COTTON FIBRE EVALUATION

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ABSTRACT

With the objective of developing new and improved strains of cotton for intensive cultivation in the Hambantota—Tissamaharama and Walawe Project areas, a Cotton Technological Research Laboratory was set up at the Regional Research Station, Angunakolapelessa. This laboratory is fully equipped to test quantitatively the main fibre characteristics of cotton.

In this paper, identification by definition and importance of the main fibre characteristics of cotton are described, along with the role of fibre evaluation in the purity maintenance of cotton variety HC 101.

INTRODUCTION

The quality of cotton varies considerably among different varieties. It is not easy to define quality in absolute terms. However, attempts have been made to evaluate it in terms of different physical characteristics such as length, fineness and strength of fibre. One of the main functions of the Cotton Technological Research Laboratory is the determination of these characteristics as well as the spinning performance of samples of cotton in order to estimate the quality of each sample in as reliable a manner as possible. Hence these tests are of particular importance to the breeding of new varieties.

Cotton breeding is a laborious process and it takes many years to evolve a variety having the desired fibre quality and economic yield potential. The breeder has very often to start from a single plant. Seeds from the selected plants are sown in rows and the produce of each single plant grown out of these seeds is first examined for quality and other desirable characteristics from the agricultural and economic points of view so as to select seeds from the plants giving the best results for further trials. This procedure for selecting seeds of the best plants is repeated during several successive generations, by sowing the selected seeds in rows during the earlier generations and in plots during later ones until a strain is evolved which gives consistent results year after year, a good yield of lint having the desirable quality and resistance to pests and diseases. It will thus be seen that several hundreds of samples have to be examined for quality before a suitable strain is evolved. This emphasises the importance of these tests for breeding new and improved strains of cotton.

Fibre Dimensions

The unit from which the many complicated textile structures are assembled is the single fibre, a very small beam characterised by great length relative to its cross-section. Two dimensions important to the spinner are fibre length and fineness. Fibre length and fineness of man-made fibre can be controlled in the production process. Yet the influence of natural fibres may still be felt because man-made fibres may have to be processed on machines designed to suit the natural fibres. Further, when natural and man-made fibres are blended their dimensions must be compatible. The measurement of natural fibres is a task which is not made any easier by the fact that variation exists not only between different types of the same fibre but also within the same type. Thus, Sea Island cottons are longer than American cottons, but within a sample of Sea Island or American cotton there is a variation in length between fibres. Because of this variation it is necessary not only to derive a single length value to characterise a sample but also to obtain an index of the variation present.

Fibre Length Measurements

A logical approach to the problem would be to take a representative sample of fibres and the length of each individual fibre measured over a suitable scale. Values are then classified and the necessary statistical calculations carried out to produce the arithmetic mean. In addition, some graphical representation of the results may be desirable and could be in the form of a histogram or frequency polygon. But the arithmetic mean is not the most convenient quantity from the point of view of the mill technician who has to decide on the settings of rollers of his spinning plant. The alternative quantity used in the measurement of the length of cotton for the setting of rollers of the spinning plant by the mill technician is the effective length which is defined as the length of the main bulk of the longer fibres. The modern term used in the textile industry is the 2.5% span length.

Importance of Fibre Fineness

In the determination of the merit of a material for spinning, fibre length is often taken as the criterium whereas for many purposes the fineness of the fibre is of equal and sometimes of greater importance. When irregularity is considered it can be shown that even with perfect machines the best yarn that can be produced is one in which the fibres are distributed along the strand in a random order. Martindale shows that the irregularity in the strand is dependent upon the average in number of fibres in a cross section. With a greater number of fibres in the cross section the basic irregularity is reduced. For a given count, the average number of fibres in the cross section will depend on the fibre fineness: the finer the fibre the higher the number and the lower the irregularity.

Another way of looking at this effect is to consider what happens when we start with a given material and try to spin finer and finer yarns. As the yarn becomes finer the number of fibres in the cross section diminishes and the irregularity increases until a point is reached when spinning any finer becomes impracticable and the spinning limit has been reached. Starting with a coarse fibre the spinning limit is reached fairly soon. Summerising these ideas, two points emerge:

1. If a given count is spun from a fine and coarse fibre, a more uniform and a stronger yarn will result from the fine fibre.

2. A fine fibre can be spun to finer counts than a coarse fibre.

Broadly speaking, the finer fibre the greater the total surface area available for inter-fibre contact and consequently less twist is needed to provide the necessary cohesion. This is reflected in the twist factors used for different types of material. Fibre finenees is expressed in gram per inch and referred to as micronaire value.

Fineness of the fibre also affects several mechanical properties and therefore influences the behaviour of the fibre during processing and the properties of the resultant yarn and fabrics. Two fibre properties of importance are the torsional rigidity (resistance to twisting) and stiffness (resistance to bending). Hence, it may be noted that a fibre which is difficult to twist will probably be difficult to spin because spinning necessarily involves the twisting of the fibre. A stiff fibre will affect the ability of the fabric to drape and hang gracefully.

The mass per unit length of a fibre is referred to as linear density and also is a measure of fineness of fabric.

Fibre Strength

Fibre Strength is generally considered to be next to fibre length and fineness in the order of importance among fibre properties. But for cotton, beyond a certain span length this property assumes even greater significance. The different measures available for reporting fibre strength are breaking strength, tensile strength and tenacity or intrinsic strength. Breaking strength denotes the maximum tension the fibre is able to sustain before it breaks. In the case of cotton fibre it depends upon various factors such as the inherent strength of the material constituting it, the number and intensity of weak places and its area of cross section. It is mainly due to the last factor that coarse cottons generally give higher values for fibre strength than finer ones. In order therefore to compare strength of two cottons differing in fineness, it is necessary to eliminate the effect of the difference in cross sectional area by dividing the observed fibre strength by the cross sectional area. However, the determination of area of cross section is difficult in the case of cotton fibres due to the irregular shape of the cross sections. Hence, it is a common practice to divide the breaking load by the fibre weight per unit length, which can be taken as proportional to cross sectional area, assuming the density to be the same for all varieties of cotton. The value so obtained is known as intrinsic strength or tenacity. Intrinsic strength is found to be better related to spinning quality than the breaking strength.

In actual practice fibres are not used individually but in groups such as in yarns or fabrics. Thus bundles or groups of fibres come into play during the tensile break of yarns or fabrics. Further, the correlation between spinning performance and bundle strength is at least as high as that between spinning performance intrinsic strength determined by testing individual fibres. Testing bundles of fibres takes less time and involves less strain than testing individual fabrics. In view of these considerations, determination of breaking strength of fibre bundles has assumed greater importance than single fibre strength tests and hence, fibre bundle strength is used in quality evaluation of cotton. The precisely strength index used in the measurement of bundle strength is defined as the ratio of breaking load in pounds to the weight of the bundle in milligrams.

MATERIALS AND METHODS

In the determination of 2.5 percent span length of cotton fibres a Servo and Digital fibrograph with photo electric cells for scanning parallel cotton fibres was used. The digital counters of the instrument gave various "span lengths" by simple push button controls. The 2.5 percent span length which is the required fibre length corresponds to that length which would be spanned by 2.5 percent of the total number of fibres in the test board.

Fibre fineness, which is also a measure of resistance offered to the flow of air through a plug of fibres, was measured using a micronaire. This instrument measures directly fibre weight per unit length and is calibrated in micrograms per inch, also commonly termed the micronaire value.

The Stelometer which is a pendulum type instrument was used in the determination of bundle strength of cotton fibres. The clamps, used to hold fibre bundle when free from the protruding fibres, are loaded in the slots on the top of the pendulum. When the pendulum is allowed to move tension is applied to the bundle and the pendulum stops as soon as the bundle breaks. Then the breaking load is read on the scale. Broken fibres are collected from the clamps and the weight is determined in milligrams. Bundle strength is computed in accordance with the definition.

RESULTS AND DISCUSSION

Tables 1, 2 and 3 give the test results in respect of span length, fineness and bundle strength respectively of HC 101. Table 1. 1, 2. 1 and 3. 1 indicate the frequency distribution of the respective parameters mentioned above. In assessing the difference in the parameters, Indian standard values are considered as nominal values for the respective parameters. Significant testing of means of the respective parameters (Tables 1.2, 2.2 and 3.2) of HC 101 reveals that except the span length, the other two fibre properties are subject to variation and the variation is significant at 1 percent level, and as such the variety will be subjected to a series of tests involved in the second phase of analysis. Hence, the main assessment will be on the spinning performance of the variety. Depending on the spinning performance of HC 101, its cultivation during the following season will be decided. Figures 1, 2 and 3 are the graphical forms of the frequency distribution of data in respect of HC 101. It may be concluded that HC 101 is deteriorating gradually in basic fibre properties, and as such it may be necessary to replace it with a better variety.

ACKNOWLEDGEMENTS

The author is grateful to Prof. Lakdas. D. Fernando for kindly scrutinizing the scripts and offering useful suggestions.

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Table 1. 2.5% Span Length Test Values

Sample No.	*Span length (mm)*	*Sample No.*	*Span length (mm)*
1	30.0	18	27.1
2	30.4	18	29.2
3	30.1	20	29.2
4	28.4	21	31.2
5	30.4	22	27.9
6	30.2	23	31.4
7	28.8	24	27.8
8	29.8	25	35.4
9	36.8	26	40.1
10	35.6	27	35.3
11	29.2	28	32.0
12	29.2	29	30.0
13	27.6	30	30.4
14	29.0	31	26.4
15	28.4	32	24.4
16	25.8	33	27.6
17	33.6	34	34.6

Table 2. Fibre Fineness Test Values

Sample	*Fineness*	*Sample No.*	*Fineness*
1	4.5	17	4.6
2	4.6	18	4.0
3	4.1	19	4.7
4	3.8	20	4.4
5	4.4	21	4.4
6	4.0	22	3.9
7	4.6	23	3.5
8	4.9	24	4.4
9	3.4	25	4.4
10	3.6	25	3.6
11	3.7	27	4.2
12	4.6	28	4.9
13	4.6	29	4.4
14	5.0	30	4.1
15	4.8	31	4.4
16	3.6	32	3.5
		33	4.6
		34	4.4

Table 3 Fibre Bundle Strength Test

Sample No	*Bundle strength (lb/mg)*	*Sample No*	*Bundle strength (lb/mg)*
1	7.8	19	7.6
2	7.9	20	6.6
3	7.1	22	7.0
4	6.3	22	6.5
5	6.8	23	6.9
6	7.4	24	7.2
7	7.0	25	9.0
8	7.5	26	9.7
9	8.3	27	8.6
10	8.1	28	9.3
11	6.4	29	6.6
12	7.3	30	7.1
13	6.0	31	7.4
14	7.2	32	6.9
15	7.5	33	6.0
16	6.7	34	7.7
17	7.7		
18	6.9		

Table 1. 1 Frequency distribution of 2.5% Span length values

Class Interval (mm)	*Class Value (mm)*	*Class Frequency*	*Class Frequency x Mid value of class*
23 — 24	23.5	01	23.5
25 — 26	25.5	02	51.0
27 — 28	27.5	07	192.5
29 — 30	29.5	14	4413.0
31 — 32	31.5	03	94.5
33 — 34	33.5	01	33.5
35 — 36	35.5	04	141.6
37 — 38	37.5	01	37.5
39 — 40	39.5	01	39.5
	Total	34	1026.6
	Average		30.2

Table 2.1. Frequency Distribution of Fineness Values

Class Interval	*Class Value*	*Class Frequency*	*Class Frequency × Mid Value of Class*
3 — 3.1	3.05	0	0
3.2 — 3.3	3.25	0	0
3.4 — 3.5	3.45	02	6.90
3.6 — 3.7	3.65	03	10.95
3.8 — 3.9	3.85	04	15.40
4.0 — 4.1	4.05	05	20.25
4.2 — 4.3	4.25	07	29.75
4.4 — 4.5	4.45	06	26.70
4.4 — 4.5	4.65	04	18.60
4.8 — 4.9	4.85	02	9.70
5.0 — 5.1	5.05	01	5.05
	Total	34	143.30
	Average		4.2

Table 3.1. Frequency Distribution of Bundle Strength Values

Class Interval	*Class Value*	*Class Frequency*	*Class Frequency × Mid Value of Class*
5.8 — 6.0	5.9	02	11.8
6.2 — 6.4	6.3	02	12.6
6.6 — 6.8	6.7	05	33.5
7.0 — 7.2	7.1	09	63.9
7.4 — 7.6	7.5	06	45.0
7.8 — 8.0	7.9	04	31.6
8.2 — 8.4	8.3	02	16.6
8.6 — 8.8	8.7	01	8.7
9.0 — 9.2	9.1	01	9.1
9.4 — 9.6	9.5	01	9.5
9.8 — 10.0	9.9	01	9.9
	Total	34	252.2
	Average		7.4

Table 1.2 Simplified calculation of the standard deviation from a grouped frequency distribution for significance testing of mean span length

Class Value of span length (mm)	*Frequency*	*Deviation from new origin*	*Deviation x Frequency*	*Deviation*	*Deviation² x f*
X	F	X — A	F(X — A)	(X — A)²	f (X—A)²
23.5	1	— 7	— 7	49	49
25.5	2	— 5	— 10	25	50
27.5	7	— 3	— 21	9	63
29.5	14	— 1	— 14	1	14
			— 52		
31.5	3	1	3	1	3
33.5	1	3	3	9	9
35.5	4	5	20	25	100
37.5	1	7	7	49	49
39.5	1	9	9	81	81
			42		418
			— 10		

New origin A $= 30.5$

Mean X $= 30.5 - \frac{10}{34} = 30.21$

Uncorrected sum of squares $= 41.8$

Correction $= \frac{(-10)^2}{34} = 2.94$

Corrected sum of squares $= 418 - 2.94 = 415.06$

Variance $= \frac{415.06}{34} = 12.20$

Standard deviation $= \sqrt{\text{Variance}} = \sqrt{12.00} = 3.49$

Standard error $= \frac{3.49}{34} = 0.59$

But nominal value $= 29$

$\frac{29 - 30.21}{0.59} = \frac{1.21}{0.59} = 2.05$

Because 2.05 is less than 2.58, difference in span length is statistically insignificant at 1 % level.

Table 2.2 Simplified calculation of the standard deviation from a grouped frequency distribution for significance testing of mean fineness

Class of value fineness	*Frequency*	*Deviation from new origin*	*Deviation x frequency*	*Deviation*	*Deviation² x f*
X	f	(X — A)	f(X — A)	$(X-A)^2$	$f(X-A)^2$
3.05	0	— 1.3	0	1.69	0
3.25	0	— 1.1	0	1.21	0
3.45	2	— 0.9	— 1.8	0.81	1.62
3.65	3	— 0.7	— 2.1	.49	1.47
3.85	4	— 0.5	— 2.0	.25	.10
4.05	5	— 0.3	— 1.5	0.09	.45
4.25	7	— 0.1	— 0.7	0.01	0.07
		— 4.9			
4.45	6	0.1	0.6	0.01	0.06
4.65	4	0.3	1.2	0.09	0.36
4.85	2	0.5	1.0	0.25	0.50
5.05	1	0.7	0.7	0.49	0.49
		1.6			5.12
		— 3.3			

New origin A = 4.35

Mean X $= 4.35 - \frac{3.3}{34} = 4.25$

Uncorrected sum of squares = 5.12

Correction $= \frac{(-3.3)^2}{34} = 0.32$

Corrected sum of squares $= 5.12 - 0.32 \doteq 4.80$

Variance $= \frac{4.80}{34} = 0.14$

S. D. $= \sqrt{0.14} = 0.37$

S. E. $= \frac{.37}{34} = 0.06$

But nominal value = 4.0

$\frac{4 - 4.25}{0.06} = \frac{0.25}{.06} = 4.16$

Because 4.16 > 2.58, difference in fineness is statistically significant at 1% level.

Table 3.2. Simplified calculation of the standard deviation from a grouped frequency distribution for significance testing of mean bundle strength

Class Value of bundle strength	*Frequency*	*Deviation from new origin*	*Deviation x frequency*	*Deviation*	*Deviation² x f*
X	f	X—A	f (X—A)	(X × A)²	f(X—A)²
5.9	02	— 1.6	— 3.2	2.56	5.12
6.3	02	— 1.2	— 2.4	1.44	2.88
6.7	05	— 0.8	— 4.0	.64	3.20
7.1	09	— 0.4	— 3.6	.16	1.44
		— 4.0			
7.5	06	0.4	1.6	0	0
7.9	04	0.4	1.6	.16	6.40
8.3	02	0.8	1.6	.64	1.28
8.7	01	1.2	1.2	1.44	1.44
9.1	01	1.6	1.6	2.56	2.56
9.5	01	2.0	2.0	4	4.00
9.9	01	2.4	2.4	5.76	5.76
		8.4			34.08
		4.4			

New origin A = 7.5

Mean X $= 7.5 + \frac{4.4}{34} = 7.63$

Uncorrected sum of squares = 34.08

Correction $= \frac{(4.4)}{34} = 3.32$

Corrected sum of squares = 34.08 — 3.32 = 30.76

Variance $= \frac{30.76}{34} = 0.90$

S.D $= \sqrt{.90} = 0.95$

S.E $= \frac{0.95}{34} = 0.16$

But nominal value = 7.0

$\frac{7 - 7.63}{0.16} = \frac{.63}{0.16} = 3.9$

Because 3.9 > 2.58,

difference in bundle strength is statistically significant at 1 % level.

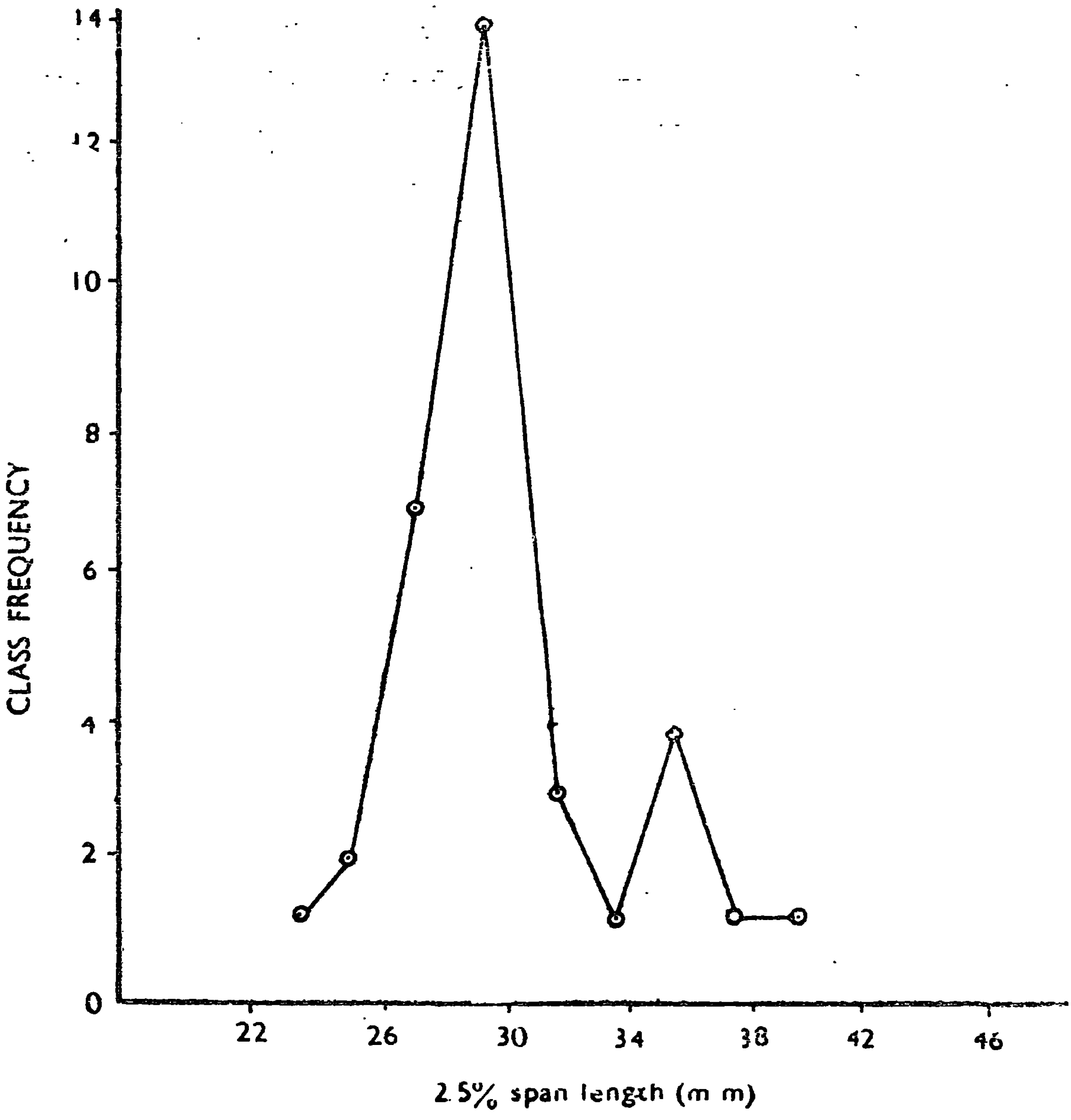

Fig. 1. Frequency Polygon of 2.5% Span Length Values

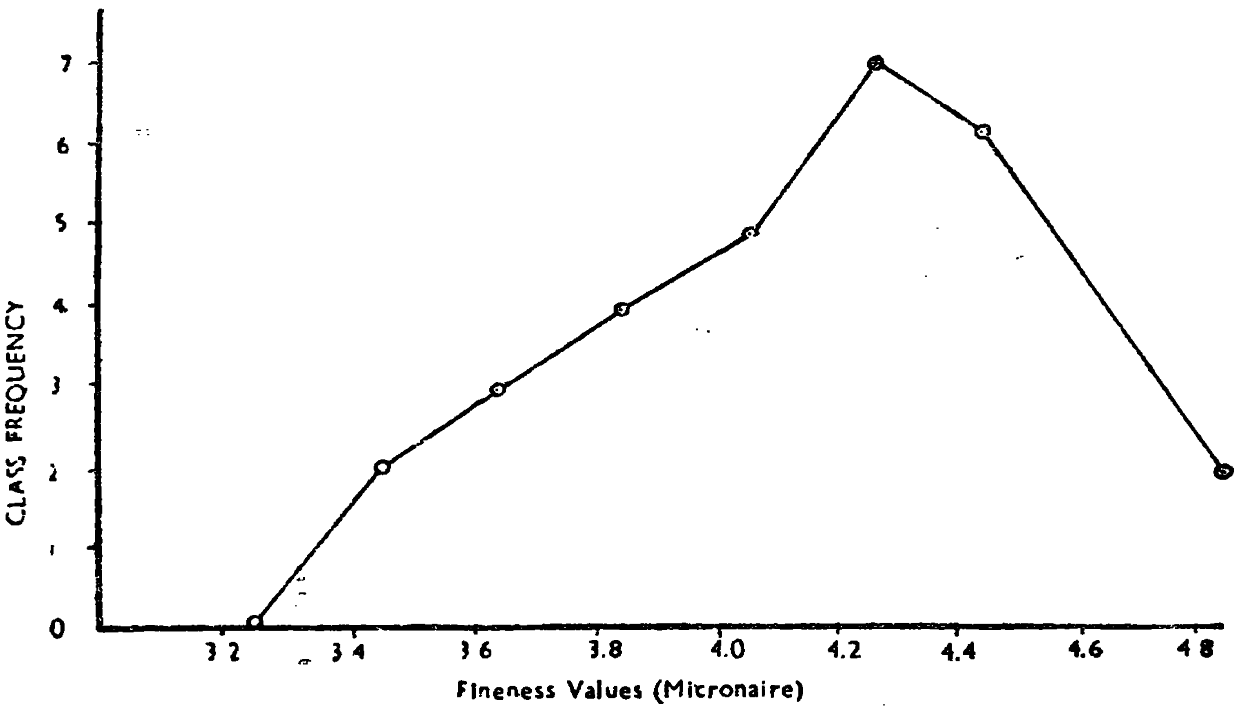

Fig. 2. Frequency Polygon of Fineness Values

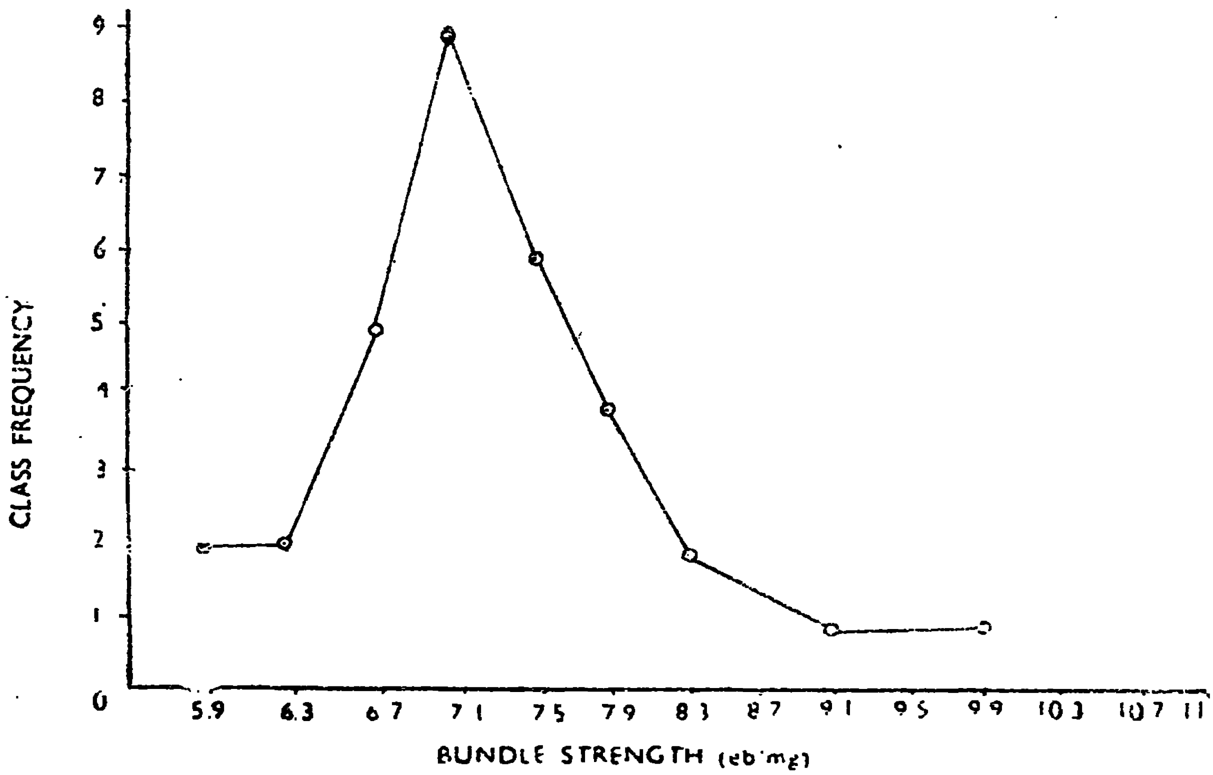

Fig. 3. Frequency Polygon of Bundle Strength