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## THE RELATION BETWEEN THE PHYSICAL FIBRE CHARACTERS AND THE SPINNING QUALITY OF JUTE.—I.

BY

C. R. NODDER, K. R. SEN and B. K. CHAKRABARTI

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# THE RELATION BETWEEN THE PHYSICAL FIBRE CHARACTERS AND THE SPINNING QUALITY OF JUTE.—I.

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## INTRODUCTION.

On general principles and from results which have been obtained with other fibres it is to be expected that the behaviour of jute in spinning and the quality of the yarn produced (these together being called broadly "spinning quality") will be linked more or less closely with certain measurable characters of the fibre. In this paper only physical characters are considered. Attention will be confined to Strength, Fineness and Flexibility. These are probably the most important physical characters which should be considered in relation to spinning quality. Other characters such as lustre, frictional properties, "packing quality", and degree of "speckiness" are for future consideration. Chemical composition also will be dealt with separately.

The present paper describes results so far obtained on a number of samples of fibre which have been spun in the laboratories and examined for physical characters. These results give fair promise that it will be possible to establish methods of predicting spinning quality by the measurement of fibre characters.

## SAMPLING.

The quantity of fibre used in the actual measurements of strength, fineness and flexibility is necessarily small in comparision with the quantity that is spun, even although the special spinning technique in use requires only about twenty pounds of fibre.

The procedure employed to ensure that the sample for physical tests corresponds satisfactorily with the sample that is spun has been described elsewhere [1]. It now remains to describe the procedure employed in preparing the small working samples for the various physical tests from the larger sample (normally 3 lb.) which is taken from the fibre that is spun [1].

In the present work fibre tests have been made only on the middle portion of the fibre, the root and crop ends being excluded. The rather lengthy procedure now to be described is necessary to ensure proper sampling in the small quantities used for the actual tests.

The fibre is placed on a special balance (Fig. 1) in order to find the "middle" (roughly the centre of gravity of the three-pound morah). The procedure is considered preferable to finding the middle by measuring.

The middle point, *i.e.*, the position opposite the fulcrum of the balance, is marked with a red thread. The fibre is then spread out, keeping the butt ends as level as possible, and fifteen inches are marked off on either side of the mark and the middle thirty inches so measured is cut out. This is then cut into three 10-inch lengths—"upper", "middle" and "lower", which are kept separate. These will be called U, M and L respectively. Each of the lots of fibre (U, M & L) is then sorted out roughly by eye according to colour, softness, barkiness, etc., about six classes being made. Then three piles (a, b and c) are made by taking fibre, reed by reed,* from the various classes which have been sorted out. This is done systematically until all the fibre has been used up. If one or two reeds remain in any class they are split and distributed into the three piles. In this way nine piles are obtained :—

| | | | |
|---|---|---|---|
| Top | $U_a$ | $U_b$ | $U_c$ |
| Middle | $M_a$ | $M_b$ | $M_c$ |
| Root | $L_a$ | $L_b$ | $L_c$ |

The *a*, *b*, and *c* piles are then mixed as follows :—

$U_a$, $M_a$, and $R_a$ are mixed by placing the fibre reed by reed in rotation into three fresh piles. These three piles are then again mixed by taking about 6 reeds of each in rotation and

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*By a *reed* of fibre is meant the collection of strands derived from one jute plant.

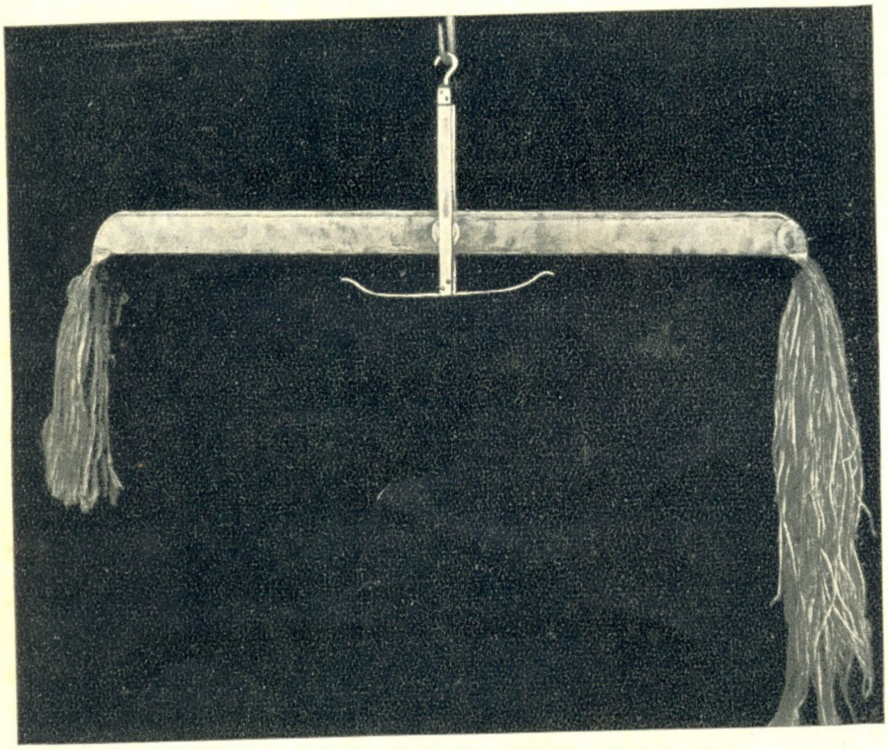

Fig. 1
Special Balance.

forming three more piles. The three piles are then united and together give sample A.

Similarly samples B and C are obtained from the *b* piles and the *c* piles. The tests for fineness, flexibility and strength are carried out in triplicate, using sample A, B and C. For this purpose each reed of A is split into three parts and three piles are made, one for each type of test. These piles are known as the test samples. Before they are used they are given a combing treatment.

## COMBING.

Since spinning quality is to be judged mainly from the qualities of the yarn obtained when fibre is spun by a standard process and since in spinning the fibre undergoes a number of treatments which may be described as "combing" (the word not being used in any technical sense) it is considered desirable to give the working samples a combing treatment before the various physical tests are made.

Eventually it may be possible to devise a small machine for this purpose in order to rule out any personal element but at present a standard hand-combing treatment is given, employing rows of gill-pins fixed to a table in the manner of a hackling tool.

The pins used are:—

(*a*) for preliminary combing, one gill stock from Second Drawing Frame, with two rows of pins, nineteen pins per row. Back row 15/16″ projection, front row 1·1/32″ projection. No. 15 B. W. G. 2·75 pins per inch.

(*b*) for final combing, two gill stocks from Hessian Roving Frame fixed in contact so as to make four rows of pins. Sixteen pins per row, 13/16″ projection. No. 17 B. W. G., 7 pins per inch.

The test sample is weighed out roughly into 2 gram lots and each lot is combed five times each end on the coarser comb and then five times each end on the finer comb. The method of handling is kept as uniform as possible. The combed portions are then united and are ready for testing.

## MEASUREMENT OF FINENESS.

Measurements of the fineness of wool, silk and cotton are comparatively straightforward but with bast fibres, and particularly in the case of jute, certain difficulties arise. If a single "reed" (the fibre coming from one jute stem) of fibre is opened out it is seen that the fibre is arranged in a kind of meshwork of branching and anastomosing strands.

This is particularly easily seen near the root end but it is present also throughout the whole length of the fibre (Fig. 2). In the case of, say, wool a very good estimate of fineness can be made either by cutting the fibre to a definite length and counting and weighing a fair number of strands or by projecting the magnified image of the fibre on to a screen and so measuring the diameter directly. The mesh structure of the jute fibre makes such methods less suitable. The fragments obtained when a sample of fibre is cut to a definite length (whether, say, 2 mm., 10 cm., or any greater length) are not simple strands but display various degrees and types of complexity. Any attempt to count the fragments as one, two, three, etc. units according to the apparent complexity, or to split the fragments into apparently single strands, is attended by too much personal bias.

The method adopted for the work now under consideration is as described below. Many other methods have been tried and improved methods are constantly being sought. One important object is to discover a method which is (*a*) rapid and suitable for routine work and (*b*) free from personal bias. While the present method is generally satisfactory it is rather too time-consuming, although reasonably free from personal bias.

Fibre strands from a combed test sample are cut accurately into 10 cm. lengths and ten separate bundles are prepared. Any short strands are removed as far as possible by holding the bundles at the end and shaking. Each bundle is spread out as evenly as possible and small bundles are removed from the edges and middle of the spread-out bundles and placed together to form ten new bundles. These are spread out and from one edge of each ten fragments are removed one at a time, as they come. Each separate fragment is counted as one, irrespective of its complexity or degree of branching. In this way bundles of one hundred fragments are

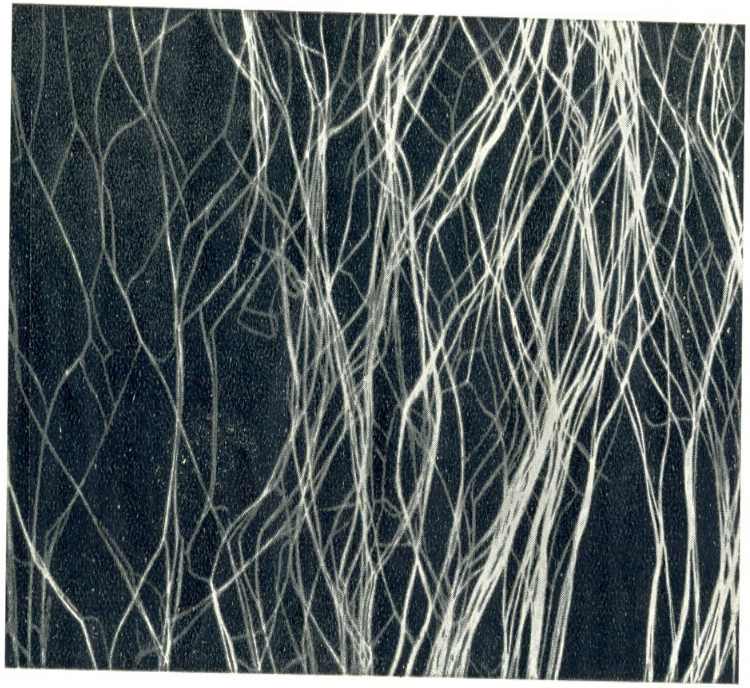

Fig. 2.

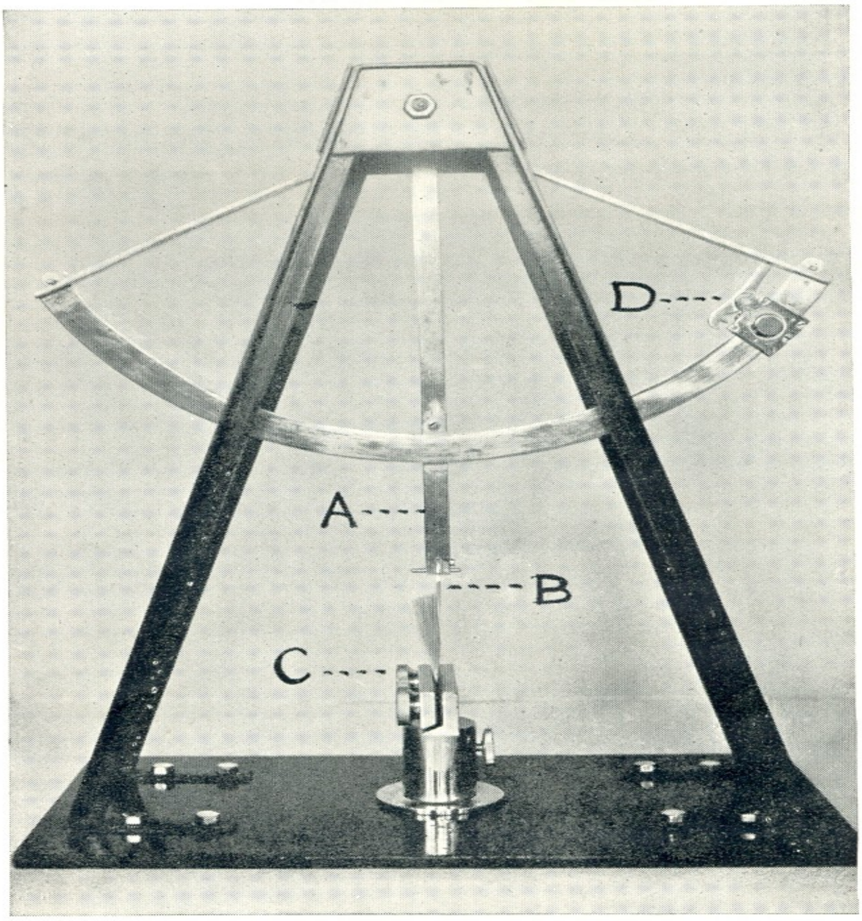


Fig. 3
Flexibility Tester.

made up. The process is continued until thirty bundles of a hundred fragments each have been prepared.

The other two test samples are treated similarly so that ninety bundles are prepared in all. These are weighed on a chemical balance.

In adopting this method the underlying consideration was the expectation that a high proportion of coarse or complex fragments in the combed sample would be associated with low spinning quality, while the presence of a high proportion of fine, simple strands would be associated with good spinning quality.

## MEASUREMENT OF FLEXIBILITY.

The apparatus used in this work for comparing the flexibility of different samples of fibres is illustrated in Fig. 3. The instrument was designed in the Laboratories and constructed by the Mathematical Instrument Office, Calcutta. It consists of a pendulum (A) mounted on ball-bearings and carrying a rectangular blade (B) at its lower end. The fibre is arranged in a clamp (C) in such a way that the blade overlaps the tuft of fibre by a definite amount. The pendulum is allowed to fall from a definite height by releasing the catch (D) fixed to a graduated quadrant. The number of times the blade of the swinging pendulum crosses the tuft before it comes to rest is counted.

The conditions of the test are standardised as follows :—

| | |
|---|---|
| Length of test bundle ... | ... $1\frac{1}{2}$ in. |
| Weight of test bundle ... | ... 0·150 gram. |
| Height of fringe ... | ... $\frac{1}{4}$ in. |
| Width of fringe ... | ... $\frac{1}{2}$ in. |
| Amount of overlap ... | ... $\frac{1}{8}$ in. |
| Height of fall of pendulum | ... Standard |
| Number of bundles tested for each sample ... | ... 30 |

The test bundles are made up from a combed test sample by cutting to $1\frac{1}{2}$ in. length, separating into ten parts, spreading out each part and taking small tufts from different places in each part until the 0·150 gram is made up. Then further small tufts are taken in the same way until the thirty bundles required have been prepared. After the test bundle has been mounted in the clamp and spread as uniformly as possible to the standard half-inch width it is trimmed to the standard quarter inch height, with the use of a gauge.

The test gives a measure of the flexibility in arbitrary units. Experiments in which various numbers of layers of paper were used for test show that the number of times the blade crosses the tuft is approximately proportional to flexibility within the range 10 to 30. The construction of the instrument is such that copies which may be expected to give similar results can easily be made if required.

## MEASUREMENT OF STRENGTH.

In the experiments enumerated in this paper the actual tensile strength or breaking load was not measured, but the ballistic work of rupture of standard bundles of fibre strands. This character is no less important than tensile strength and is closely related to it, any variations from proportionality being due to differences in extensibility, which are small.

The instrument used is shown in Fig. 4. It was designed in the Laboratories and constructed by the Mathematical Instrument Office, Calcutta. The principle is similar to that of the well-known ballistic yarn tester but modifications have been made to enable a short test-length to be used. The bundle of fibre is fixed in the clamps *A* and *B*. The position of clamp *A* is adjustable so that different test-lengths may be used.

The standard conditions used in the present experiments are as follows:—

| | |
|---|---|
| Length of test bundle ... | ... 7 in. |
| Weight of test bundle ... | ... 0·200 gm. |
| Distance between jaws ... | ... 10 cm. |
| Height of fall of pendulum | ... from 100 mark. |
| Number of bundles tested for each sample ... ... | ... 50 |

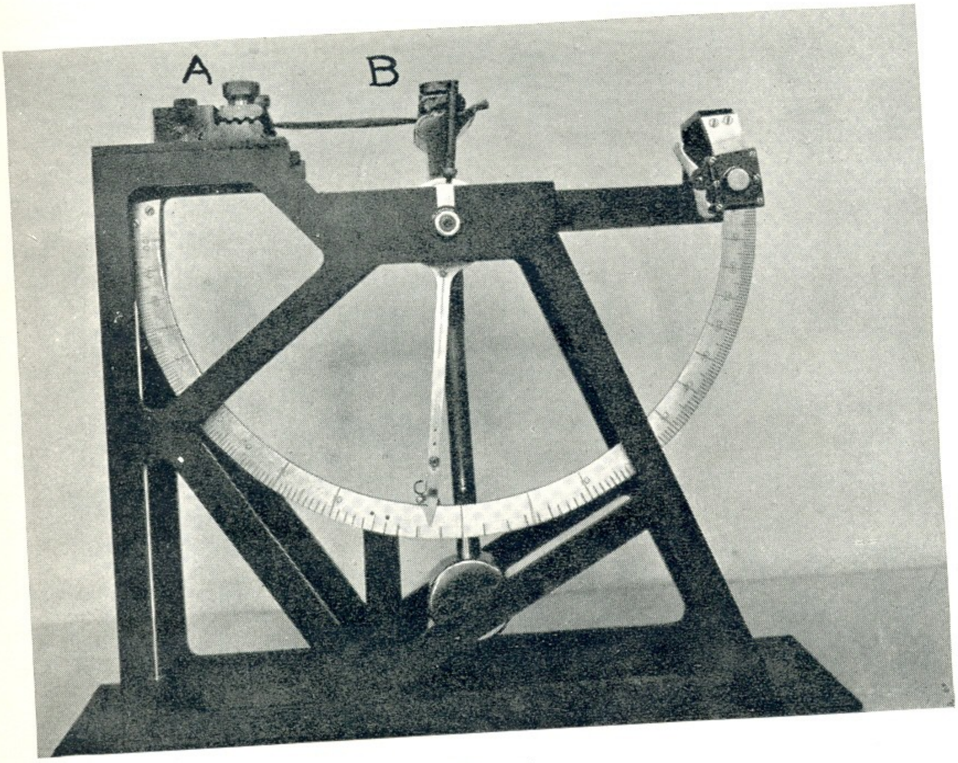


Fig. 4
Ballistic Fibre Tester.

The test-bundles are made up from the combed test sample by cutting out 7-in lengths from about the middle, separating into ten parts, spreading out and collecting strands from different places in each of the ten parts until the required 0·200 gram has been obtained. Fifty bundles are made by taking further strands from each of the ten parts.

The scale of the instrument is graduated harmonically so that the divisions are (approximately) proportional to inch-pounds of work. As in the ballistic yarn tester the height to which the pendulum rises after the bundle has been broken is indicated by a light pointer which it pushes forward. The pointer has a pawl which works against a ratchet on the quadrant.

The quadrants are graduated from 100 (horizontal position of pendulum) to zero (vertical position), the units being arbitrary. The work absorbed in breaking the test-sample is taken as the difference in height (as read on the scale) to which the pointer is pushed when no sample is clamped in the jaws and the height to which it is pushed when the sample is broken.

## YARN CHARACTERS.

The details of the measurements carried out on the yarn spun from the samples under test will be described separately. For the present purpose it is sufficient to give the following information.

The single thread breaking loads are determined on Goodbrand electrically driven testers with a test-length of 30 inches and a 12 in. per minute traverse of the lower clamp. The tests are carried out at 75% R. H. and 80° Fahr. and prior to testing the sample of yarn is allowed to hang for several days in the conditioned test-room.

Three hundred tests are made on each sample of yarn and the sampling technique ensures that these are suitably spread over the whole of the yarn spun (normally ten spinning bobbins).

The regularity of the yarn is tested by weighing on a Schopper balance two hundred and fifty two-inch lengths and calculating the co-efficient of variation. The greater the co-efficient of variation the lower the regularity.

## EXPERIMENTAL RESULTS AND DISCUSSION.

In Table I are shown the results obtained on thirteen samples of fibre on which spinning trials and physical measurements have been carried out. The yarns were spun to 10 lb. grist by the standard procedure (Technological Research Memoir No. 1).*

In Figs. 5 to 10 yarn characters are shown plotted against fibre characters.

Apart from such characters as colour and speckiness most of the information required in assessing the quality of a yarn, and hence of the fibre from which it was spun, is given by the quality ratio (single thread breaking load divided by grist and, for convenience, multiplied by 100) considered in conjunction with the coefficient of variation of the weights of standard (2-inch) lengths, which is a measure of the degree of irregularity. When it is desired to express yarn quality as a single figure we may substract this coefficient of variation (C) from the quality ratio (Q), remembering that a high value for (C) generally corresponds with low quality. The result (Q - C) may have a negative value, although such cases have so far been found only in sacking weft yarns (*e.g.*, Q = 42, C = 44). In the case of 10 lb. yarns a negative value would, it is judged, mean that there would be so many yarn breaks in spinning and weaving that it would not be a practical proposition to work the fibre (unless, of course, it were mixed with a preponderating quantity of better fibre).

The normal range of (Q - C) in commercial yarns of about 10 lb. grist is 25 to 75 a good average being about 50 (Q = 80 and C = 30). The best value so far met with in trial spins in the Laboratories is about 100 for a sample of Jat Tossa.

Although further work may suggest a formula which is preferable from the point of view of the relative weight given to the characters Q and C, little doubt is felt that (Q - C) adequately represents yarn quality for practical purposes.

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*No. 9 was spun to 8 lb. grist. The sample was included as it was one of the few fibres with very low quality ratio for which spinning results were available when the work on fibre characters was commenced. Data available indicate that this difference generally has only a small effect on quality ratio under the conditions of the T. R. L. spins.

TABLE I.

| | Serial No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference No. ... ... ... | J-49 (1-6) | J-51 (1-5) | J-9 (10 & 20) | J-45 (1-6) | J-7 (2, 3, 13 & 16) | J-5 (1 & 2) | J.32 (13) | J-52 | J-12 (1) | J-14 | J-144 | J-57 (1-5) | J-25 (1-4) |
| | Species ... ... ... | Caps. | Caps. | Caps. | Caps. | Caps. | Caps. | Caps. | Olit. | Olit. | Olit. | Caps. | Caps. | Olit. |
| Q | Quality Ratio of Yarn ... ... | 49·7 | 52·7 | 62·7 | 63·4 | 71·4 | 81·5 | 89·6 | 100·7 | 109·2 | 105·6 | 101·2 | 57·7 | 108·1 |
| | Standard Error of *do.* ... ... | 0·88 | 0·95 | 1·07 | 1·07 | 1·57 | 1·31 | 1·64 | 1·67 | 1·62 | 1·91 | 1·68 | 1·07 | 2·04 |
| C | Coefficient of variation of wts. of 2-in. length of yarn, % ... ... | 34·3 | 34·9 | 31·3 | 27·1 | 25·1 | 32·6 | 26·4 | 25·6 | 24·5 | 22·9 | 26·4 | 33·8 | 20·5 |
| | Standard Error of *do.* ... ... | 1·53 | 1·56 | 1·40 | 1·21 | 1·12 | 1·46 | 1·18 | 1·14 | 1·10 | 1·02 | 1·18 | 1·51 | 0·92 |
| M | Mass per unit length of fibre "fragments" (micrograms/cm ) ... | 123·9 | 137·1 | 146·4 | 123·9 | 106·5 | 125·7 | 109·2 | 97·9 | 97·1 | 82·1 | 89·0 | 102·3 | 79·2 |
| | Standard Error of *do.* ... ... | 3·14 | 3·97 | 4·02 | 3·51 | 2·13 | 3·57 | 3·18 | 1·72 | 2·04 | 1·25 | 2·10 | 2·60 | 1·16 |
| F | Flexibility of Fibre (arbitrary units) ... | 17·3 | 18·9 | 15·3 | 18·4 | 19·1 | 17·2 | 17·2 | 20·5 | 20·0 | 20·4 | 20·9 | 17·2 | 17·5 |
| | Standard Error of *do.* ... ... | 0·13 | 0·24 | 0·13 | 0·14 | 0·16 | 0·22 | 0·17 | 0·18 | 0·14 | 0·17 | 0·12 | 0·15 | 0·16 |
| B | Ballistic work of rupture of fibre. (Arbitrary units) ... ... | 6·6 | 8·5 | 10·8 | 9·7 | 9·8 | 15·4 | 17·5 | 13·5 | 21·1 | 24·6 | 15·6 | 6·8 | 20·8 |
| | Standard Error of *do.* ... ... | 0·10 | 0·17 | 0·16 | 0·14 | 0·14 | 0·22 | 0·21 | 0·17 | 0·25 | 0·31 | 0·16 | 0 09 | 0·19 |
| | $\frac{B}{M} \times 100$ | 5·3 | 6·2 | 7·4 | 7·8 | 9·2 | 12·3 | 16·0 | 13·8 | 21·7 | 30·0 | 17·5 | 6·6 | 26·2 |
| | $\frac{B \times F}{M} \times 10$ | 9·2 | 11·7 | 11·3 | 14·4 | 17·6 | 21·1 | 27·6 | 28·3 | 43·5 | 61·1 | 36·6 | 11·4 | 45·8 |
| | $\frac{F}{M} \times 10$ | 1·40 | 1·38 | 1·05 | 1·49 | 1·79 | 1·37 | 1·58 | 2·09 | 2·06 | 2·48 | 2·35 | 1·68 | 2·21 |

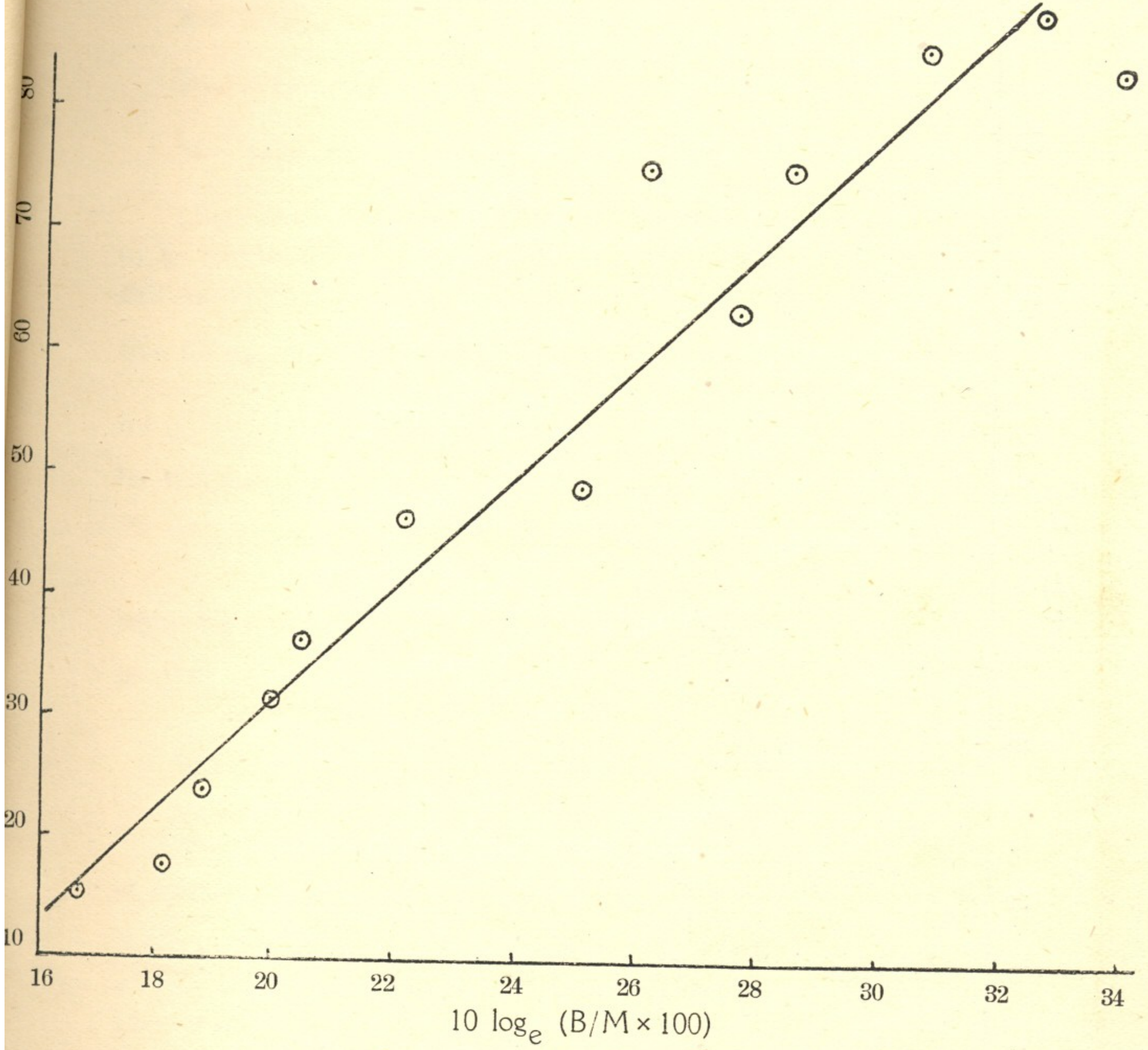



Fig. 5,

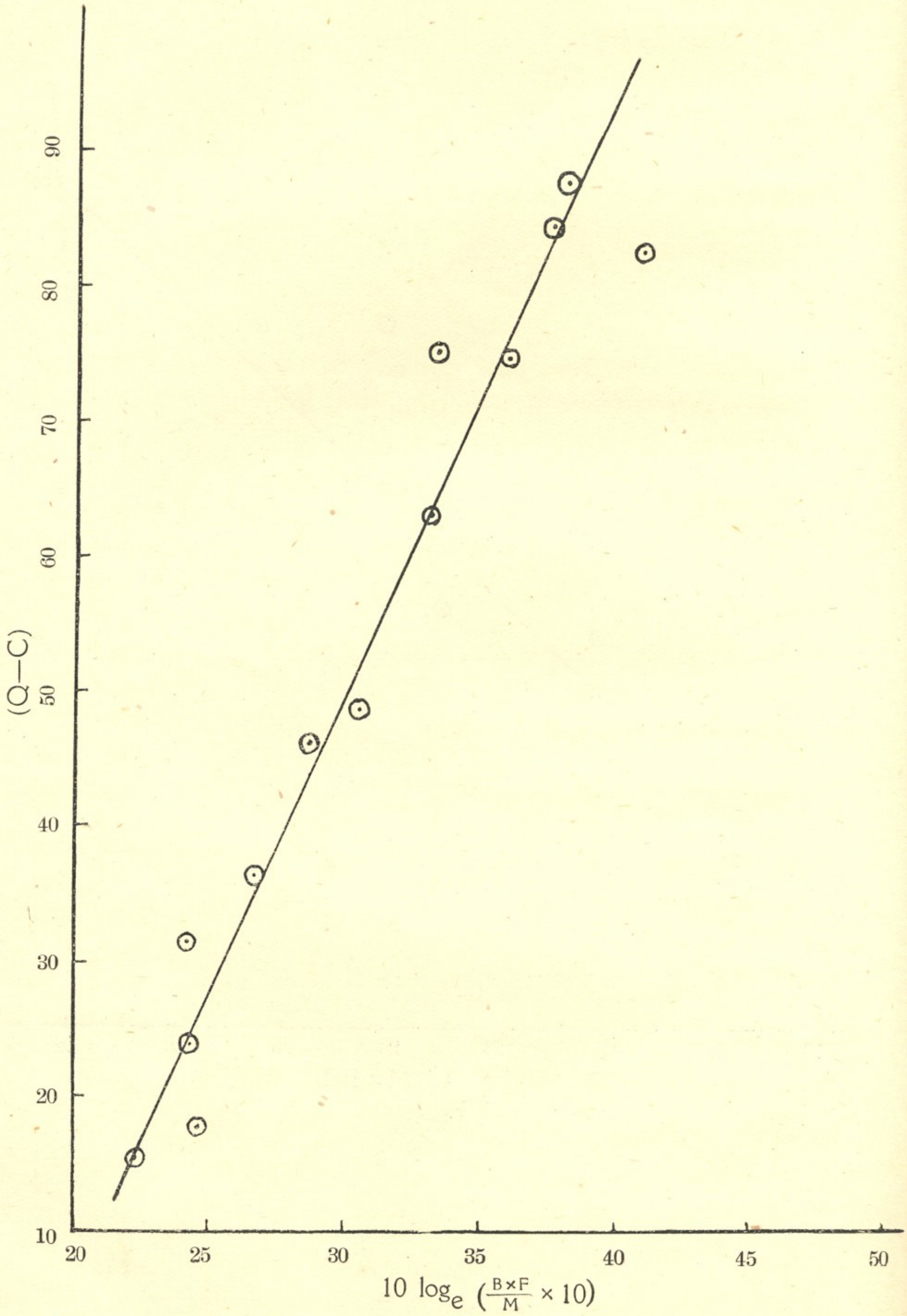

90
80
70
60
(Q—C) 50
40
30
20
10
20
25
30
35
40
45
50
10 $\log_e\left(\frac{B \times F}{M} \times 10\right)$

Fig. 6.

Tentative indices of fibre quality may be obtained by combining the results found for strength, fineness and flexibility.

In Figs. 5 and 6, Q – C is plotted against $10 \log_e \left(\frac{B \times 100}{M}\right)$ and $10 \log_e \left(\frac{B \times F}{M} \times 10\right)$ respectively.

B = Ballistic work of rupture

F = Flexibility

M = Mass per unit length of fibre fragments (Micrograms/cm.)

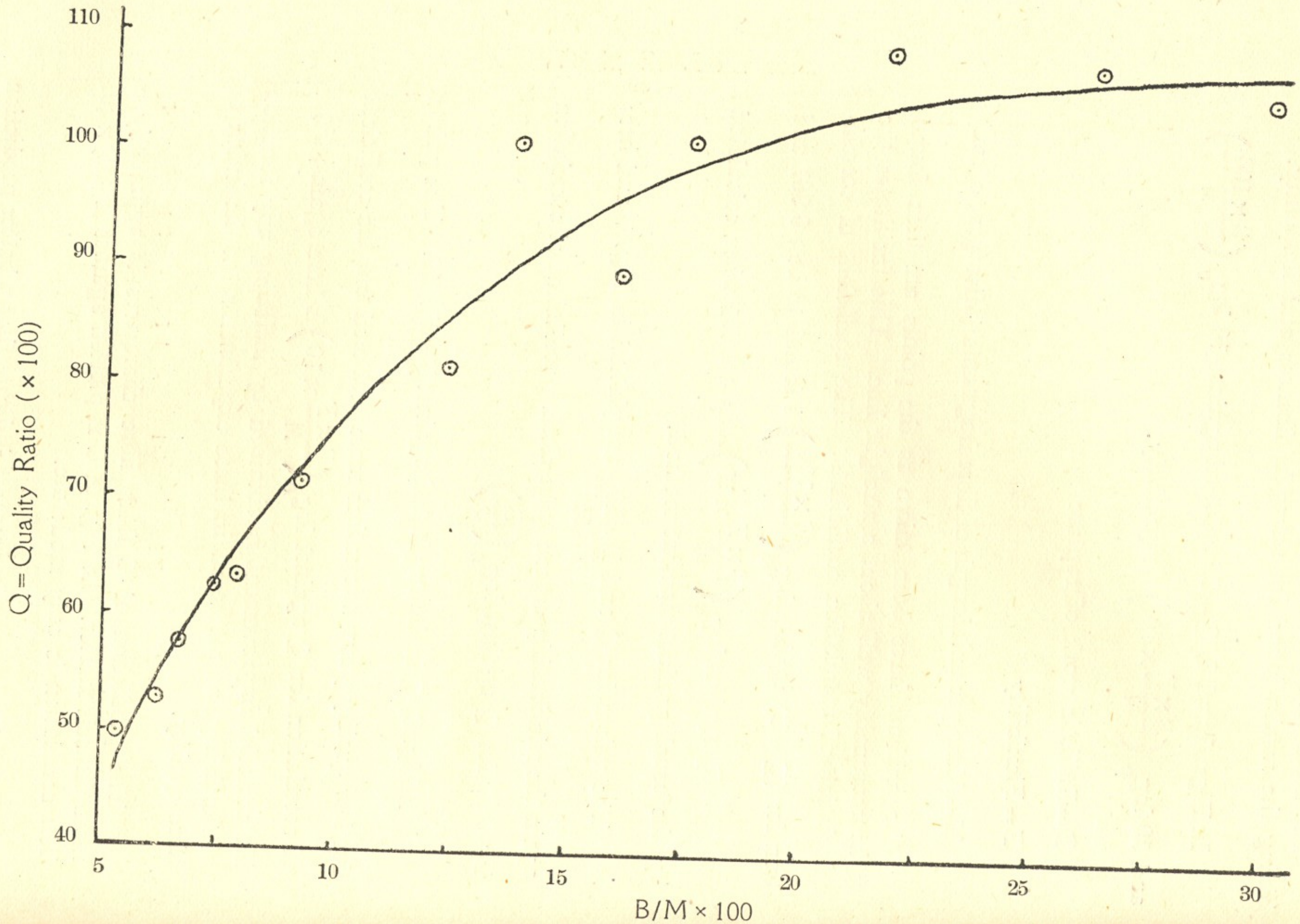
Logarithms have been taken as the points are then found to lie reasonably well about a straight line. This facilitates the calculation of correlation coefficients. The coefficient of correlation for (Q – C) against $\log_e\left(\frac{B \times 100}{M}\right)$ is found to be + 0·967 and for (Q – C) against $\log_e\left(\frac{B \times F}{M} \times 10\right)$ it is + 0·971 when calculated by the usual product-moment method.

The values for Q and $\frac{B \times 100}{M}$ are plotted in Fig. 7 and here again the relationship is seen to be close. coefficient of correlation is + 0·97 for Q against $\log_e\left(\frac{B}{M}\right)$

In Fig. 8, Q is shown plotted against $\frac{B \times F}{M} \times 10$. The points for low quality yarns are rather more scattered but the coefficient of correlation for Q against $\log_e\left(\frac{B \times F}{M} \times 10\right)$ is here again + 0·97. No material improvement is obtained by including any function of flexibility, as measured in these experiments, in the index of fibre quality.

The prediction of C from fibre characters is apparently a more difficult matter. In Fig. 9, C is plotted against (F/M) × 10. The correlation is only moderate.

Experiments now in progress indicate that a better prediction of C will be possible by including in the index of fibre quality a


Q = Quality Ratio (× 100)
110
100
90
80
70
60
50
40
5
10
15
20
25
30
B/M × 100

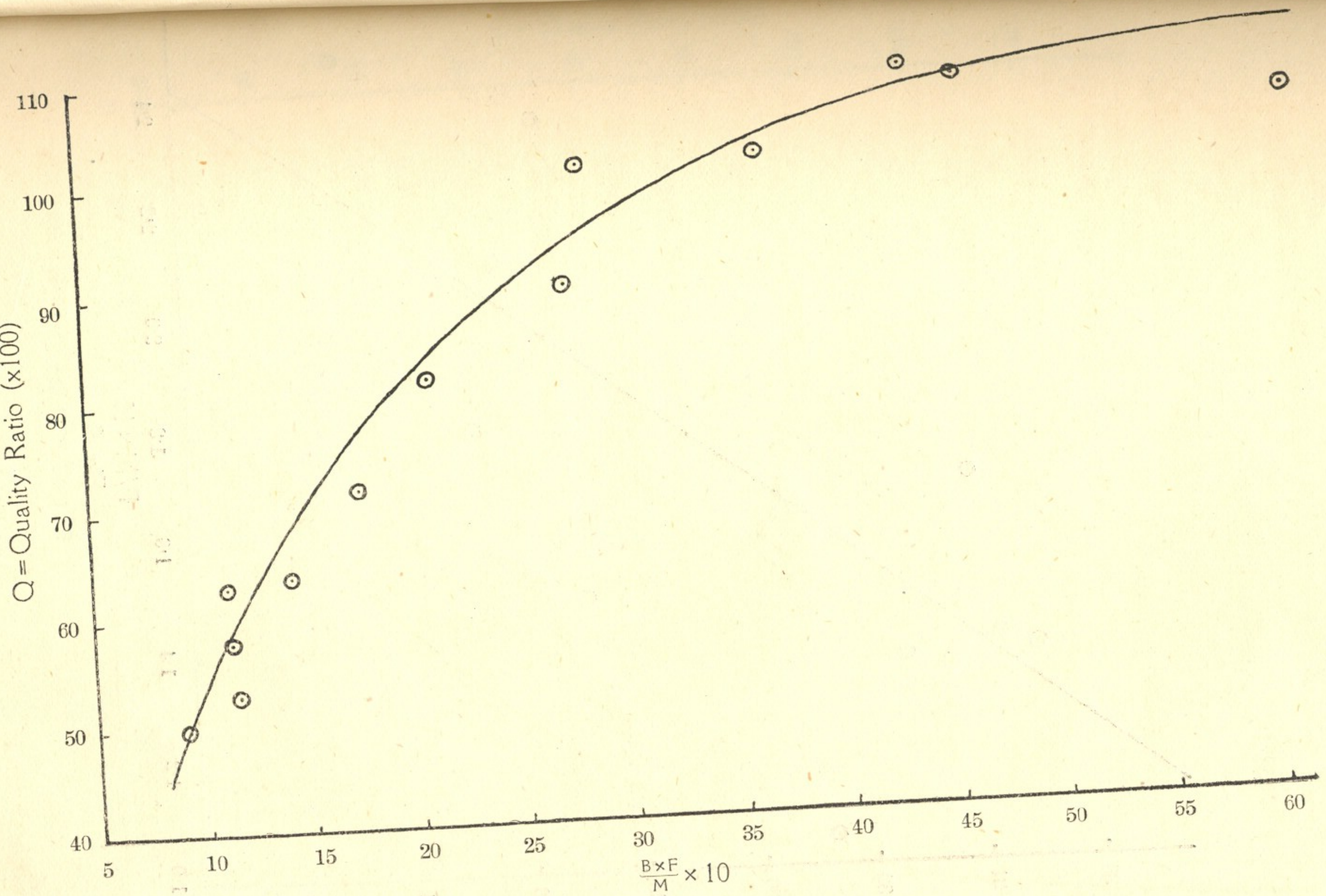
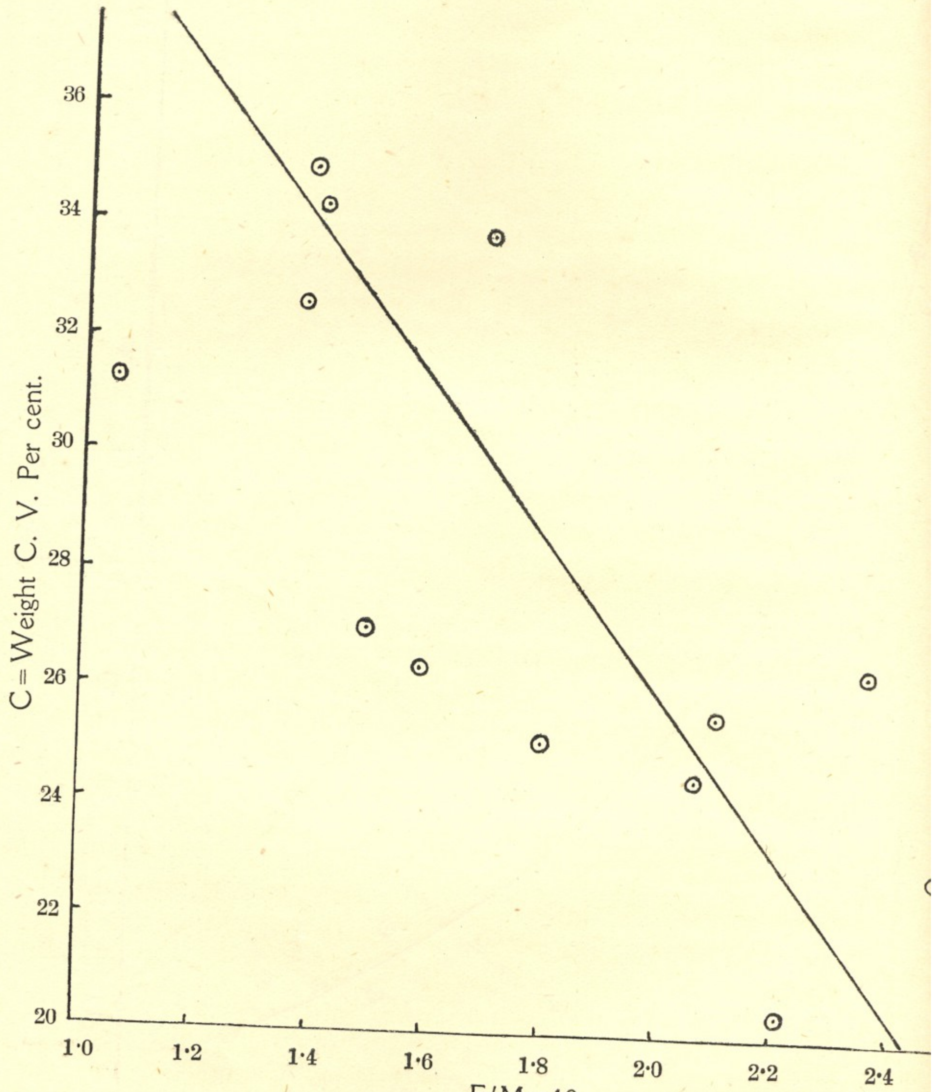

Q = Quality Ratio (×100)
110
100
90
80
70
60
50
40
5
10
15
20
25
30
35
40
45
50
55
60
$\frac{B \times F}{M} \times 10$

Fig. 8



36
34
32
30
28
26
24
22
20
C = Weight C. V. Per cent.
1·0
1·2
1·4
1·6
1·8
2·0
2·2
2·4
F/M × 10

Fig. 9.

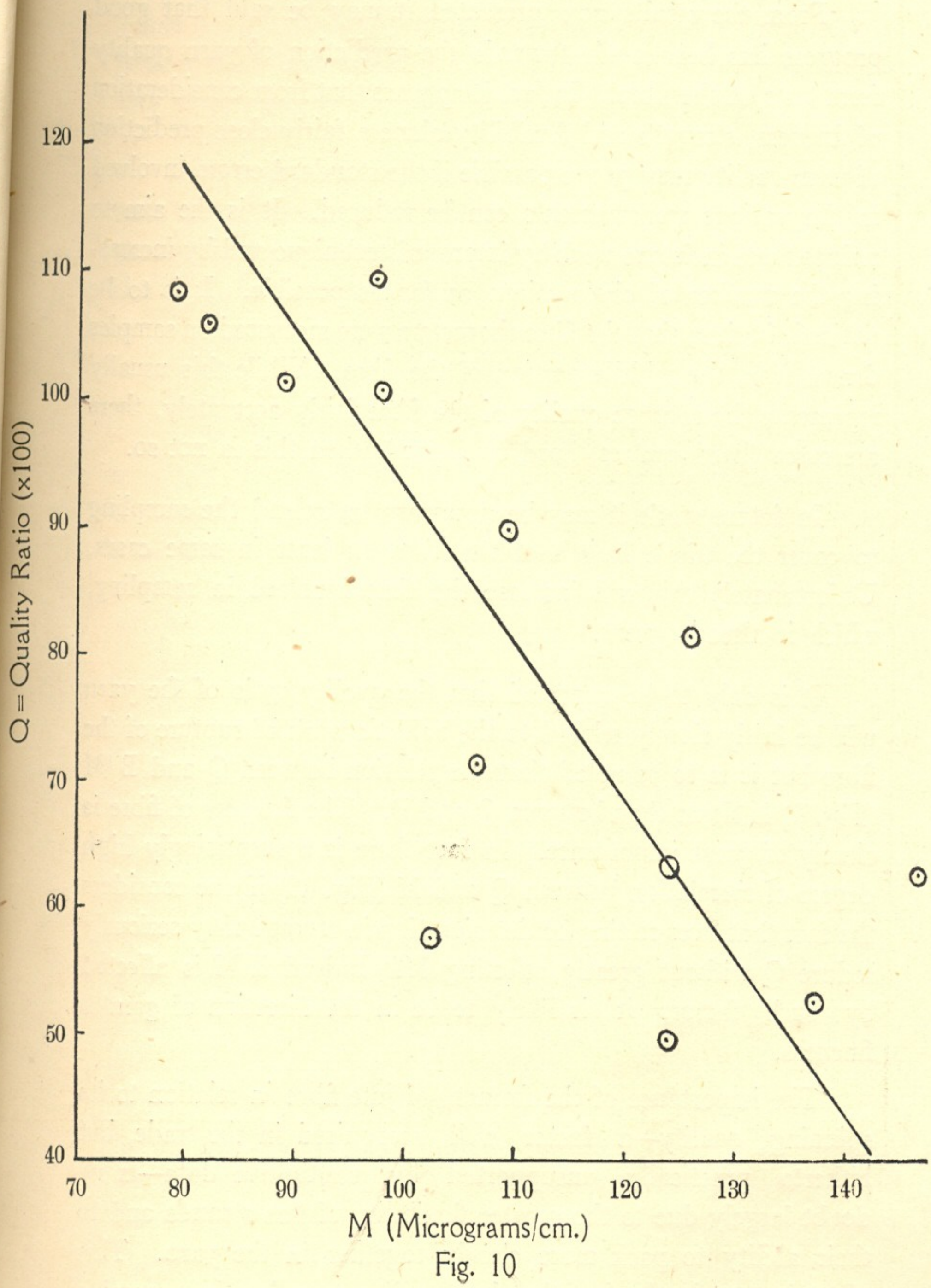

Q = Quality Ratio (×100)
120
110
100
90
80
70
60
50
40
70
80
90
100
110
120
130
140
M (Micrograms/cm.)

Fig. 10

factor which represents the "packing quality" of the fibre. It is found that fibre of high quality when compressed under standard conditions packs to a smaller volume than fibre of low quality. This work will be described separately.

From the results now presented it may be said that good progress has been made towards the prediction of yarn quality from tests on the fibre. In fact it appears that from consideration of fineness, strength and flexibility alone a fairly close prediction of yarn quality may prove possible if the standard errors involved in the various measurements can be reduced. It is the aim to reduce these in future work by improved technique and by increasing the number of observations as far as possible. It is to be noticed, further, that the fibre characters were measured on samples drawn from the middle portion of the fibre. While this usually represents the average quality of the fibre fairly accurately, there are cases (hard centres, hard crop, etc.) when this is not so.

In future work it may be necessary to extend the sampling to cover the whole length of the fibre, at least in some cases. Unfortunately this will increase the time involved in sampling, which is already great.

It is only to be expected that the quality ratio of the yarn will be fairly closely related to the ballistic work of rupture of the fibre but it is to be noted that the relation between Q and B/M (Fig. 7) is closer than between Q and B. The fineness of fibre is clearly of great importance. In fact there is a surprisingly high degree of correlation between Q and M (Fig. 10) if one considers the fact that over-retting or deterioration in storage may seriously reduce Q without greatly affecting M. Indeed if M is affected by such factors it is likely to be in the direction of greater fineness.

The importance of the fineness of jute fibre in relation to its spinning quality—a factor well recognised in the trade, but hitherto practically unsupported by quantitative data—is no doubt largely due to the greater flexibility of fine strands and to their ability to pack more closely together in the yarn. This effect is seen in the fact that low quality yarn has in general a lower apparent density than high quality yarn. In practice it is recognised too that, as with flax, a fibre which feels "light in hand" is usually of low quality. Further work on "packing quality" using several methods of comparison which have been worked out, will show to what extent this is connected with the fineness of the fibre strands.

Attention has been called above to some of the more important relationships which are to be found in the data presented in Table I. It would be easy to show graphically other relationships besides those illustrated in Figs. 5 to 10 but it appears unnecessary to call special attention to these.

It is considered wise to postpone a full discussion of the physical significance of the fibre characters in relation to spinning quality until further data have been accumulated and other fibre characters have been examined.

## CONCLUSION.

From the present work it appears possible on the basis of results of the measurements of fibre characters to classify fibre, covering the normal range of quality, into ten classes with a reasonable expectation that the error will not exceed two classes. This is not sufficiently accurate for practical purposes. It might be agreed that a grading into, say twenty classes on the basis of the predicted value of (Q - C) with an error not exceeding one class would be sufficiently accurate for practical purposes. Whether or not this is possible further work alone can show. It seems in any case out of the question to expect greater accuracy than that in routine tests. In actual spinning trials under the carefully controlled conditions of the laboratory tests it is possible that, in replicate tests, differences of up to five units may occur in quality ratio, which has a range of, say, 40 to 120 (cf. Table IX in T.R.L. Memoir No. 1). It is not likely that this can be materially improved upon, so that even upon a basis of actual spinning trials a grading into more than sixteen classes is hardly feasible. It is hoped with some confidence that the incorporation in the index of fibre quality of other characters now under study, particularly "packing quality", will improve the accuracy of classification from the measurements of fibre characters very materially.

The spinning trials were carried out under the supervision of Mr. A. S. Gillies. The yarn and fibre tests were made under

the immediate supervision of Mr. M. K. Mukhopadhyay, Senior Tester, and Mr. T. Ghose made statistical calculations.

## REFERENCES.

(1) Indian Central Jute Committee Technological Research Memoir No. 1, "A Technique for Spinning Yarn Samples from Small Quantities of Fibre", by C. R. Nodder and A. S. Gillies.

IMPERIAL COUNCIL OF AGRICULTURAL RESEARCH

# Prospects of Chemical Retting for Jute

BY

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# PROSPECTS OF CHEMICAL RETTING FOR JUTE

By C. R. Nodder, M.A. (Cantab.)

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THE ordinary ('rural') method of extracting jute fibre is very cheap and on the whole very satisfactory. Any conceivable process of chemical retting would certainly be much more expensive. There would be factory overheads, depreciation of plant and machinery, increased labour and supervision charges, power and, probably, fuel to pay for and perhaps water filtration or water treatment and possibly artificial drying, which is very expensive.

To justify the considerably greater cost of chemically retted fibre it would have to possess very pronounced advantages over ordinary fibre, such as greater strength, greater fineness, less liability to rotting, greater freedom from speck and bark, capability of being bleached more easily, and so on.

It seems out of the question to consider treating the whole jute stems as the cost even with the cheapest chemicals is likely to be prohibitive.

### *Economies*

It would be necessary to 'decorticate' the dried, or partly dried, stems with a suitable machine and treat the crude fibre so obtained. The ratio of liquor to fibre would be between 5 : 1 and 20 : 1. Using the latter ratio 1,000 lb. of crude fibre would require 20,000 lb. of solution. If a 1 per cent solution were used (and it is fairly certain that no suitable chemical could be used in greater dilution) the quantity of chemical required would be 200 lb., and this is not likely to cost less than Rs. 12-8, or Re. 1 per md. of crude fibre. But the 1,000 lb. of crude fibre would yield perhaps only 600 lb. of finished fibre. The chemical cost on the finished fibre might therefore be Rs. 1-12 per md. If a lower liquor-ratio were used it is likely that the solution would need to be proportionately stronger.

Actually one treatment with any one suitable cheap chemical is not likely to give the desired result, and Rs. 3 per maund is likely to be the very lowest figure for costs of chemicals, per maund of finished fibre. No notable economies by re-use of solutions, recovery of chemicals or sale of by-products can be visualized at present.

This then is the probable minimum cost of chemicals alone. From experience with flax it may be suggested that the cost per maund of finished fibre for the other charges (depreciation, supervision and labour, power and fuel, etc.) would quite certainly be not less than Rs. 5 and might be anywhere between Rs. 5 and Rs. 20, according to the process and type of plant used. It is fairly certain that the chemically retted fibre would have to be sold at twice the cost of ordinary fibre at least to make even a small profit.

If the fibre produced could be sold at say £40 per ton when average ordinary jute was selling at £20 per ton it is possible that a chemical retting process might be workable. This is not necessarily an absurdly high figure for it is lower than the price of Italian hemp up to 1934 and far lower than the price in 1938. In a normal year good average flax sells at £60 to £80 per ton. If the chemically retted jute could replace these fibres for certain purposes there might therefore be a demand for it at £40 per ton, or even higher.

### *Hand-picking high quality jute*

On the other hand one must take into account the fact that by hand-picking from high quality marks of ordinary jute it would be possible to produce a very high-class fibre, strong, fine and lustrous and free from speck, at a price far below £40 per ton in a normal year and it may be doubted if the chemically retted fibre would show many advantages over fibre so obtained. If best quality jute were chosen while it was *on foot* and taken to a central rettery (which might be a stretch of river where retting conditions were very satisfactory) and retted there under careful supervision, it is extremely likely that fibre of very fine quality could be produced and subsequent hand-picking would yield a final product of superlative quality. Enormous quantities could be produced in this way more cheaply than by any conceivable chemical or mechanico-chemical extraction process.

### *Cost of chemicals*

A word may be said about the chemicals that might be used in chemical retting. The question of price practically confines attention to the cheaper mineral acids and the cheaper alkalis—sulphuric acid, sodium carbonate, caustic soda, sodium silicate. Hypochlorite solutions might be possibly used in one stage of a process. Phosphates and all organic chemicals (except perhaps cheap soaps) appear to be ruled out by cost considerations. Ammonium oxalate has an excellent 'retting' action, but at say £90 per ton its cost seems prohibitive. Nevertheless one must remember the marvels that have been achieved in the way of recovery of chemicals and the utilization of by-products, particularly in paper manufacture. A chemical retting process permitting of similar recoveries may be found in future, but it does not appear to be available at present. In the case of flax good progress has been made in the chemical treatment of mechanically extracted fibre (' natural flax ') after some of the preparatory spinning processes have been carried out, for example, by chemical treatment of the rove. After chemical treatment the rove can be spun to a good strong yarn up to 25's lea, very suitable for ducks and canvases, and no doubt passable yarns up to 80's lea can be produced.

To work jute on similar lines it would be necessary to construct 'decorticating' machinery suitable for dealing with the thick, hard jute stems, and further machines would be necessary to break down the coarse ribbons of fibre so obtained into fine strands. As compared with flax this problem appears difficult, but it may not be insoluble and it is on these lines that developments may be possible. A mechanically extracted fibre suitably softened and opened up by further mechanical treatment, might very well sell at a price not far different from ordinary jute. A modified 'Linra' Crimper-decorticator might prove suitable for the preparation of the unretted fibre.

Experiments on a jute softener show that freshly cut jute stems may be fairly satisfactorily 'decorticated' on such a machine. A modified machine with fewer rollers and the addition of beater blades is likely to be quite suitable.

Transport of the crude fibre is likely to be a problem. But in a suitably situated factory no doubt very considerable quantities of fibre could be treated without incurring very high transport costs and if there were special virtues in the chemically retted fibre it might have at least a limited demand for special purposes.

Samples of chemically retted jute produced by the Van Besouw process have been examined and appear to be satisfactory, but nothing is known of the production costs or the quality of the straw that was treated (for example, whether or not it was specky).

Chemical retting processes or mechanico-chemical treatments may one day come into their own, but everything will depend on the costs in relation to the enhanced qualities of the fibre, if any, and on the comparative costs of the product and of the fibres it might replace.

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...e "Journal of Scientific and Industrial Research," Volume 4, No. 3, September, 1945, pages 128—129

# THE UTILIZATION OF JUTE WASTE

By C. R. NODDER

(*Technological Research Laboratories, Indian Central Jute Committee*)

THE waste products coming from jute manufactures form only a small percentage of the raw material, if we except the *stick* left when the fibre is stripped from the stems after retting.

Normally, all the low-quality, barky fibre can be used in producing coarse weft yarns for sackings and the waste consists only of very short fibre fragments and pieces of *bark* together with any dust and sand that may be present. This waste often forms less than five per cent. of the raw fibre, and since some five per cent. of mineral oil is added to the fibre in batching, the weight of cloth produced is roughly equal to the weight of raw jute used ; it may even be more.

Jute cuttings are passed through a teaser-card and the waste from this machine together with the waste falling below other cards, looms, etc., is taken to the "dust-shaker." The fibrous material is retained and can be reused for sacking weft mixes. The waste or *dust* rejected by the shaker forms the only real waste. It is often burnt in the boilers.

The dust-shaker waste is too dirty for use in paper manufacture. Its cellulose content is low. There is some possibility that it might find a use in the manufacture of synthetic plastics, though it is doubtful if it could be used without being largely supplemented by other materials, such as the short fibre from the dust-shaker, and by fillers such as wood-flour or jute fibre of reasonable quality and moderate purity. In considering possible uses, it is to be remembered that it may contain five per cent. or more of mineral oil. There may be possibilities of using it, along with other combustible materials, in making briquettes for fuel. This seems to be worth further attention as one of the most promising outlets. Possibilities for the shaker fibre are in the manufacture of needle-felts and tarred roofing-felts and the like.

There are a number of products obtained in jute processing which may be diverted to other uses instead of being reused in spinning. These are :—

(*a*) cuttings—(stiff, barky fibre cut off from the long jute),

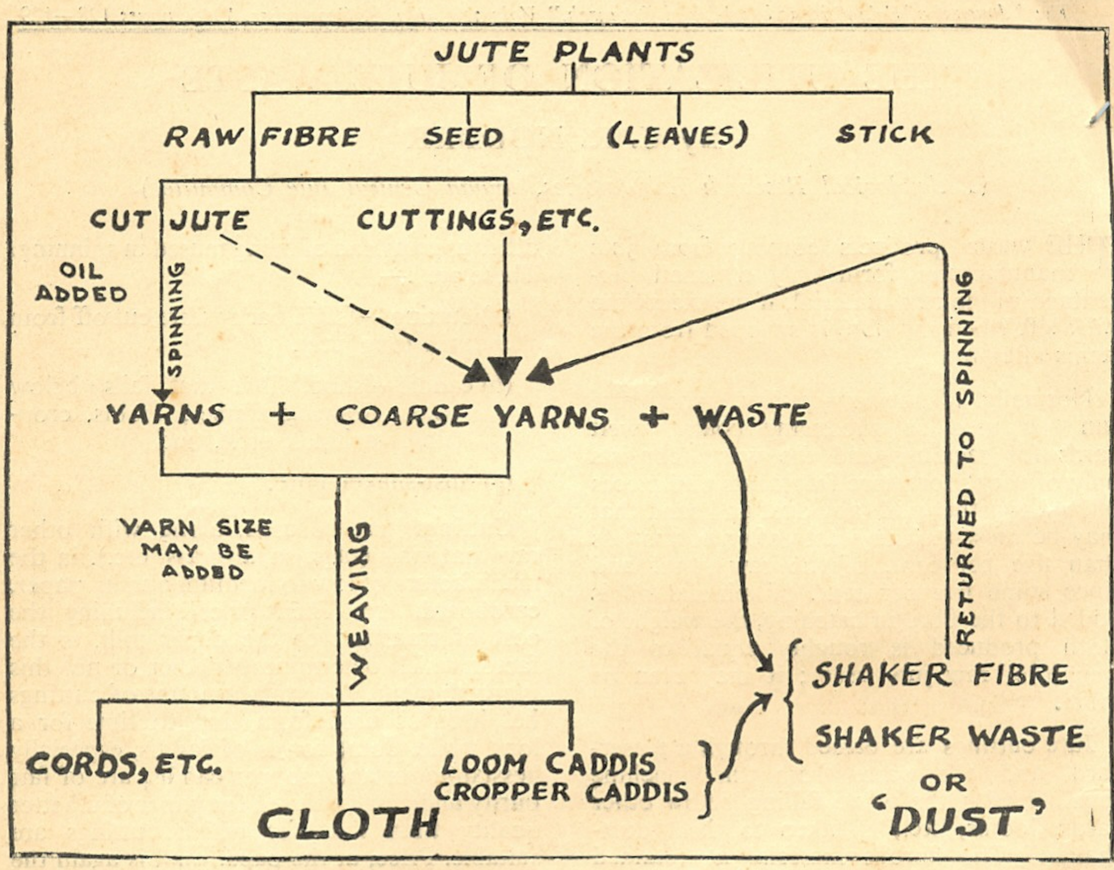
(*b*) caddis—(short fibre that falls below cards, drawing frames, looms, cropping machines, etc.), and

(*c*) dust-shaker fibre.

Cuttings may be used, along with other raw materials (rags, sabai grass, etc.), in the manufacture of low to medium quality paper, cardboard, etc. Their price, including the cost of transport to the paper mill, is the factor which determines whether or not this is worth while. A certain amount of cuttings has been so used from time to time for a long while. Some forms of caddis, especially hessian-loom and cropper caddis, are of fair purity and could be used for paper of a better quality than that for which cuttings are suitable. Price, at the paper mill, is again the governing factor. Jute fibre is a good insulator for heat and there are possibilities of using caddis as a packing material for such purposes, either loose or compressed. Teased cuttings are cheap and might be similarly used.

Dust-shaker fibre can be used for low quality paper and for making strawboards and insulating boards (for sound and heat) and similar products. It has been found suitable, after disintegration, as a filler in plastic compositions for injection moulding. Jute sticks are suitable for use in the manufacture of brown wrapping paper if used to the extent of about 25 per cent. along with other raw materials. The pulped stick merely acts as a filler. But the stick is bulky and the costs of transport are high. The sticks have well-known rural uses, as in the construction of shelters for betel-vines.

Fibre of very low quality, such as that extracted from jute left in the field until the seeds are ripe, falls along with cuttings as regards possible uses. Jute wax along with mineral oil could be extracted from various forms of waste by means of organic solvents




but it is doubtful if such extraction would be economical. Flax *pouce* contains more wax of a better quality and it has been proposed to extract it and use the product for boot polishes, etc., but apparently there have been no commercial developments.

Jute waste can hardly compete with cotton linters as a raw material for rayon, on account of the high proportion of non-cellulosic impurities.

It may be said that price in relation to that of competitive products, and the costs of transport, are the factors which mainly govern the development of uses of jute by-products. The paper trade is well aware of the possibilities and would no doubt take advantage of any materials offered at a suitable price. Since mills are able to use very low quality fibre for sacking weft they are not faced with serious problems in the disposal of waste and no revolutionary developments can be visualised by the disposal of shaker waste. Nevertheless, the *Indian Central Jute Committee* is continually seeking possible outlets for shaker-waste and for the diversion of the by-products of higher quality. It may also be said that the trade has the problem of reducing and utilizing waste well in mind and would not be slow to follow up promising proposals. A number of possible uses that have been mentioned have been suggested by Mr. A. S. Gillies, Manager, who has had long experience of jute mill problems. Two Nissen huts have been heat-insulated by packing teased cuttings between two roof layers and the effect is about equivalent to external thatching with paddy straw. Prof. B. C. Guha has had considerable success in the utilization of shaker-waste and shaker-fibre for the production of a thermosetting plastic (Jutelite) and the process has been covered by a patent.

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# The Colour of Shamla Jute: Its Cause and Removal

The colour of jute fibre, which varies widely from sample to sample, is an important subject for study both from the industrial and scientific points of view. Fibre from *Corchorus olitorius* tends to have a reddish brown colour while the fibre from *C. capsularis* at its best is a pale creamy-white colour. Analyses made in these Laboratories have shown that the reddish colour commonly found in *olitorius* fibre is due neither to a higher lignin content nor to a higher iron content as compared with *capsularis* fibre. Thus an average figure of 11·3 per cent. lignin content has been found for the former as against 12·3 for the latter. For iron content the former showed an average value of 0·041% (range 0·012 to 0·069) and the latter 0·033 (range 0·017 to 0·045). There was no relation between depth of red colour and iron content in *olitorius* fibre.

*Olitorius fibre* often has quite a dark grey colour instead of the more usual reddish brown colour and grey samples of *capsularis* fibre are not uncommon. The cause of the colour of such fibre (popularly known as *shamla* jute) was not definitely known. Matthews (*Textile Fibres*, p. 763, 1923) says ". . . . if steeped in muddy water the fibre takes a dark-grey colour," while Chowdhury (*Jute and Jute Substitutes*, p. 51, 1933) says ". . . the quantity of iron, although very small, has something to do to discolour the jute." In the first report on *The Marketing and Transport of Jute in India*, published by the Indian Central Jute Committee, we read (p. 51) "It has been noticed that when water is reddish brown the fibre is likely to be blackish. This is due, it is said, to the action of iron salts contained in the water. Water of this sort is quite common in West Bengal and in parts of Bihar. It is quite probable that the dark grey colour of *shamla* jute is the result of retting in such water. This point, however, requires to be verified by chemical experiments."

Estimations of the iron content of various samples of jute have shown that it is distinctly higher in *shamla* fibre than in other samples (about 0·1 per cent. as compared with 0·02 to 0·01 per cent.)—*vide* Annual Report, I. C. J. C., 1940-'41, p. 130.

It had been found at the Jute Agricultural Research Laboratories at Dacca that the tannin content of *olitorius* plants is higher than that of *capsularis* plants (I. C. J. C. Bulletin, Vol. III, p. 236). The idea suggested itself that the dark colour of *shamla* fibre might be due to the production of a kind of ink on the fibre by the combination of the tannin in the plant with iron compounds in the retting water and early in January, 1941, some experiments were made to test this hypothesis. It was soon found that ordinary retted jute fibre contained little or no tannin, no doubt because it was leached out during retting. Consequently, when ordinary pale-coloured jute fibre is steeped in a dilute solution of a ferric salt it does not take on a grey shade. But if the fibre is previously steeped in a dilute solution of tannic acid and then treated with a solution of a ferric salt, a grey colour similar to that of typical *shamla* fibre appears, as expected, the depth of colour depending on both the concentration of the tannic acid and of the ferric salt solution. Further confirmation was obtained by the following experiments—(1) The dark grey colour of *shamla* jute is removed very quickly by treatment with dilute oxalic acid or dilute mineral acids. (2) The colour of jute fibre usually darkens on steeping in a solution of tannic acid, no doubt on account of the presence of sufficient iron compounds on the fibre to combine with the tannin and produce a certain amount of "ink". (3) Dry bark from mature jute stems which we had stored in the Technological Research Laboratories was chemically retted with

2 per cent. sodium fluoride solution in the presence of a little ferric ammonium sulphate (ferric fluoride is soluble in water). The fibre obtained had a dark grey colour similar to that of *shamla* jute. (4) We also made a number of experiments (beaker-scale) in which jute (dry, mature plants) was allowed to ret biologically with various amounts of iron in the retting water. Under these conditions it was found that the minimum quantity of iron in the retting water that will produce a *shamla* colour was about 0·01 per cent., the colour produced with that quantity being a light grey.

The dark-grey colour of typical *shamla* jute can be removed by very simple treatments. Oxalic acid solutions are far more effective than dilute solutions of hydrochloric or sulphuric acid. Even N/50 oxalic acid solution at a liquor-ratio of 1 : 10 completely removes the *shamla* colour. A very rapid effect is obtained with N/10 oxalic acid. An acid mixture containing oxalic acid crystals (0·06 p.c.), sulphuric acid (0·25 p.c.) and hydrochloric acid (0·25 p.c.) is very cheap and quite effective (I. C. J. C. Annual Report, 1940-'41, p. 130). In all such treatments it is imperative that every trace of acid should be washed out before the fibre is dried. Otherwise tendering is likely to occur. The acid solution may be used more than once, with the addition of a little fresh acid as required. This will reduce the cost.

Yarn spun from *shamla* jute has been found to suffer no significant loss in strength (as compared with yarn steeped in pure water) by treatment with N/10 oxalic acid for far longer than is required to remove the colour. Thus in one experiment the treated yarn had a mean breaking-load of 8·92 lb. as compared with 9·09 lb. for yarn steeped in water.

It may be noted that it is desirable that the water used in washing the treated fibre should have a very low iron content. The most costly part of the process is likely to be the drying, but during a large part of the year natural drying should be possible.

The increase in the value of the fibre may more than balance the cost of treatment. *Shamla* fibre often takes on after treatment the rather deep reddish colour which is preferred for some purposes.

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Calcutta, 7-6-1942.

# THE INDIAN CENTRAL JUTE COMMITTEE

## TECHNOLOGICAL RESEARCH PAMPHLET

**No. 2**

**Assessment of Spinning Quality.**

By

C. R. NODDER

**March, 1946.**

**CALCUTTA.**

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# Assessment of Spinning Quality.

*A short review of the problems and possibilities of assessing quality by means of routine small-scale spinning trials.*

BY

C. R. NODDER

The assessment of the spinning quality of jute involves considerations which do not arise in the case of cotton, for example, and it is of interest to study the differences in some detail.

In the first place we may outline a method which is used in the Technological Research Laboratories of the Indian Central Cotton Committee for judging the spinning quality of a sample of cotton. In this method certain standards are laid down for the count-strength product (breaking load multiplied by lea count) of yarns of various counts. These standard count-strength products increase with increasing lea count (that is, increasing fineness of the yarn), this being in accordance with practical requirements. A graph in which standard count-strength product (measured horizontally) is plotted against count (measured vertically) consequently rises from left to right. Now if a particular sample of cotton is spun to, say, three different counts it is found that the count-strength product *falls* with increasing count (increasing fineness of yarn); if the results are plotted the graph falls from left to right. Where it intersects the graph for the standards one may read off a count which is termed the "highest standard warp count" and this is taken to be approximately the finest yarn that could be spun from the samples and show a strength (with a twist factor of 4) that was up to the standard laid down.

It may be asked whether a similar procedure could not be followed in the case of jute. The following points arise:

With jute, before the spinning operations are begun we have to consider what proportion of fibre shall be cut off from the root end, whereas we can process a parcel of cotton without any such preliminaries. In fact, the kind of yarn for which a parcel of jute will be used is not, in general, determined merely by the way it would behave, and the quality of the yarn that would be produced, if the fibre were processed as a whole. Instead, we have to consider the following points:

(*a*) How much must be cut from the root end to make it suitable for the yarn which it is desired to spin? Two complications arise here. Firstly, a particular parcel will not normally be spun by itself, but will be blended with other qualities. Secondly, a given parcel heavily cut might be suitable for a hessian warp mix and lightly cut it might be suitable for a sacking warp mix—and so on.

(*b*) Is the colour of the parcel suitable for the yarn in view?

(*c*) What is the position regarding the prevalence of faults (speck, runners, hard crop, etc.)?

These points have to be considered *in addition* to such factors as strength, fineness and flexibility. A little thought shows that in judging the spinning quality of a pacel of jute the general procedure must be (a) to remove the barky 'cuttings' from the root end and note the quantity and quality of these cuttings and (b) to spin the cut jute separately to a sufficient number of counts to indicate its potentialities with reasonable accuracy. In routine trials aimed at the assessment of spinning quality it is not possible to make a very comprehensive examination, which would involve (a) spinning to various counts with different amounts cut from the root end (b) blending with other qualities (c) processing on various systems of machines (d) variations in batching procedure. Our practical aim must be to see how we can gain the maximum information from the cut jute spun to, say, two counts (chosen, for example, from 3 lb., 6 lb. 10 lb. 20 lb.) and it is also important to know how far the results obtained at one standard count (say 10 lb.) can be used as a general guide to quality. It will probably be agreed that spinners could form a very good idea of the quality and value to the mill of a parcel of jute if they were supplied with the following information :—

(*a*) quantity and quality (particularly hardness) of the cuttings produced in 'clean' cutting.*

(*b*) colour of the cut fibre.

(*c*) nature of the faults, if any, in the cut fibre.

(*d*) strength and regularity of the yarn obtained by spinning the cut fibre by standard procedures to (a) 10 lb. yarn and (b) to one other count chosen from 3 lb. 6 lb. and 20 lb. under guidance from the behaviour observed when spinning to 10 lb. (or, alternatively, chosen under guidance from the results of a hand-and-eye examination of the fibre, and possibly also having regard to the types of yarn that are in production—many mills may not be interested in the result obtainable at 3 lb. and 6 lb.).

In the work of the Technological Research Laboratories assessment of quality has been so far based mainly on results obtained by spinning to 10 lb. yarn (the standard chosen being actually 10·3) though in some cases spins to 3 lb., 5 lb. or 8 lb. have been made in addition. The reasons for the choice of a 10 lb. yarn as standard for general assessment are as follows : Jute yarns may be broadly classified, into three groups (a) fine yarns, say 2½ lb. to 6 lb. (b) hessian warp and weft, sacking warp (c) sacking weft. Sacking weft yarns, being composed mainly of cuttings, form a class apart and need separate consideration. The hessian yarns together with sacking warp form by far the largest proportion of the remainder and it is information as to the behaviour of fibre when spun to such yarns that is of greatest use to spinners as a whole. Now hessian warp yarns average about 8½ lb. in grist, hessian weft yarns generally run round about 9 to 12 lb. in grist and sacking warp yarns average about 10 lb. The range of 8 lb. to 13 lb., with a grand

* If a definition of 'clean' cutting is required it may be regarded as removing from the root-end as much as is necessary to make the fibre suitable for a B class hessian warp.

mean of $10\frac{1}{2}$, covers the great bulk of yarns in practical production, aside from sacking weft. It is considered that from spins to the Technological Research Laboratories standard 10·3 lb. yarn very useful information can be gathered as to the probable behaviour of fibre when spun to any ordinary hessian yarn or sacking warp yarn. It is only rarely that a parcel of jute which was better than another when spun to 10 lb. would prove inferior to the other when they were spun to say 8 lb. or 13 lb.

The behavour at finer counts is certainly of importance in relation to the general improvement of the jute crop and the development of new or extended uses and it is with the realisation of this that fine-spinning machinery has been installed in Technological Research Laboratories. A selected number of samples are now being spun to 3 lb. yarn as well as 10 lb.

We now return to a consideration of the possibilities of applying to cut jute a method similar to that employed for estimating the 'highest standard warp counts' in the case of cotton. In the first place we may note that the range of counts in large scale production is much smaller with jute than with cotton, and the number of types of yarn produced from jute is much smaller. Aside from sacking weft, the normal production, except for relatively small quantities, does not go outside the range of, say, 5 lb. to 15 lb. The corresponding range for cotton would be about 10's to 100's leas. A second point is that a variation in leas may be secured in cotton by merely changing the spinning draft more readily than with jute.

Now different systems of machines (with different pinning, speeds, ratios, etc.) are used for producing jute yarns of various types. Even with the best available systems for fine yarns the quality ratio* obtainable at a 3 lb. yarn spun from the finest jute available does not exceed that obtainable from medium quality fibre spun to 10 lb. yarn. Here we have a difference from cotton which is of great importance for the problem under discussion. That is, our standard quality-ratios (corresponding

* Breaking load divided by grist and (for convenience) multiplied by 100.

with lea-strength products) would not steadily increase in passing from coarse to fine yarns (sacking weft excluded). Certainly, hessian weft yarns are generally somewhat weaker and heavier than hessian warp yarns but the differences in grist are fairly small and from the behaviour of a parcel of fibre when spun (with a twist factor of about 11·0) to 10 lb. yarn we can get a very good idea of its suitability for a warp or weft; the range of quality ratios obtained from different types of jute spun to 10·3 lb. yarn (with 3·43 t.p.i.) is 45 to 125. Jute that gives a quality ratio of 80 to 100 can generally be regarded as suitable for hessian warp (provided, of course, that the yarn is suitable as regards colour and degree of speckiness); this range covers fairly well the qualities of hessian in normal production. Fibre that gives a quality ratio exceeding 100 when spun to 10 lb. is of a quality that can often be more usefully used for finer goods (carpet yarns, special canvases, etc.), though it will often find a use in blending with weaker fibre for hessian yarns and even sacking warp. Fibre that gives a quality ratio below 80 when spun to 10 lb. can be used for sacking warp or the lower qualities of hessian weft, or judiciously blended with other fibre. But jute that gives a quality ratio below 70 when spun to 10 lb. should not be used in large proportion for any goods that are expected to give good service, though of course a small admixture in blends with stronger fibre may be reasonable. (In the foregoing we mean by 'spun to 10 lb.' that the Technological Research Laboratories standard process, actually for 10·3 lb., as described in Technological Research Memoir No. 1 is followed, t.p.i. being 3·43).

From what has been said it will appear that a method similar to that employed for cotton is hardly applicable to jute. The information desired by jute spinners can be obtained as far as hessian yarns and sacking warp are concerned from a standard 10 lb. spin, and additional spins to other counts, where necessary, would give good guidance as to the suitability of the fibre for fine yarns. The use of a graph-intersection method such as that referred to in an early paragraph seems hardly necessary over the range of counts of say, 8 to 13. It remains for the future to study the methods most suitable in the case of jute in assessing its capabilities over the ranges of, say, $2\frac{1}{2}$ to 5 lb. and 5 lb. to 9 lb., using appropriate systems of machines (fine-spinning system and hessian warp system respectively) in each case. At 3 lb. grist we are near the limit of fineness of yarns that can be spun on available machinery as a practical proposition and it is not safe to argue from behaviour at, say, 5 lb. grist how a given parcel will spin at 3 lb. It may be emphasised that while the setting up of standard quality ratios at various counts for yarns spun from cut jute is not likely to present any difficulties, it is not to be expected that the standard quality ratio would increase with increasing fineness of yarn, in contradistinction to what is the case with cotton. The following figures are provisional, and for illustration only, but they will serve to illustrate the kind of relationships that may be expected.

| *Good quality Cut Jute*<br>Similar for all spins; spun to various counts on different systems (twist-factor 11·0) | | | *Provisional Standards*<br>For various grists using better quality fibre with increasing fineness of yarn and appropriate twist-factors. |
|---|---|---|---|
| Grist lb. | System | Quality Ratio. | Quality Ratio. |
| 3 | fine spinning | 75 | 80 |
| 6 | ,, ,, | 90 | 90 |
| 6 | hessian warp | 85 | 90 |
| 8 | ,, ,, | 100 | 90 |
| 10 | ,, ,, | 105 | 90 |
| 10 | hessian weft | 100 | 85 |
| 15 | ,, ,, | 105 | 80 |

The actual relationships will depend on details of machines and of processing; the advent of improved machinery or improved qualities of jute might change one's ideas regarding any provisional standards that might be set up. The standards suggested above apply to fine yarns and hessian yarns, made from clean cut jute. Sacking weft is so different that it must be dealt with quite separately; the quality-ratio runs at present in the neighbourhood of 45. Sacking warp yarns vary considerably in quality but an average quality-ratio figure is about 75; a small proportion of cuttings or barky fibre is often admissible in the mix. For tarpaulin yarns the quality ratios run somewhat similarly to those for hessian yarns, but it is important that weft should be at least as strong as the warp and a standard of 85 for warp and 90 for weft would be reasonable. There are various qualities of hessians, sackings, etc., and if only one standard is chosen for each of the yarns concerned it can only represent some kind of average value; there is something to be said for making it represent an average for good to medium qualities, as tending to keep the general quality at a high level. The provisional standards indicated are worked out on such a basis.

There are many complications, among which is the effect of twist factor on quality ratio; generally weft yarns are spun with a lower twist factor than warp yarns of the same grist. Moreover, the factor used for the warp is commonly higher than that which gives maximum strength, a matter that is compensated for by greater resistance to wear and greater extensibility. The effect of twist factor on strength forms the subject of a separate publication and from the results obtained at with one factor it is possible to estimate reasonably well what the strength would be with a higher or lower factor. In Technological Research Laboratories standard spins the twist factor is $3{\cdot}43\sqrt{10{\cdot}3}$, that is, about 11·0. This, as is desirable if the results of the standard spin are to be used as a general indication of quality, is intermediate between the factors commonly used for weft and warp, in yarns with a grist in the neighbourhood of 10.

The judgment of the suitability of a parcel of jute for blending with another quality (or other qualities) to produce a yarn of a particular type is governed by some general principles, some of which may be fairly obvious. Thus, the colour and degree of speckiness of a yarn will be governed by the colour, speckiness and proportions of the components of the mix. Weak fibre may be judiciously blended with fibre which by itself would give a strength in excess of that which is actually required. There are grounds for believing that when white jute is blended with white, or tossa with tossa, the strength of the yarn produced will be at least as high as that calculated from the weighted mean of the components, and may sometimes be higher. This is a useful guide; the fact that the actual strength is sometimes higher than the calculated weighted mean is in consonance with the common practice of including a proportion of 'soft' jute in a mix. 'Soft' jute is usually weaker than 'Hard'. When white and tossa jute were blended the strength of the yarn obtained was found, in a number of Technological Research Laboratories spins, to be lower than the weighted mean calculated from the results obtained with the components spun separately. Consequently, when it is required to add a proportion of strong fibre to a white jute mix that would otherwise give too weak a yarn, the addition of good quality white jute (rather than tossa) may be preferable—that is, more efficient and economic.

Decisions as to whether a particular parcel of fibre is suitable for a mix for warp yarn or for a mix for weft yarn will be governed by its colour, degree of speckiness, strength and, in many cases, by its its 'softness'. If weft yarn is to be used in a cloth where it is important that, after finishing, the interstices should be well closed, a good proportion of 'soft' fibre may be included (always having regard to the necessity of maintaining sufficient strength). In 'soft' jute the strands tend to be finer, on account of a greater breakdown of the fibre-system in retting and/or or on account of the natural characters of the fibre bundles produced by the growth of the plant (such characters being influenced by the strain of jute grown and soil and climatic conditions). If the 'softness' is mainly a result of some degree of over-retting the fibre is likely to be weak.

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# INDIAN CENTRAL JUTE COMMITTEE

## TECHNOLOGICAL RESEARCH PAMPHLET

No. 3

**Some Notes on the Strength of Jute Ply-Yarns.**

By

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It would also be necessary to study S/S, S/Z, Z/S and Z/Z ply-yarns. A full investigation of the subject will require a great deal of work and many thousands of tests. For the study of the effect of singles and doubling twists on strength alone it would be necessary to study various qualities of jute at various grists with a range of singles and doubling twists; in addition it would be necessary to study doubled (folded) yarns with two, three, four, etc. plies.

It is well-known that over the range which is of practical importance, extensibility and resistance to wear increase steadily as twist is increased. It is also certain that the hardness (resistance to the flattening) increases steadily and that penetrability by yarn sizes, and chemical solutions generally, decreases steadily as twists are increased. The importance of the results described below is that they indicate that with a specified singles twist (close to that required for optimum strength in the ply-yarn) the doubling twist may be varied over a considerable range without greatly affecting the strength. Consequently, the doubling twist employed for a particular job will be largely determined by requirements as to wear-resistance, extensibility, penetrability and, in the case of cloth woven from the yarns, behaviour in finishing (closing up of interstices, etc.). As production costs increase with increasing twist this will also be a factor in determining choice of twists.

This work must be regarding as of a preliminary nature, narrowing down the field for future more extensive investigations.

## EXPERIMENTAL.

For the present work two qualities of white jute (Dacca tops and Hard Mill Middles) were used. The singles were spun to 10 lb. yarn by Technological Research Laboratories standard procedure, except that the singles twist was 4·64 turns per inch. (nominal twist factor 14·7*)

Experiments were made with 2·5, 2·73 and 3.0 t.p.i. doubling twists and further experiments with 2·65, 3·00 and

*Twist-factor=turns per inch multiplied by square root of grist, the letter expressed as pounds per spyndle of 14,400 yards.

3·33 t.p.i. doubling twist. In each experiment 9 spinning bobbins were used and the following scheme was followed.

| | | Source of constituent singles. | |
|---|---|---|---|
| For lowest doubling twist | ... | (a) First third of babbins | 1, 2, 3 |
| | | (b) Second ,, ,, ,, | 7, 8, 9 |
| | | (c) third ,, ,, ,, | 4, 5, 6 |
| For medium douling twist | ... | (a) First third of bobbins | 4, 5, 6 |
| | | (b) Second ,, ,, ,, | 1, 2, 3 |
| | | (c) Third ,, ,, ,, | 7, 8, 9 |
| For highest doubling twist | ... | (a) First third of bobbins | 7, 8, 9 |
| | | (b) Second ,, ,, ,, | 4, 5, 6 |
| | | (c) Third ,, ,, ,, | 1, 2, 3 |

The experiments were done in triplicate (A, B, C in tables), giving nine means (each from 100 tests) for the estimation of the strength at each twist.

The detailed results are given in the tables at the end of this pamphlet.

In the tables both nominal and actual (as found by tests) doubling twists are given. The latter tend to fall a little below the nominal, but for practical purposes the nominal twists are probably more useful.

## DISCUSSION.

The singles twist employed for Z/S ply-yarns, that is, the type with which we are now concerned, must be higher, for optimum strength in the ply-yarn, than the twist required to give optimum strength in the singles; in doubling some of the singles twist is taken out. There are grounds for believing that the singles twist employed is not far from the optimum; it may be little lower than the optimum but further work will be required to settle the matter.

The jute used for the earlier series of tests (Table I) was exhausted and a new parcel had to be used for the second series (Table II).

The mean results for each series are as follows :—

| I (J 794) | | II (J 795) | |
|---|---|---|---|
| Doubling t.p.i: (nomidal) | Quality Ratio | Doubling t.p.i. (nominal) | Quality Ratio |
| 2·5 | 90·3 | 2·65 | 106·1 |
| 2·73 | 92·5 | 3·00 | 108·0 |
| 3·00 | 95·2 | 33·3 | 107·4 |

In spite of the care taken in the work, and the large number of strength tests made, the individual bobbin results are somewhat erratic (Tables I & II).

From results obtained with singles yarns it is likely that the true curves for the two samples run fairly parallel. The second series shows the highest quality ratio at 3·0 t.p.i. doubling twist, but the rather steep rise in quality ratio in the first series in passing from 2·73 to 3·0 t.p.i. indicates that the true maximum is at a little more than 3·0 t.p.i. The combined results suggest that maximum strength is given by about 3·1 t.p.i. doubling twist. More work would be required to establish the optimum twist quite accurately, but the rather small effect of doubling twist on strength over the range of, say, 2·7 to 3·5 t.p.i. is sufficiently clear.

We must remember that the present work refers to 10 lb. singles spun with 4·64 t.p.i. singles twist and made into 3-ply yarn. It is often convenient to express the doubling twist in terms of singles twist (t) divided by the square root of the number of plies (n). A doubling twist of 3·1 t.p.i (which is no doubt close to that which gives maximum strength) is 1·16 times $t/\sqrt{n}$. It is likely that for 2-, 4-, and 5-ply yarns a doubling twist of $1{\cdot}16 \times t/\sqrt{n}$ would give a strength close to the maximum obtainable with a given singles twist, but, here again, more work must be done to see the exact relationships;

until further data are available the foregoing formula may be used.*

The following will be a useful practical guide :—

(1) A strength not far from the maximum possible in ply-yarns made from singles (in the neighbourhood of 10 lb. grist) can be obtained by using a singles twist factor of 14 to 15 and a doubling twist (nominal) equal to 1·16 times singles twist divided by the square root of the number of plies.

(2) Where high extensibility and/or good resistance to wear (by rubbing), combined with good strength, is desired lower twists should not be used.

(3) Where a lower extensibility is desirable, and/or resistance to rubbing is less important, the doubling twist may be equal to singles twist divided by square root of the number of plies without much sacrifice of strength.

It is only possible to speak at present in general terms of the results likely to be obtained with other singles twists and at other grists; some data have been obtained but they are inadequate for a detailed discussion. With approximately 10 lb. yarns it is probable that a singles twist factor of 12 with doubling twist equal to about 1·16 times $t/\sqrt{n}$ would still give very good (though probably not maximum) strength, but resistance to wear would be considerably lower; on the other hand sizes and chemical solutions would penetrate more easily and costs of spinning and doubling costs would be reduced.

With finer yarns the general indication is that singles twists should be somewhat lower, and with coarser yarns somewhat higher, in order to obtain maximum strength. A doubling

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*The present experiments indicate a doubling twist of 3.1 t.p. as the most probable value for maximum strength ; the actual (average) t p.i. found in the ply yarns twisted with 3·0 t.p.i. is 2·96. The twisting was done on a spinning-frame with a few spindles modified so that the necessary S doubling twist could be given. If in practice, on proper twisting frames, the difference between nominal and actual twist is lower a nominal doubling twist of approximately 3·07 (that is, 1·15 times $t/\sqrt{n}$) might give maximum strength.

twist of from 1·0 to 1·16 times $t/\sqrt{n}$ would be appropriate for the production of strong ply-yarns.

If hard-twisted ply-yarns of good strength are required a singles twist-factor of 16 might be used (for yarns in the neighbourhood of 10 lb. grist), with a doubling twist equal to 1·16 times $t/\sqrt{n}$, where, as before, it is the number of turns per inch used for the singles and n is the number of plies. Such a ply-yarn will have good resistance to rubbing.

The quality ratios given in the tables were obtained by dividing strength by resultant grist. During doubling some contraction in length takes place, accompanied by an increase in resultant grist. In aiming at the production of a ply-yarn of a specified grist this must be borne in mind. The data obtained in one experiment show that a 9·5 lb. yarn when made into 3-ply with 3·0 t.p.i. doubling twist gave a resultant grist of 29·9 (as compared with 28·5 obtained by multiplying 9·5 by 3). A contraction of nearly 5% is indicated in this case.

The quality-ratio of the ply-yarn is considerably greater than that of the singles. In one experiment a singles yarn with a quality-ratio of 83·5 gave a 3-ply yarn with quality-ratio 108·0.

Thanks are due to Mr. A. S. Gillies, (Manager), Dr. K. R. Sen (Senior Research Physicist), Mr. S. B. Bandopadhyay (Head Tester) and various members of the testing staff for supervising and carrying out the work.

## TABLE I.

*White Jute (J 794) 10 lb. yarn (nominal). Singles twist 4·64 t.p.i. Strength, etc. at various doubling twists.*

| Doubling t.p.i nominal | Source of singles | A Resultant grist | A Doubling t.p.i. actual | A Strength (lb.) | A Q.R. | B Resultant grist | B Doubling t.p.i. actual | B Strength (lb.) | B Q.R. | C Resultant grist | C Doubling t.p.i. actual | C Strength (lb.) | C Q.R. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2·50 | a | 32·6 | 2·42 | 29·8 | 91·5 | 30·9 | 2·17 | 26·6 | 86·0 | 31·0 | 2·45 | 26·3 | 84·8 |
| | b | 32·0 | 2·38 | 29·1 | 90·8 | 30·6 | 2·21 | 28·1 | 91·6 | 28·9 | 2·38 | 25·1 | 86·8 |
| | c | 33·2 | 2·40 | 31·1 | 93·7 | 32·2 | 2·13 | 30·7 | 95·3 | 30·5 | 2·38 | 28·1 | 92·1 |
| 2·73 | a | 33·4 | 2·55 | 33·2 | 99·4 | 29·7 | 2·73 | 28·3 | 95·3 | 30·6 | 2·63 | 26·3 | 86·1 |
| | b | 31·9 | 2·59 | 29·3 | 91·9 | 30·3 | 2·61 | 28·0 | 92·6 | 30·4 | 2·65 | 27·1 | 89·1 |
| | c | 33·7 | 2·56 | 29·2 | 86·8 | 31·2 | 2·70 | 31·2 | 100·1 | 31·5 | 2·67 | 28·7 | 91·1 |
| 3·00 | a | 32·5 | 2·85 | 31·1 | 95·6 | 29·8 | 2·89 | 28·0 | 94·0 | 30·3 | 2·80 | 28·5 | 94·2 |
| | b | 32·5 | 2·92 | 30·5 | 94·0 | 32·7 | 2·89 | 32·2 | 98·5 | 30·4 | 2·79 | 28·1 | 92·2 |
| | c | 31·9 | 2·85 | 31·1 | 97·4 | 31·2 | 2·87 | 29·3 | 93·9 | 30·7 | 2·87 | 29·9 | 97·3 |

*Mean values*

| Nominal Doubling twist t.p.i. | Actual doubling twist A | Actual doubling twist B | Actual doubling twist C | Actual doubling twist Grand mean | Quality Ratio A | Quality Ratio B | Quality Ratio C | Quality Ratio Grand mean |
|---|---|---|---|---|---|---|---|---|
| 2·50 | 2·40 | 2·17 | 2·40 | 2·32 | 92·0 | 91·0 | 87·9 | 90·3 |
| 2·73 | 2·57 | 2·68 | 2·65 | 2·63 | 92·7 | 96·0 | 88·8 | 92·5 |
| 3·00 | 2·87 | 2·89 | 2·82 | 2·86 | 95·7 | 95·5 | 94·6 | 95·2 |

A general rise with increasing doubling twist over the range 2·5 to 3·0 t.p.i. is indicated.