants.

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