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10—THE INTRINSIC STRENGTH OF COTTON

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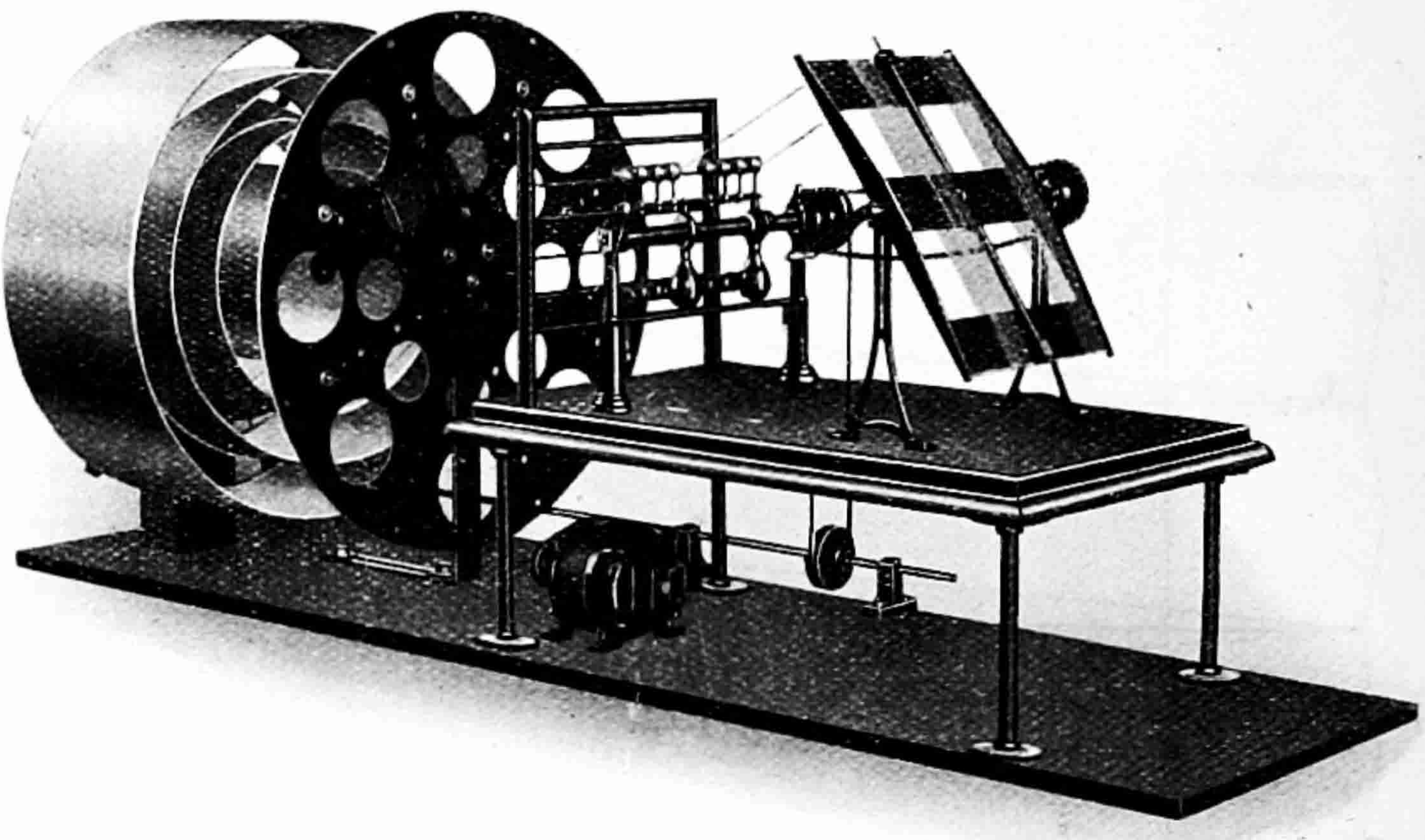

10—THE INTRINSIC STRENGTH OF COTTON

By N. W. Barritt, M.A.

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INTRODUCTION

It seems fairly obvious that yarn strength must ultimately depend upon the strength of the individual hairs, yet various attempts to prove this have not been successful. In this respect the experience of graders and spinners is distinctly at variance with experimental results.

Miss Clegg[1] analysed the breaking process, and after allowing for the number of hairs that slip without breaking, she found it was not possible to correlate yarn strength with fibre strength.

Turner[2] investigated this relation in 14 types of Indian cotton, and found a negative correlation between yarn strength and fibre strength. After making allowance for the number of hairs in the cross section of the yarn by dividing the fibre strength by the fibre weight per inch, he still found that no correlation existed. He attributes this to various reasons, viz. insufficient data, errors of experiment and sampling, and especially to the presence of numerous disturbing factors in yarn structure, which mask the real effect of the fibre strength. He also remarks that the difficulty is rather to explain why high values are sometimes obtained for yarn strength.

Burd[3] in the West Indies published the results of hair tests and spinning tests of 10 Sea Island cottons carried out in the laboratory of the Fine Cotton Spinners' and Doublers' Association at Bollington. These results are summarised in the following table—

Sample	Hair Weight per cm. in ·001 mgm.	Hair Strength in Grams	Intrinsic Strength Ratio	Lea Test in Lb. at 240's
1	111	4·30	395	17·6
2	119	4·51	379	16·0
3	116	4·31	371	15·8
4	105	4·28	407	15·3
5	104	3·33	320	17·5
6	105	3·87	368	18·0
7	105	3·75	357	17·3
8	128	3·94	308	15·5
9	101	3·85	381	17·7
Commercial Control Sample	115	3·20	278	16·6

The correlation coefficient between the yarn strength and hair strength works out at —·41, a value which is not very significant, but the negative sign implies that low hair strength is correlated with high yarn strength. On dividing the hair strength by the hair weight per cm., the correlation coefficient is reduced to +·031, which indicates the absence of any correlation between yarn strength and hair strength per unit weight, thus confirming the results obtained by Turner.

Balls[4] introduces the term "intrinsic strength" to describe this ratio of hair strength to hair weight per cm., and claims to have established a correlation between this ratio and yarn strength amongst 50 samples of cotton from six different countries and spun under different conditions. He attributes the low degree of correlation to the method of yarn testing in vogue, and by applying the strength-gradient theory described by Pierce[5] produces evidence which leads him to believe that in 2-fold yarns the "peak" strength of yarn is identical with intrinsic hair strength. Since the "peak" strength is not a real property of yarn, but only a mathematical deduction for the strength of the hairs in short lengths, its use would appear to be begging the question.

The problem, however, is of considerable interest not only to the spinner but also to the grower, who ought to know the possibilities in the breeding of stronger cottons. With this object in view the writer has investigated this correlation amongst 14 samples of Egyptian cotton consisting of 5 strains (or pure lines) of the one variety Sakellaridis.

METHOD

Pure strains of one type of cotton were used so as to diminish, if possible, the other variable factors of the cotton hairs, which by their influence on the conformation and structure of the yarn, might disturb the relation between fibre strength and yarn strength. The hair weights per cm. were determined on 1,000 hairs of each sample by weighing four measured bundles of 250 hairs on an assay balance sensitive to ·01 mgm. The hair strengths were determined on 250 hairs of each sample by means of the Magazine Hair Tester of Dr. Balls. As it was found that hairs mounted overnight gave higher results than hairs tested soon after mounting, the drying effect of the hot wax was corrected by wetting each hair after mounting by means of a camel-hair brush. The great variation in humidity of the Egyptian climate was controlled by placing a piece of ice on the magazine plate, whereby the temperature surrounding the hairs was kept below the dewpoint, and errors due to viscosity of the wax avoided. The spinning tests were carried out by the Fine Spinners' and Doublers' Association.

The results obtained are given in Table I.

Table I

Sample	Hair Weight per cm. in ·001 mgm.	Hair Strength in Grams	Intrinsic Strength Ratio	Count Strength Product at 140's
1	155	4·7	303	2284
2	145	4·4	303	2207
3	146	4·3	294	1940
4	139	4·0	287	1964
5	141	4·0	283	2019
6	141	4·0	283	2002
7	139	3·9	280	2067
8	146	4·1	280	1989
9	159	4·3	270	2052
10	134	3·6	268	1913
11	151	4·0	264	1998
12	137	3·6	262	1766
13	159	4·1	260	2141
14	157	3·9	248	1927

The correlation coefficient between the count strength product of the yarn and the intrinsic strength of the hairs works out at $+·55$, which implies the existence of only a slight correlation. (Fourteen samples require a correlation coefficient of not less than ·66 to be significant.) The coefficient between hair strength and count strength product is $+·79$, which indicates a definite correlation between these two factors.

From these figures we must conclude that the introduction of the factor of number of hairs (weight per cm.) in the cross-section of the yarn diminishes the correlation between yarn strength and hair strength. This is only possible on the supposition that hairs of low weight per cm. tend to lie less regularly in the yarn, so that the effect of their greater number is not realised in the strength of the yarn. The probability of this occurring is shown by the existence of a positive correlation of ·47 between yarn strength and hair weight per cm. The value is small, but the positive sign is contrary to that obtained by other workers for more diverse types of cotton. It suggests that the differences in hair weights of these particular samples are not a true measure of "fineness," but merely indicate differences in the maturity of the samples. The degree of maturity is of great importance in determining the amount of collapse of the hairs on drying, and therefore largely controls the conformation and the spinning properties of the hairs.

The relation between intrinsic strength and maturity was investigated in case of Ashmouni cotton by testing samples of cotton picked at five-day intervals during the ripening of the bolls.

The results were as follows—

Table II

Age of Boll Days	Hair Weight per cm.	Hair Strength in Grams	Intrinsic Strength
25	80	1·6	200
30	124	2·3	185
35	137	2·5	182
40	170	3·4	200
45	188	4·1	217
50	205	4·4	214

These results show a tendency to a slight increase in intrinsic strength with maturity.

The relation between intrinsic strength and "fineness" is shown by the following results obtained from a sample of Sakel cotton that had previously been used in an investigation of the variation of hair weight per cm. Two bundles of hairs of very low hair weight and two of high hair weight were selected, and the hair strength determined in the Magazine Hair Tester.

Table III

No. of Hairs	Hair Weight per cm.	Hair Strength in Grams	Intrinsic Strength
75	133	4·0	300
81	137	4·23	308
76	170	4·43	260
83	172	4·7	273

These results are remarkable in showing two very different intrinsic strengths in the same sample of cotton.[6] The differences between the coarse and fine bundles are greater than any possible experimental error, since all the hairs weighed in each bundle were subsequently accounted for in the Magazine Hair Tester. The differences in hair weights in this case are not due to differences in maturity, but rather to real differences in "fineness" of the hairs.

Comparing the results of Tables II and III, it would appear that low hair weight per cm. is only associated with high intrinsic strength when the cotton is fully matured. The correlation ratio between these two factors in Table I is only —·2, which is negligible. This is due to the fact that each of the 14 samples is of a similar composite nature to the sample in Table III, and averaging the results of each sample destroys the correlation.

DISCUSSION

The satisfactory establishment of a correlation between intrinsic strength and yarn strength would appear to present almost insuperable difficulties. But there can be little doubt that it exists. The increase of hair strength with humidity[7] or on mercerisation is reflected in the increase in yarn strength from the same cause,[8] and probably is the best evidence obtainable in support of this correlation.

The demand of the spinner for a strong cotton is doubtless a sound one, being based on long experience, but it is not apparently connected with strength per unit weight of fibre.

The results of the tests on Sea Island cotton quoted above give an intrinsic strength of 278 for the commercial sample, which produced a yarn with a count strength product of 4,000, whilst Sakel cottons with an average intrinsic strength of 277, produced yarns with an average strength of only 2,000, though spun at more favourable counts. No evidence other than staple and fineness has yet been given to account for this difference in efficiency between these two types of cotton.

The grower must conclude that "fineness" is more important than anything else, but since there are two kinds of fineness it must be defined as low hair weight combined with maturity of the fibre. Maturity may be measured in terms of hair weight per unit diameter, so that the selection of cotton for staple and low diameter of fibre would appear to offer everything the spinner can reasonably ask and all the grower can hope to supply.

REFERENCES

[1] Clegg, C. G. J. Text. Inst., 1926, **17**, T591.
[2] Turner, A. J. Ind. Cent. Cotton Comm. Bull., No. 12, Series 7, 1928.
[3] Burd, L. H. Spinning Tests of St. Vincent, Sea Island Cotton, Kingstown, 1925.
[4] Balls, W. L. Studies of Quality in Cotton. Chap. XII. MacMillan, 1928; and Cairo Scientific Soc., Dec. 1927.
[5] Pierce, F. T. J. Text. Inst., "The Weakest Link," 1926, **17**, T355.
[6] Barritt, N. W. Annals of Applied Biology, 1929.
[7] Mann, J. C. J. Text. Inst., 1927, **18**, T253.
[8] Pierce, F. T., and Stephenson, R. J. J. Text. Inst., Vol. 1926, **17**, T645.