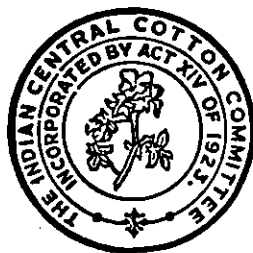


October, 1949.

Technological Bulletin
Series B, No. 43.

INDIAN CENTRAL COTTON COMMITTEE TECHNOLOGICAL LABORATORY



CAUSES OF NEPS IN INDIAN COTTON YARNS

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Price Re. 1/-.

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Causes Of Neps In In

(arns

By A. N. GULATI, *Technolo*

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AS an outcome of discussion on "Neppiness in Cotton" at the Conference of Cotton Breeders held in July 1944, the Technological Laboratory was asked to investigate if factors other than immaturity of lint were involved in the formation of neps. Accordingly the present investigation was undertaken to determine the nature of nep-inclusions for ascertaining the causes of neps in Indian cotton yarns.

It is rare to find a cotton yarn completely devoid of neps. All Indian cotton yarns have neps to a more or less extent, and some cotton varieties are quite notorious in this respect.

Neps are determined per unit length of yarn at the Laboratory, but these counts refer to only true neps, i.e., neps made up of fibres only. The practice is to ignore the seed-coat and leaf fragments occurring in the yarn, which though distinct in the grey state, merge with true neps in the bleached goods. It is, therefore, proposed to study them along with true neps for the purpose of the present investigation.

Nep does not exist in the living boll according to Balls (1928) and is made by handling, ginning and especially carding. Although no attempt is made in the present study to assess the share of ginning, and only a few preliminary observations are made on carding, yet the observations on nep-inclusions tell a good deal of the story. It is indicated what the basic sources are, and in what proportion they occur in different neps.

The basic sources vary in amount in different cottons partly as inherent features and partly as fluctuations arising out of changes in environment. In view of the knowledge gained, a few suggestions are made for precluding the inherent causes and for avoiding some sources at the time of picking and baling.

Material

Twenty-one samples of yarn varying in counts from 6s to 40s and in the number of neps per yard from 0.2 to 11.0, were selected for this study. These samples

originated from twelve distinct varieties, and represented nine different counts and four commonly cultivated botanical groups of Indian cottons, viz., (i) *G. arboreum* var. *neglectum forma bengalensis*, and (ii) *forma indica*, (iii) *G. herbaceum*, and (iv) *G. hirsutum*.

Beside the yarn samples, two cloth samples, namely, grey and bleached made from combed Co. 3 cotton yarns, and a cotton (M4-45/2) at different stages of manufacture together with its eliminated wastes, were also examined for neps.

Method

In order to make every inch of yarn accessible to examination and to facilitate removal of neps for further detailed observations, yarn was wound on black cards with the help of a mechanical card winder. A cloth broker's hand lens was employed for spotting a nep and a pair of pointed forceps to pluck it out of the yarn. Most of the neps come off quite easily, but some had to be extricated with the aid of dissecting needles.

A convenient number of neps or related structures was collected on a microscope slide moistened with 18 per cent. caustic soda solution. The neps were then arranged and opened out so as to separate and parallelise the component fibres in each. The preparation was finally covered with a cover glass and examined under a magnification of 300 times to determine the following details :—(i) Nature of inclusions, (ii) number of fibres, (iii) average length of fibres, (iv) maturity count of fibres, and in a few cottons (v) number of apical ends of fibres.

About 200 neps, seed-coat and leaf fragments, etc., were examined for each sample of yarn. Besides these details, average weight of a fibre-nep, of a seed-coat or leaf fragment, and proportion of loose fibre entangled around the latter were also determined.

These results were supplemented with those on (i) neps per yard determined by the spinning section, and (ii) fibre properties determined by the Fibre-testing

Section of the Laboratory for the purpose of verifying statistically some conclusions emanating from this study.

Results

The data discussed in the paper are set out in Tables I to X. Table I contains the results adopted from the other sections of the Laboratory, and Tables II to VII plus IX and X deal with the observed results. Results included in Table VIII for standard Indian cottons are taken from Technological Bulletin Series A, No. 63 while the rest are taken from other tables.

Tables II to VII deal respectively with (i) the percentage incidence of neps, (ii) mean number of fibres, (iii) mean length of fibres, and (iv) mean maturity percentages in each type of nep besides finally some miscellaneous data on (a) percentage proportion of loose fibre entangled with seed-coat fragments, etc., (b) mean weight of a seed-coat or leaf bit, etc., (c) mean weight of a fibre-nep, (d) observed and calculated results of the mean number of fibres in a fibre-nep, and (e) apical ends in fibre-neps.

Table IX deals with neps from cloth pieces and Table X with neps at various stages of yarn manufacture. The data are discussed hereafter under the following sections :—

I. Incidence of neps and related structures.

II. Detailed study of each type of nep in yarns, viz., A. Fibre-neps, B. Seed-coat fragments, C. Leaf bits, etc.

III. Neps in grey and bleached cloth.

IV. Neps and related structures at various stages of yarn manufacture.

neps per unit area of card web or cloth, and (iv) proportion of nep types in a random population of neps. While the first three indicate the relative neppiness in one or the other form, the fourth is directly useful in tracing the sources of neppiness.

The data for neps per gramme of yarn weight and neps per yard are included in Table I, columns 7 and 8. The comparison of the two sets indicates that neps per yard in different counts of different cottons do not provide as good a measure for comparing neppiness of a cotton as do the neps per gramme. To illustrate the point, it will be seen from the data that the most neppy sample (7290) with 11 neps per yard is not the most neppy when considered on the basis of neps per gramme. Further, as shown below, different counts of different cottons, even when they have the same number of neps per yard, are not similar in respect of neps per gramme.

Sample No.	7288	7064	7198
Counts	20	30	40
Neps per yard	5.1	5.2	5.0
Neps per gramme	188.9	288.9	370.4

The data on neps per gramme also reveal that some neps are either added during drafting for finer counts or are just uncovered, but there is a limit beyond which neps actually decrease instead of increasing in finer counts as shown below. The limit however, appears to be different in different cottons and in sample 7064, the neps per gramme continue to increase upto 40 counts.

Sample No.	7365			7355			7064		
Counts	20	24	30	20	30	40	20	30	40
Neps per grm.	18.5	35.6	27.8	18.5	44.5	37.5	240.7	288.9	459.3

The conclusions arrived at in these discussions are summarized at the end of the paper.

1. Incidence of Neps and Related Structures

There are four aspects of the incidence of neps in cotton, namely, (i) neps per unit length of yarn, (ii) neps per unit weight of yarn, cloth or even cotton, (iii)

In view of the limited value of neps per yard and the additional information that the neps per gramme offer, it is suggested that the neppiness of different samples of cotton be expressed as neps per gramme instead of neps per yard in future. Neps per gramme, as pointed out by Balls (1928), can be usefully determined at various stages of manufacture to trail the neppiness of raw cotton upto the finished

fabric made from it, thus indicating the part played by machines in forming neps.

Neps per unit area have also a limited value like the neps per yard and, therefore, will not be dwelt upon any further here.

These results, however, refer to fibre-neps only, and do not include the seed-coat and leaf fragments, etc., which although differentiable in grey materials are no longer so in bleached goods unless examined microscopically. In order to determine the proportional share of fibres, seed-coat fragments, and leaf bits, etc., in the formation of neps, the fourth aspect of incidence of neps was studied in the course of the present investigation. Table II embodies the classified results on the basis of three main categories of nep-forming materials. The mean results are accompanied by data for two independent sets of hundred observations in each of the 21 samples of yarn. Chi-square and standard error of the mean results are also included in the tabulated data.

Deviations of each set of observations from the mean indicate that except in the case of four yarns, the chi-square is not high enough to be significant at 5 per cent. level for two degrees of freedom, thereby suggesting that the population of neps and related structures in these yarns is generally homogeneous.

The standard error data which are worked out for two categories, namely, fibre-neps and others, show that the two sets of data for each sample of yarn differ significantly from their means only in two of the four cases in which chi-square was significant. Obviously the variability in question is reduced by grouping the seed-coat fragments with leaf bits, etc., as in 30s and 20s yarns of sample 7365. The homogeneity of the two sets of data for most of the sample is, thus, further established.

The data are also shown by a bar diagram in Fig. 1 where the data are arranged in a descending order array of fibre-neps. The diagram shows at a glance that Jarila (Akulkbeda) has the largest proportion of fibre-neps, and type 35/1 (Raya) has the least proportion of them. These positions are reversed with respect to the proportion of seed-coat bits; but leaf bits occur most in Wagotar 4-1 (Dholka) and do not occur at all in Co3. 30s yarn. The three types of neps

vary between the following minimum and maximum values.

Types of nep	Percentages		
	Mini- mum	Maxi- mum	Mean
Fibre-neps	49.5	90.5	76.6
Seed-coat fragments..	6.5	44.5	18.8
Leaf bits	0.0	22.0	4.6

The mean results point out that about three-fourths of the ugliness of Indian cotton yarns is caused by fibre-neps, and it is only the remaining one-quarter which is contributed by seed-coat and leaf fragments. However, the share of fibre-neps can be lowered to about 50 per cent. or raised to 90 per cent.; seed-coat fragments fluctuate between 6.5 and 44.5 per cent., and leaf bits vary between 0 to 22 per cent.

A perusal of the data in Table II further shows that the cottons in the *bengalensis* group of *arboreums* are most variable in regard to fibre-neps and seed-coat fragments, and that *herbaceums*, both of which are closed boll types, have the largest proportion of leaf bits, while *hirsutum*s have a consistently higher tendency to throw off seed-coat fragments than the *indica* and *herbaceum* cottons. These generalisations, however, cannot be carried too far on account of the rather small number of samples in two of the four groups, and the presence in some of the *bengalensis* cottons of a higher tendency to throw off seed-coat bits than even the *hirsutum* cottons.

2. Detailed Study Of Nep-Types In Yarn Samples

The abovementioned three broad categories of neps were further found to be divisible into sub-groups based on the nature of their inclusions as given below:—

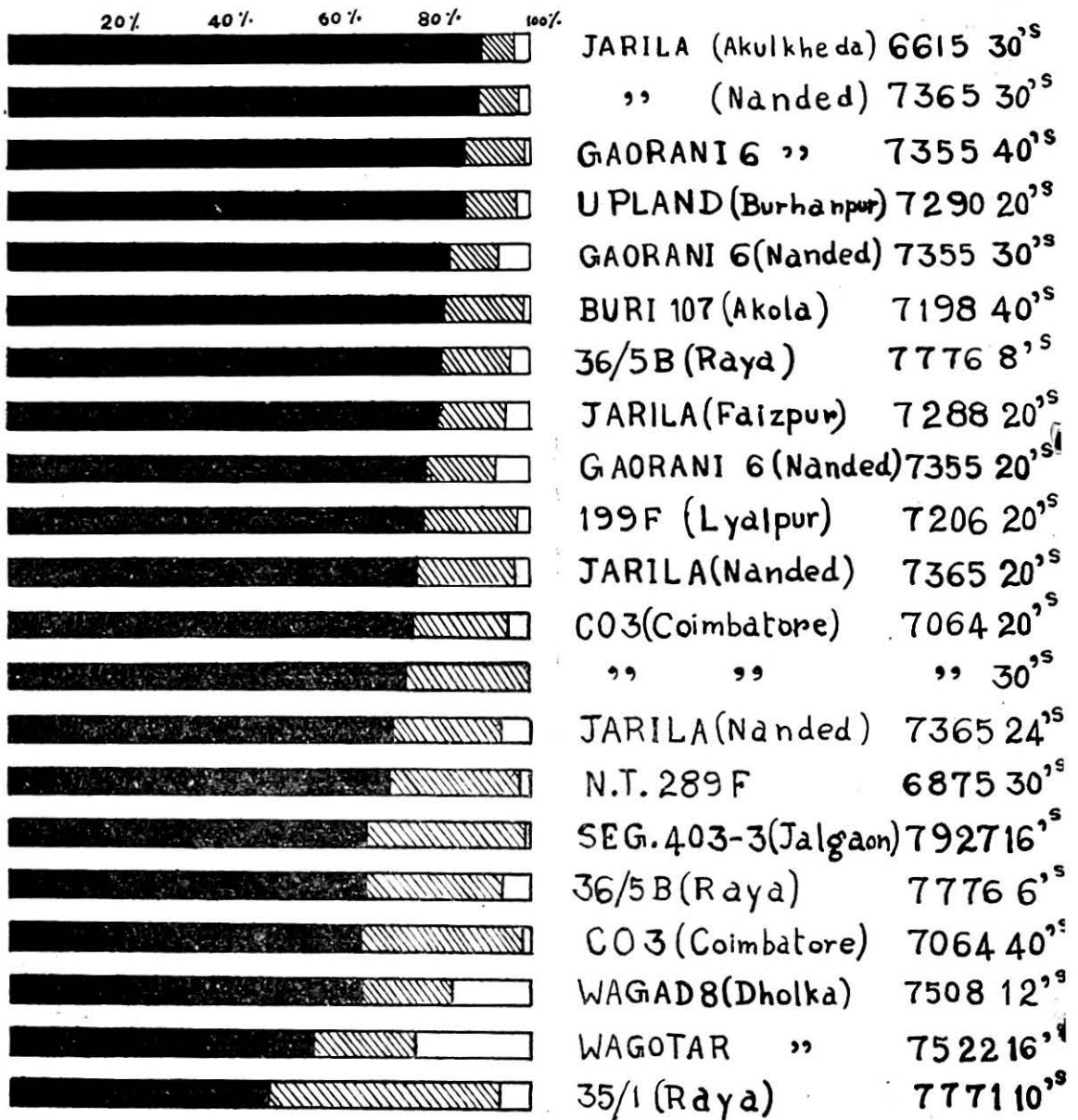
A. Fibre-neps contained either (a) matted fibres or (b) entangled fibres. The entangled fibre-neps were arbitrarily grouped in the following three sub-groups.

(i) Those containing 90 per cent. or more immature fibres;

(ii) Those containing 50 per cent. or more mature fibres; and

(iii) Those containing mixed fibres in proportions other than those of the above two groups.

PERCENTAGE INCIDENCE OF FIBRE NEPS , SEED-COAT FRAGMENTS AND LEAF-BITS ETC.



ALL-FIBRE-NEPS,
 SEED-COAT FRAGMENTS,
 LEAF-BIT ETC.

Fig. 1

B. Seed-coat fragments bore either, (a) mature fuzz, (b) half-mature fuzz or (c) immature fuzz.

C. Leaf bits, etc., included neps having (a) leaf bits, (b) jute fibre pieces, or (c) a wild silk fibre.

Each of these sub-types is discussed at some length below.

A. *Fibre-neps*.—Strictly speaking, the term nep is applicable to a fibre-nep only. Examination of thousands of such neps revealed that the fibre involved in making them was either matted or entangled. Matted fibre comes from prematurely dead bolls and also occurs on and around perforations made by insect attack in partly diseased bolls. The matted fibre is glued together and is seldom easily separable. It takes the form of lustrous flakes in ginned cotton. During the passage of cotton through the blow room and carding operations, a good part of the matted fibre is generally eliminated, but some of it is broken up into smaller bits by the beating and tearing action of the machinery, and lingers on in the card web and thence into the yarn in the form of lustrous specks. A few of these specks may be further eliminated in the waste collected by the woollen top clearers of the draw frame, slubbing, inter, and roving frames, or even the top and lower rollers of the ring frame; but the fact is that a few of them do get into the yarn structure. It is pointed out that the nep-content of these wastes is pretty high, although the quantity of these wastes is very small indeed.

(a) *Matted fibre-neps*.—Matted fibre-neps are quite easy to recognise with a hand lens or even visual inspection after some practice. The percentage proportion of such neps in the various samples is indicated in column 3 of Table III. It is interesting to note that they occur in all samples to a more or less extent. Jarila (Akulkheda, 6615) registers them in the largest proportion (12.5 per cent.) and in 199F (7206) their proportion is the lowest (2.5 per cent.). The occurrence of a large proportion of matted fibre neps in Jarila cotton led us to investigate whether other samples of Jarila shared this feature or not. Accordingly 12 samples of Jarila from six localities were examined for the presence of matted fibre flakes. Despite the fact that they belonged to the 1944-45 season instead of 1942-43 of the former

sample, they all had a fair amount of matted fibre flakes in them. Out of two other Jarila yarns included in this study, one again had an above average value (7288), while the other (7365) had a value approaching the average at least in one of the three counts of yarn. It is interesting to note that the last two samples belonged to the 1943-44 season. Thus, it was observed that Jarila cottons from nine different localities and three different seasons had a common characteristic of having a fair amount of matted fibre in its lint.

The fibres in this type of neps have no convolutions, nor any secondary cellulose in their walls. But for their contour lines, it would be impossible to estimate their number in a nep. They are dead hairs which were distinguished by Miss Clegg (1930) from immature hairs by the complete absence of secondary cellulose in their walls. A nep of this type is illustrated in Fig. 1 of Plate I.

It is pointed out that matted fibres are not taken into account in maturity tests, and hence constitute the first cause of neppiness not included in the immaturity percentages of a cotton. Other particulars of an average nep of this type are :—

Mean incidence percentage ..	6						
Mean number of fibres ..	50						
Mean length (mm.) ..	2.6						
Mean maturity	<table> <tbody> <tr> <td>{ Mature ..</td> <td>5%</td> </tr> <tr> <td>{ Half mature ..</td> <td>3%</td> </tr> <tr> <td>{ Immature (dead) ..</td> <td>92%</td> </tr> </tbody> </table>	{ Mature ..	5%	{ Half mature ..	3%	{ Immature (dead) ..	92%
{ Mature ..	5%						
{ Half mature ..	3%						
{ Immature (dead) ..	92%						

These particulars show that matted fibres occur entangled with a few ordinary fibres. In fact, it would not be possible for lumps of matted fibre to occur in the yarn structure without the aid of ordinary fibres. As the lumps of matted fibre which occur in ginned cotton are usually much larger, it is obvious that they are fragmented until the size seen in yarns is attained. It is highly probable that matted fibre-lumps which escape elimination as blow room waste, are broken up in the card, because the specks of matted fibre which emerge in the card web or the card strip waste are indeed smaller than those seen in the ginned cotton.

(b) *Entangled fibre neps*.—The second group of fibre-neps is made up of entangled fibres in contrast to the matted fibres of the first group. In order to see

how the three maturity grades of fibres took part in forming these neps, a further classification into the following three groups was resorted to. Group (i) contained 90 per cent. or more of immature fibres ; group (ii) contained 50 per cent. or more of mature fibres ; and group (iii) had mixed fibres. Another reason for adopting this classification was to bring the present classification on lines similar to those suggested by Miss Clegg (1934). According to her, homogeneous dead neps had an incidence of 54 per cent. in Empire cotton yarns. If we combine the incidence of matted fibre neps with that of group (i) of the entangled fibres since both have dead and immature fibres, our results compare as below with Miss Clegg's data.

which have 70 per cent. immature hairs in their composition, and the remaining 3 per cent. which also have 22 per cent. immature hairs. Taking all the entangled fibre-neps collectively, an average nep contains 14 per cent. mature fibres, 9 per cent. half-mature fibres, and 77 per cent. immature fibres. The importance of immature fibres in forming these neps is thus evident. Immature fibres have a well-known tendency to tangle. They are weak too (Gulati and Ahmad, 1935), and are in consequence most susceptible to breakage in processing. An indirect evidence of breakage of fibres is afforded by the low mean length of fibres in a nep, while a direct evidence is provided by the occurrence of 5 to 7 apical ends of fibres per nep as shown in Table VII. It is of interest

Present Results		Miss Clegg's data	
	Per cent.	Per cent.	
Matted fibre-neps + Entangled fibre-neps having over 90 per cent. immature fibres . .	31	54	Homogeneous dead neps.
Group (iii) of entangled fibre-neps.	64	42	Immature and mixed neps.
Group (ii) of entangled fibre-neps, i.e., containing 50 per cent. or more mature fibres.	5	4	Process neps.

The classification followed in the present investigation is shown in Table III, but the mean percentages shown above are modified from those given in the table on the basis of a total population of fibre-neps to make them comparable with Miss Clegg's figures.

The following are the particulars of an average nep of each of the three sub-types of entangled fibre-neps which are illustrated in Figs. 2, 3, and 4 of Plate I.

to note here that Clegg and Harland reported the occurrence of apical ends of fibres in neps as early as 1923. According to Koshal and Ahmad (1932) about 80 per cent. fibres break near the apical end in strength tests and this is confirmed by the observation that apical ends occurring in neps are not necessarily immature, but are derived from mature and half-mature fibres also. (See Fig. 4, Plate II). The source of nep-forming fibres, therefore,

Particulars	(i) 90% Immature fibres.	(ii) 50% Mature fibres.	(iii) Rest
Mean incidence per cent.	18.0	3.0	49.6
Mean number of fibres	43	31	35
Mean length of fibres (mm.)	2.7	3.9	3.1
Mean maturity per cent. {			
Mature	3	67	17
Half mature	1	11	12
Immature	96	22	71
Maximum length of fibres in a nep (mm.) . .	14	12	16

The above mean results which are derived from Tables III to VI, lead to the following four important observations:

(i) The incidence percentages show that the total of 71 per cent. of entangled fibre-neps comprises 18 per cent. such neps which are almost wholly formed of immature fibres, 50 per cent. such neps

though chiefly derived from the immature component of the staple yet partly lies in the other components also.

(ii) The low mean length of fibres included in neps points out that nep-forming fibres are essentially short. Either the fibres involved are naturally so, or are derived from long fibres as a result of

breakage during processing. That the fibres do actually break after carding was detected by Ahmad (1938) in four cottons. Mean length of four samples of Lasani cotton in the raw lint stage and of fibres untwisted from the spun yarns of the same samples also confirmed the above observation. These mean length results are :—

Sample No.	8943	8944	8945	8946
Mean length of raw cotton (mm.)	26.67	26.16	25.65	22.86
Mean length of fibres from the yarn (mm.)	21.59	21.84	22.35	21.84

Having established that the staple invariably breaks during processing, it was next investigated which length grade was actually affected and to what extent. Fibre-length distributions of M4-45/2 cotton were determined before and after spinning obtaining the following values :—

Length grades	2/8"	3/8"	4/8"	5/8"	6/8"	7/8"	8/8"	9/8"	10/8"	11/8"	12/8"
Raw cotton (% by weight)	2.4	3.0	5.1	5.8	8.1	11.2	18.7	22.3	15.3	6.4	1.7
Fibres from 44s yarns (% by weight)	2.1	6.2	9.5	10.5	12.8	16.9	17.3	14.4	6.2	2.9	1.2

These results clearly show that after spinning the proportion of fibres below one inch increases, while the proportion of fibres of one inch and longer lengths decreases.

Strangely, a similar indication followed a statistical study of correlations between neps per yard or per gramme on the one hand and proportion of short 2/8" plus long fibres (above one inch), long fibres alone, or immature component of either in the raw cotton on the other. The following correlation coefficients were worked out:

	Neps per yard	Neps per grm.
Short and long fibres of 11 samples	+ .594	—
Long fibres of 11 samples	+ .591	+ .648
Immature component of long fibres of 11 samples	+ .622	+ .620
Short and long fibres of 10 samples	+ .975	+ .946
Immature component of above samples	+ .982	+ .873
Long fibres alone of 10 samples	+ .977	+ .946
Immature component of above 10 samples	+ .985	+ .879

It will be noted that the coefficients of correlation for 11 samples were just on the border line of significance at 5 per cent. level, but those for 10 samples were almost perfect. One of the 11 varieties, viz., Jarila (Akulkheda), did not

fit in. Before explaining the erratic behaviour of this cotton and with a view to generalising the result, the study of correlations was extended to one season of Standard Indian cottons, i.e., 1944-45, since both the data were availa-

ble for them. These results were :—

	All Standard Indian cottons (20 samples)	Neps per yard	Neps per grm.
Short and long fibres		+ .750	+ .808
Immature component of above		+ .466	+ .437
Long fibres alone		+ .744	+ .804
Immature component of above		+ .498	+ .478
Immature component for 18 cottons		+ .729	..

These results indicate that just as in the present samples, the proportion of long fibres is directly correlated with neps per yard, while the addition of short fibres does not improve the relationship. Secondly, the immature components in standard cottons do not maintain the high correlations noticed in the present samples, but present a distinctly improved relationship only on elimination of two cottons, viz., Cambodia Co. 2, and saw ginned Sind Sudhar. Two cottons thus behaved erratically in this set too. Let us now examine, why?

Taking the saw-ginned Sind Sudhar Standard cotton first, it is noticed that it has more neps than can be accounted for

by its long and immature fibres. A comparison of the data for this sample with those for the roller-ginned sample of the cotton reveals that the increase in neppiness of the saw-ginned sample is associated with decrease in the proportion of long fibres (see Table VIII). Evidently the saw gin broke the long immature fibres from the staple and provided extra material for additional number of neps. The cause of the erratic behaviour of this cotton in the correlation lies in the use of saw gin.

In the case of Cambodia Co. 2 Standard cotton, despite the high proportion of immature long fibres, the neppiness was rather low. The fact that immaturity of fibres varies in different length grades of a cotton and the trends are different in different cottons (Clegg, 1932), was examined. But in view of the results published by Iyengar (1939) that in Co. 2 cotton longer length grades have more immature fibres than the rest of the length grades, the above situation would be rather worsened than explained. As it is a unique feature in this cotton, it will be studied at greater length in a future investigation in respect of both the nature of neps and the maturity percentages side by side.

Coming to Jarila (Akulkheda) cotton, included in the present study, its erratic behaviour in the correlation is due to high nep content and comparatively low long fibre content. As the immaturity in long fibres as noticed in the fibres untwisted from the yarn is much less (only 6 per cent.) than that (18 per cent.) in the whole sample, the variability of immaturity in different length grades does not again explain the case. However, a perusal of the detailed analysis of neps of this cotton in Table III shows that this cotton has the largest number of matted fibre neps, and also a very large proportion of neps having over 70 per cent. immature fibres in their composition. Columns 4 and 6 of Table III.

It is probable that the immature fibres which went into the composition of the neps were derived from both the matted fibre and also long immature fibres which were accordingly so few in the normal yarn structure.

Since long fibres, notably the immature among them are even on *a priori* grounds most prone to breakage and entanglement in processing, it is necessary before assert-

ing their role as nep formers to see what happens to the short fibres initially present in the raw cotton. Wastes notably of fibrous origin were examined in the case of one cotton (M4-45/2) for this purpose.

This cotton had 2.4 per cent. fibres in the 2/8" length group. At this rate, the 8-lb. sample, with which the spinning operation was started, should have about 3 ozs. of fibres of this length group. Although fibres of this length grade were present in blow-room wastes, and in card strips and cylinder-doffer wastes, they were found to be concentrated in the licker-in fly waste. The last named wastes weighed 1-3/10 ozs. which is only slightly less than half the total weight of this length group in the whole sample. In view of this observation it is presumed that much of the short fibre initially present in the raw cotton is rejected before the cotton completes its passage through the card. However, fibres of this length group are not absent from yarn structure as noticed earlier in this discussion. At any rate, the short fibres originally present in raw cotton have almost no role to play as nep formers, while those obtained from breakage of long fibres, notably immature, do appear to be the chief source of neps of the entangled fibre type.

In order to obtain a prediction formula for neps from the fibre-length distributions and the maturity percentages, the following correlations for the combined set of present samples with the standard cottons were also worked out. One of these relationships is illustrated in text Fig. 2.

30 samples	Neps per yard	Neps per grm.
Short and long fibres ..	+ .678	+ .714
Immature component of above ..	+ .767	+ .714
Long fibres only ..	+ .678	+ .714
Immature component of above ..	+ .786	+ .736
Immature component of above for 29 cottons, i.e., without Cambodia cotton.	+ .893	..

Assuming the correlation to be linear, the following regression equation was arrived at from the last mentioned correlation coefficient.

$$Y = 0.9197x - 0.1440 \text{ where}$$

Y = Neps per yard, x = Immature component of fibres longer than an inch (per cent. proportion of fibres longer than an inch multiplied by per cent. immature hairs).

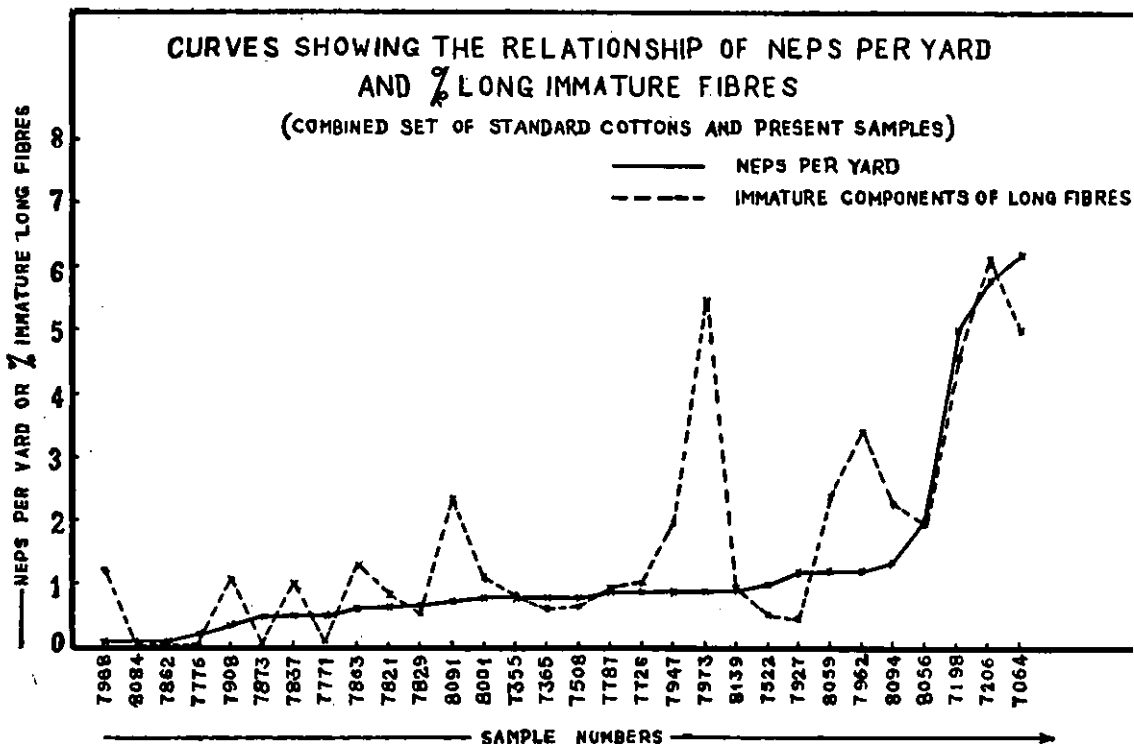


FIG. 2

The values predicted with this equation are given in column 10 of Table VIII. On comparison with the observed values (column 4) a mean deviation of 41 per cent. was noticed. As this deviation was too much, and the curves in Fig. 2 show that the distribution is not linear, a better fit was sought by the second degree parabolic equation which was worked out to be as below :—

$$Y = 0.3347 - 0.0659x + 0.2230x^2$$

The calculated values yielded by this equation (column 11, Table VIII) improved the fit only slightly such that the mean deviation was still 36 per cent. Although the fit obtained is not quite satisfactory, the equation, nevertheless, provides a rough and ready method for assessing the neps in yarn originating from entangled fibres in an unspun sample from its Balls Sorter length distributions and percentage of immature hairs, until an improved equation is worked out for which percentage of immature hairs will have to be worked out separately for fibres longer than an inch.

In this connection, it is interesting to point out that the regression equation

based on the correlation coefficient of + .985 between neps per yard and percentage proportion of immature long fibres in the present samples, yielded calculated values which fitted very well with the observed data. These values are also included in Table VIII, column 12. The mean deviation in this case was 13.8 per cent. This equation is:—

$Y = 1.0008x + .3142$ where Y = neps per yard and x = percentage proportion of fibres longer than an inch multiplied by percentage of immature hairs.

Text Fig. 3 illustrates the common trend indicated by the two properties under discussion.

(iii) The third point emerging from these results is that as mean length of fibres in a nep increases, the number of fibres in a nep decreases. Fewest number of fibres occur in neps containing over 50 per cent. mature fibres, and the mean length here is the longest. Similarly fibres are most numerous among immature fibre-neps, and the mean length is the shortest there. Obviously, mature fibres resist fragmentation more than the immature ones.

In view of the negative correlation between the mean fibre-length in a nep

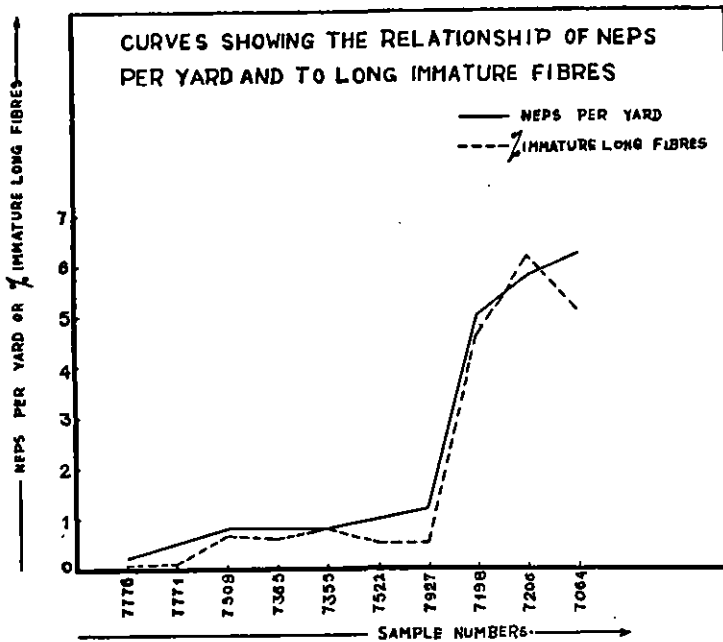


Fig. 3

and the number of fibres in a nep, the validity of an assumption, that mean nep-weight would vary directly with mean fibre-weight per unit length of the sample was examined. The data required are embodied in columns 5 and 6 of Table VII. The value of r was found to be + 0.86 which is highly significant.

This confirmation further led to the application of a check on the correctness of the observations on the number of fibres in a nep. Accordingly mean number of fibres in a nep was calculated from the mean fibre-weight per unit length and the mean length of fibres in a nep. These results are also set out in Table VII (columns 7 and 8). It will be seen that the correspondence of calculated value is quite close in 8 out of 12 cases. It may be pointed out in this connection that fibre-weight values were determined on these samples two years earlier by the Fibre-testing Section of the Laboratory than the observations on neps which were made by the writer.

(iv) The fourth point emanating from this study deals with the mature fibres which enter into the composition of neps. Observations on neps containing 50 per cent. or more of mature fibres showed that the mature fibres included in neps were either apical ends, mechanically damaged fibres or were characterized by the presence

of kinks and spurs along their length. Kinked and spurred fibres are naturally bent or looped, and in consequence have an extra propensity to tangle. Similarly, the mechanically crushed or damaged fibres lose their natural resiliency and, therefore, remain folded and looped. The loops sometimes become knots as seen in Fig. 2 of Plate IV. Mature fibres in neps are illustrated in Figs. 3, and 4 of Plate I and Figs. 1, 3 and 4 of Plate II. Fig. 2 of Plate II shows a long spur in a fibre removed from these neps.

The analysis of entangled fibre-neps brings out that (i) some fibres other than immature are also partly responsible for nep-formation, (ii) immature fibres occurring in group lengths longer than an inch which are most prone to both breakage and entanglement in drafting, constitute the main cause of entangled fibre-neps, and (iii) the mature fibres which enter the nep-structure are generally damaged or are broken apical ends. They are even kinked or spurred.

B. *Seed-coat fragments.*—Seed-coat fragments constitute nearly 19 per cent. of neps and related structures included in the present study. Observations on 790 seed-coat fragments showed that they varied in size from pin point to about 2 mm. in diameter, and in respect of number, length and maturity grade of fuzz borne on them. These fragments also bear stumps of lint hairs torn during ginning. A noteworthy feature of these fragments was that they invariably bore fuzz of one maturity grade only; immature fuzz on some, half mature fuzz on others, and mature fuzz still on others. Fuzz on each piece was characterized by one uniform maturity grade in all cottons, *arboreums*, *herbaceums* and *hirsutum*s.

Fuzz on mature, immature, aborted, and diseased seeds was examined. Strange as it may seem fuzz was generally mature even on immature seeds covered with

immature lint hairs. It was mature even on a few of aborted ovules. Half-mature fuzz occurred on some seeds at the chalazal end, and immature fuzz occurred on some prematurely dead seeds notably those which bore matted lint and also rarely on some aborted ovules.

Despite the varied origin of the maturity grade of fuzz on seed-coat fragments, the classification was adhered to because it still served as a means of tracing the origin of the fragments. Particulars of neps containing seed-coat fragments of each of the three types, i.e., with a distinctive maturity grade of fuzz are embodied in columns 7, 8 and 9 of Tables III to VI. These results bring out that seed-coat fragments bearing all the three types of fuzz occur in all yarn samples to a more or less extent. It is interesting to note that in 16 out of 21 yarn samples, the number of fragments bearing mature fuzz was larger than those either bearing half mature fuzz or immature fuzz. Fragments bearing half mature fuzz were as a rule few in all samples; nevertheless they showed decisively that the seeds concerned were damaged at the chalazal end in ginning. Immature fuzz bearing fragments occurred in larger number than either of the other two types in four cottons which are Gaorani 6 (7355), Jarilla (Faizpur) (7288), Wagotar 4-1 (7522), and Wagad 8 (7508). It is probable that prematurely dead seeds bearing matted fibre abound in these cottons. Among the 16 samples showing a preponderance of fragments bearing mature fuzz, the following cottons are noteworthy—35/1 (7771) and 36/5b (Raya) (7776), segregate 403-3 (Jalgaon) (7927), Cambodia Co.3 (7064) and N.T. 289F (6825). It is unfortunate that seed-cotton of these varieties was not available for confirming these observations, but it is gratifying to mention that the tendency to throw seed-coat in Cam-

bodia Co.3 has since been confirmed by the local agricultural authorities.

It may be mentioned in this connection, that observations on ginned seed have shown that the seed crushed in ginning is generally already insect attacked, although surface layers are scraped off even from healthy seeds. It is, therefore, desirable that the incidence of prematurely killed seed, and of aborted ovules be studied in relation to environment and genetical make-up of the variety in the field with a view to taking steps to reduce the occurrence of such seeds to the minimum.

Mean particulars of the three types of seed-coat fragments are summarized below, while each of these types is illustrated in Figs. 1, 2 and 3 of Plate III.

It will be noted that the mean length of fuzz and fibre together, and also their number are almost constant. Maturity, however, varies in the three types, and the chief cause of variation is the overwhelming majority of fuzz on each fragment. Representation of all grades of maturity in the three types establishes that seed-coat fragments bearing fuzz entangle ordinary fibres around them. It is possible that naked seeded varieties will not have this tendency and so yarns spun from them may be free from seed-coat bits at least. Yarns of *barbadense* cottons may be studied in this connection. One of them (Afghan-Egyptian) had no seed and leaf bits (7788) in its yarn.

The amount of ordinary fibre entangled by seed-coat fragments along with leaf bits was found to constitute about 26.2 per cent. by weight of these nep-like structures. The average weight of a seed-coat or leaf bit was found to be 3.6×10^{-5} grammes.

C. *Leaf bits, etc.*—This category includes, besides leaf bits, pieces of jute

Seed-coat fragments.

	Bearing mature fuzz	Bearing half-mature fuzz	Bearing immature fuzz
Mean incidence per cent.	10.1	2.6	6.1
Mean length fuzz and fibre (mm.)	2.1	2.2	2.2
Mean number of fibre and fuzz	73	71	74
Mean maturity per cent. { Mature	81	7	4
{ Half mature	4	81	4
{ Immature	15	12	92

fibres and coils of wild silk fibre occasionally. The leaf bits are traceable back to broken leaf and to bracteoles, sepals and inner lining of the boll cavity. The jute fibre pieces are essentially from the hessian cover, while the wild silk fibre originates from moths infesting the cotton field. These moths are the adult forms of spotted bollworm, i.e., *Erias spp.*

On an average these structures collectively do not exceed 4-5 per cent. of the total nep and related structures. Among the present samples two cottons, namely, Wagad 8 and Wagotar, stand out prominently in the matter of incidence of leaf bits, which happens to be 15 per cent. and 22 per cent. respectively. Although these were not the only cottons marked in the

remnants of sepals and bracteoles, together with the inner lining of the boll and septal walls get broken and mixed up with seed cotton to be carried to yarn structure.

Hairiness of leaf bits was thus found to be a feature of technological importance. The leaf hairs, serving as hooks, entangle fibres around some leaf bits which are further caught in yarn structure by the aid of projecting ends of the entangled fibres. See Fig. 4, Plate III and Fig. 1 of Plate IV.

The jute fibre pieces and the wild silk fibre also entangle a few fibres around them on account of the ragged and projecting ends of fibrous units in them.

Mean particulars of nep-like structures in this category are as below :—

Leaf bits, etc.

—	Leaf bits	Jute fibre	Wild silk
Mean incidence, per cent.	2.7	1.2	0.7
Mean length (mm.)	3.2	3.4	2.4
Mean number of fibres	33	38	13
Mean maturity, per cent. {	Mature	16	40
	Half mature	16	10
	Immature	68	50

raw state as leafy and very leafy (column 5 of Table I), yet they had more numerous leaf bits in the yarns than other cottons of similar category of cleanliness, viz., Jarila, N.T. 289F, 199F, and upland (Burhanpur). The point was investigated. Leaf bits of Wagad 8, Wagotar and Jarila cottons were examined. All the three cottons were hairy on the back of the leaf, but in the first two cottons, the density of hairs was definitely more than in the last named. The former had hair both on bracteoles and upper edge of the sepals, while some pieces of the inner lining of the boll had some hairs in the first two cottons. It is believed that leaf bits get entangled with fibres, only on account of the presence of stellate hairs on them. Jarila appeared to have less of them than the other two cottons.

Wagad and Wagotar cottons were further studied in the field at Viramgam, and Jagudan. It was learnt that both Wagad 8 and Wagotar were closed boll types and further differed from Jarila in this respect. These cottons are picked as bolls, and the seed cotton is removed by manual labour from the burrs. In this process, the

It may be noted that out of the three types included above, the wild silk fibre occurred most rarely, and had the least and smallest fibres which were also characterized by higher maturity percentages than in the other two types. The silk fibre-nep is illustrated in Fig. 4 of Plate IV. The silk fibre is derived from cocoons of spotted boll-worms, i.e., *Erias spp.*

3. Neps in Grey and Bleached Cloth Samples

The results of observations on neps in grey and bleached cloth made from Co.3 combed yarns are presented in Table IX. The incidence values show striking differences in the distribution of nep types in the two sets. While the grey cloth contains all the nep-types met with in carded yarns indicating that the action of combing is not selective on any one type, the bleached cloth has no matted fibre-neps, nor any leaf and seed-coat fragments. Remnants of seed-coat fragments and jute fibres are nevertheless recognisable under the microscope. Although naked eye cannot distinguish them from entangled fibre-neps at this stage, they have

been grouped separately in the table, because they were recognizable as such with the aid of the microscope.

Matted fibre-neps appear to lose their identity completely on bleaching. Obviously the cementing pectinous material which kept the fibres bound together in such neps was removed during the preparation of cloth for bleaching, i.e., during kier boiling which involves treatment with 6 per cent. caustic soda solution on the weight of cloth. The fibres are loosened and on drying they appear entangled and intertwined just like the other entangled fibre-neps made of immature fibres.

The fate of the leaf bits and seed-coat fragments in these samples is similar to that of matted fibre-neps. The leaf bits are dissolved away in kier boiling, leaving only the fibre-mass which was originally entangled round each of them. Neps of this origin can be traced at times to leaf bits if they contain a leaf stellate hair as a nucleus. Similarly on the dissolution of seed-coat fragments, fuzz entangled with fibre is left behind to tell its origin.

The action of kier-boiling for removal of non-cellulosic materials is well known. But to add to the evidence it may be pointed out that the number of entangled fibre neps has distinctly increased in bleached cloth over that in grey cloth. This increase is due to the addition of matted fibre, leaf bits and a few seed-coat bits which bore half-mature and immature fuzz. The latter would also look like the entangled fibre neps if the loose fibre entangled round them is not too little and the fuzz hairs on them not too many.

The effect of kier boiling on jute fibres is to reduce them to their ultimate cells, which on account of their spindle shaped appearance and 2 to 4 mm. lengths remain distinguishable from the surrounding cotton fibre bits.

In view of the changes brought about by kier-boiling preparatory to bleaching in seed-coat and leaf fragments, matted fibre-neps and neps containing jute fibres, such that neps from these sources look like the entangled fibre neps of grey goods to the naked eye, *it is pointed out that neppiness of bleached goods in strict sense is caused by fibres as well as foreign bodies.* It is, therefore, not only reasonable,

but most desirable to include, the foreign bodies like seed-coat and leaf fragments, etc., in any count of neppiness. As for the ugliness of the yarn, seed-coat fragments, etc., make the yarn much more ugly than the true neps.

Neps at Different Stages of Yarn Manufacture

Dr. Balls (1928) published the following results of nep-counts at different stages of yarn manufacture.

	Neps per gram.
1. Original lint	515
2. Carded sliver	755
3. Card strip	3,080
4. Comber lap	688
5. First comber waste	1,772
6. First comber sliver	109
7. Second comber waste	93
8. Finished draw frame	152

From these results he concluded that the nep content was raised by the card from 500 to 1,000 per gramme, but the card put away a quarter of it in the waste. The first comber put aside 80 per cent. of the neps into its waste, and the second comber disposed of further 30 per cent. of the remaining neps. Drafting also made a little nep.

Following these lines, the results embodied in Table X were determined for M4-45/2 cotton (sample No. 8917). Neps were counted from the raw cotton, fibrous parts of blow room wastes, card wastes, card web and finally from the yarns. In order to do so fibres were spread out in the form of thin tufts, laid side by side to cover a black cardboard piece admeasuring 5" x 4.5". The pattern thus prepared was examined with the aid of "Readex," an American instrument designed for the purpose (Pratt, 1946). While spreading the fibres on the cardboard, care was exercised to let all leaf and dust particles fall on the board so that they were also counted beside the neps. The latter appeared as distinct conglomerations of fibre similar to those noticed in yarns.

These results point out a somewhat different story from what Balls observed. The carding process of the Laboratory

surprisingly did not increase the initial nep content of the cotton. It will be further noticed that the blow room treatment eliminated only 2.6 per cent. of the total neps, while carding disposed of 11.8 per cent. more of the neps. The card web retained about 75.7 per cent. of neps initially present in the cotton, and a balance of 9.9 per cent. neps remained unaccounted for. Apparently, the difficulties involved in such observations are responsible for the unaccounted neps which under the circumstances should not be considered high. An interesting issue emerging from these observations is that if the carding process does not increase the nep content of this cotton, the cotton must have acquired all its neps in ginning from the fibres present in it. However, before stressing the finding further, and investigating how the ginning machinery makes neps, it is necessary to compare these results with those from material taken from some local mills to see if the well-known indictment of making neps on the card can be lifted or at least the card settings responsible for making or avoiding neps be determined.

Neps counted from yarns spun from this cotton further show that all the neps present in the carded web are not displayed in the trial yarns spun from the cotton and that some of the neps present in the web are eliminated in drafting with the help of top clearers right from the draw frame to the ring frame.

Like neps, the fate of seed-coat and leaf-fragments was also followed during blow room and carding treatments given to this cotton. It is seen that 36.2 per cent. of these undesirable materials passed out sticking with the fibrous wastes and about 8.0 per cent. remained in the carded web. The rest about 55.8 per cent. is usually seen free in the blow room wastes along with dust particles.

Similarly, the motes, which were quite numerous in this cotton initially were found to be eliminated to the extent of 72.9 per cent. in the blow room wastes. As they did not exist as such in the card wastes, the obvious conclusion is that the remaining 27.1 per cent. of the motes were fragmented during the opening and carding treatments and thus got mixed up with the seed-bits already discussed above.

Summary

Detailed analysis of over four thousand neps revealed the following causes of 'neps' in Indian cottons.

(1) Broadly speaking, 77 per cent. of neps are formed of fibre, and the rest originate from foreign matter such as seed-coat, leaf and jute fibre fragments, etc.

(2) The fibres entering the nep structure are traceable to matted fibre, immature fibre, damaged normal fibre, or kinked and spurred fibre.

(3) Matted fibre is responsible for 6 per cent. neps on an average.

(4) Immature fibre mostly accounts for another 18 per cent. of them. It also forms the major part of about 50 per cent. more neps.

(5) Mature fibres which are either damaged, kinked or spurred preponderate in only 3 per cent. neps.

(6) Nep-forming fibres are essentially short and the indications are that they are derived from the breakage of long fibres in general and immature fibres among them in particular.

(7) Neppiness due to fibre-neps as indicated by neps per gramme or per yard, is highly correlated with the immature component of long fibres (longer than an inch) in both the present samples and the standard cottons on elimination of three cottons. A regression equation based on this correlation is recommended for predicting the neppiness of an unspun cotton from the Balls Sorter length distributions and maturity percentages.

(8) Mean fibre weight per unit length was found to be highly correlated with mean weight of fibre-neps.

(9) Seed-coat fragments are traceable to mature seeds, diseased seeds, prematurely dead seeds, and unfertilized ovules, injured first in the gin, and then fragmented in subsequent processing.

(10) Leaf bits in raw cotton are derived from dried leaf, bracteoles, sepals, inner boll lining, etc., but it is only that leaf bit which bears stellate hairs that enters the yarn structure and entangles fibres around it. Jute fibre pieces come from the hessian cover of the bale, and the wild silk fibre comes from some moths infesting cotton fields.

(11) Seed-coat fragments and other extraneous matter entangles on an average 26 per cent. by weight of ordinary fibres around them.

(12) Kier boiling prior to bleaching dissolves the seed-coat and leaf bits, etc., and leaves fuzz and fibre-masses which resemble true neps in naked eye appearance.

(13) Observations on one cotton at various stages of manufacture indicate that the carding treatment at the Laboratory does not increase neps, but concentrates a few of them for elimination as waste. During drafting at various stages some neps appear to be removed by the top clearers.

(14) These findings indicate that a cotton for spinning nep-free yarns should have the following qualities.

- (a) Low immaturity among fibres longer than an inch, and high resistance to throw off apical ends of long fibres. Fibres with long-drawn-out "tails" at apex are not desirable.
- (b) There should be no kinked, spurred or branching fibres.
- (c) Naked seeded varieties are expected to include fewer seed-coat fragments in yarns than fuzzy seeded varieties. Fuzz and fibre left on seed-coat enable the fragments to be entangled with the fibres.
- (d) Fuzzy seeded varieties should be hard seeded, or preferably permit the lint to be ginned easily such that the seed-coat is not damaged in the process. Insect-attacked and otherwise diseased seeds get crushed in ginning, while aborted ovules pass as they are. Incidence of such seeds should be minimum in raw cotton, or else the same should be eliminated before ginning.
- (e) Tendency to bear aborted ovules should be noted at the time of selection of varieties and those with only the least tendency should be selected.
- (f) Cotton should be picked clean to avoid straw, leaf, stained and matted locks.
- (g) It should not be damp at the time of baling, and should be stored dry to avoid fungal and bacterial deterioration. Fibres thus tendered

are more susceptible to mechanical damage than ordinary fibres and in consequence increase nep-forming material.

(15) Further work on the effect of gin settings is now in hand, and it is proposed to study the effect of variation in blow room, card and subsequent settings with a view to finding out the optimum conditions for spinning nep-free yarns: In this connection, the so-called Nep-free cottons from Egypt would be worthy of intensive study.

Acknowledgments

The writer has pleasure in thanking Mr. D. L. Sen, the Director, for facilities and taking interest in the progress of this work. His thanks are also due to the Imperial Entomologist, New Delhi, who identified the cocoons, silk from which was found responsible for making some neps in the present material. He has also to acknowledge the help of Messrs. K. Venkateswaran for calculations, K. P. Pillay for general assistance, and Fibre-testing and Spinning Sections of the Laboratory for data determined by them and used in this paper.

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APPENDIX I

TABLE I

Some particulars of yarns studied for the nature of neps

Sample No.	Season	Cotton	Locality	Cleanliness group	Counts	Neps per gramme	Neps per yard	Mean fibre length (mm.)	% proportion of 2/8" + 9/8" and longer fibres	% proportion of long fibres	Mean fibre wt. per cm. × 10 ⁻⁶ gm.	Maturity percentages
1	2	3	4	5	6	7	8	9	10	11	12	13
<i>Gossypium arboreum var. neglectum forma bengalensis (H. & G.)</i>												
6615 ..	1942-43	Jarila	Akulkheda	Extremely leafy.	30s	544.4	9.8	20.6	8.7	6.5	1.79	63-19-18
7288 ..	1943-44	Jarila	Faizpur	Very leafy	20s	188.9	5.1	—	—	—	—	75-15-10
7365 ..	1943-44	Jarila	Nanded	Fair	30s	27.8	0.5	19.7	7.8	5.2	1.90	72-16-12
7365 ..	1943-44	Jarila	Nanded	Fair	24s	35.6	0.8	19.7	7.8	5.2	1.90	72-16-12
7365 ..	1943-44	Jarila	Nanded	Fair	20s	18.5	0.5	19.7	7.8	5.2	1.90	72-16-12
7771 ..	1943-44	35/1	Raya	Leafy	10s	9.3	0.5	18.9	4.1	1.9	2.43	84-10-6
7776 ..	1943-44	36/5b	Raya	Leafy	8s	3.0	0.2	18.0	2.9	1.1	2.22	83-10-7
7776 ..	1943-44	36/5b	Raya	Leafy	6s	2.2	0.2	18.0	2.9	1.1	2.22	83-10-7
7927 ..	1944-45	Seg 403-3	Jalgaon	A little leafy.	16s	35.6	1.2	21.3	7.6	5.9	2.04	77-15-8
<i>G. arboreum var. neglectum forma indica (H. & G.)</i>												
7355 ..	1943-44	Gaorani 6	Nanded	Fair	40s	37.0	0.5	21.5	10.8	9.0	1.67	81-10-9
7355 ..	1943-44	Gaorani 6	Nanded	Fair	30s	44.4	0.8	21.5	10.8	9.0	1.67	81-10-9
7355 ..	1943-44	Gaorani 6	Nanded	Fair	20s	18.5	0.5	21.5	10.8	9.0	1.67	81-10-9
<i>G. herbaceum var. frutescens Delile (H. & G.)</i>												
7508 ..	1943-44	Wagad 8	Dholka	Very leafy contains stalks	12s	17.8	0.8	19.3	6.2	3.8	1.87	60-22-18
7522 ..	1943-44	Wagotar 4-1	Dholka	Leafy	16s	29.6	1.0	19.8	4.0	2.2	1.85	50-25-25
<i>G. hirsutum Linn.</i>												
7064 ..	1942-43	Co. 3-6	Coimbatore	Clean	40s	459.3	6.2	24.5	40.6	39.0	1.49	68-19-13
7064 ..	1942-43	Co. 3-6	Coimbatore	Clean	30s	288.9	5.2	24.5	40.6	39.0	1.49	68-19-13
7064 ..	1942-43	Co. 3-6	Coimbatore	Clean	20s	240.7	6.5	24.5	40.6	39.0	1.49	68-19-13
7198 ..	1943-44	Buri 107	Akola	Clean	40s	370.4	5.0	23.2	25.7	24.2	1.26	65-16-19
6875 ..	1942-43	N. T. 289F	Not Known	Leafy	30s	250.0	4.5	—	—	—	—	83-12-5
7290 ..	1943-44	Upland	Burhanpur	Leafy	20s	407.4	11.0	—	—	—	—	74-14-12
7206 ..	1942-43	199F	Lyallpur	Leafy	20s	214.8	5.8	23.6	30.8	29.4	1.22	66-13-21

TABLE II

Percentage incidence of three main types of neps

Cotton	Sample No.	Counts	All fibre neps			Seed coat fragments			Leaf bits, etc.			Chi-Square	Standard Error $\sqrt{\frac{PQ}{N}}$
			I set	II set	Mean	I set	II set	Mean	I set	II set	Mean		
<i>Gossypium arboreum var. neglectum forma bengalensis (H. & G.)</i>													
Jarila (Akulkheda)	6615	30s	90	91	90.5	6	7	6.5	4	2	3.0	0.75	0.0207
Jarila (Faizpur)	7288	20s	83	82	82.5	11	15	13.0	6	3	4.5	1.62	0.0269
Jarila (Nanded)	7365	30s	92	88	90.0	4	12	8.0	4	—	2.0	8.09*	0.0212
Jarila (Nanded)	7365	24s	69	78	73.5	23	19	21.0	8	3	5.5	3.20	0.0312
Jarila (Nanded)	7365	20s	76	81	78.5	18	19	18.5	6	—	3.0	6.19*	0.0291
35/1 (Raya)	7771	10s	40	59	49.5	53	36	44.5	7	5	6.0	7.23*	0.0354*
36/5b (Raya)	7776	8s	76	90	83.0	19	8	13.5	5	2	3.5	6.95*	0.0266*
36/5b (Raya)	7776	6s	68	69	68.5	26	26	26.0	6	5	5.5	0.19	0.0329
Seg. 403-3 (Jalgaon)	7927	16s	70	67	68.5	29	32	30.5	1	1	1.0	0.21	0.0329
		Mean			76.0			20.2			3.8		
<i>G. arboreum var. neglectum forma indica.</i>													
17 Gaorani 6 (Nanded)	7355	40s	88	87	87.5	10	13	11.5	2	—	1.0	2.40	0.0234
Gaorani 6 (Nanded)	7355	30s	85	84	84.5	9	10	9.5	6	6	6.0	0.06	0.0256
Gaorani 6 (Nanded)	7355	20s	80	80	80.0	15	12	13.5	5	8	6.5	1.03	0.0283
		Mean			84.0			11.5			4.5		
<i>G. herbaceum var. frutescens Delile (H & G.)</i>													
Wagad 8 (Dholka)	7508	12s	71	64	67.5	18	17	17.5	11	19	15.0	2.52	0.0331
Wagotar 4-1 (Dholka)	7522	16s	59	58	58.5	23	16	19.5	18	26	22.0	2.72	0.0349
		Mean			63.0			18.5			18.5		
<i>G. hirsutum Linn.</i>													
Co. 3-6 (Coimbatore)	7064	40s	67	68	67.5	30	32	31.0	3	—	1.5	3.07	0.0331
Co. 3-6 (Coimbatore)	7064	30s	76	76	76.0	24	24	24.0	—	—	—	0.00	0.0302
Co. 3-6 (Coimbatore)	7064	20s	82	73	77.5	15	22	18.5	3	5	4.0	2.35	0.0296
Buri 107 (Akola)	7198	40s	87	80	83.5	12	19	15.5	1	1	1.0	1.87	0.0262
N. T. 289F	6875	30s	70	76	73.0	26	24	25.0	4	—	2.0	4.33	0.0314
Upland (Burhanpur)	7290	30s	83	92	87.5	15	5	10.0	2	3	2.5	5.66	0.0234
199F (Lyalpur)	7206	20s	83	76	79.5	17	20	18.5	—	4	2.0	4.55	0.0286
		Mean			77.8			20.4			1.8		
		Grand Mean			76.6			18.8			4.6		

P = Probability of occurrence of fibre neps.

Q = Probability of occurrence of seed-coat + leaf bits, etc.

N = 200 ; P + Q = 1.

* Limit of significant chi-square value at P = .05

N = 2 = 5.991

* Values significant.

TABLE III

Percentage incidence of various types of neps

Sample No.	Counts	Fibre-Neps				Seed coat fragments			Leaf bits, etc.		
		Matted fibre	Entangled fibres			Ma- ture fuzz	Half mature fuzz	Imma- ture fuzz	Leaf bits	Jute fibres	Wild silk fibre
			Imma- ture fibres over 90%	Ma- ture fibres over 50%	Mixed fibres						
1	2	3	4	5	6	7	8	9	10	11	12
7355 ..	40s	5.0	17.0	7.5	58.0	4.0	1.5	6.0	—	1.0	—
7355 ..	30s	4.0	21.0	5.5	54.0	2.5	1.0	6.0	0.5	4.5	1.0
7355 ..	20s	9.5	12.5	2.0	56.0	8.5	0.5	4.5	3.0	3.5	—
7064 ..	40s	5.5	14.0	2.0	46.0	15.0	4.5	11.5	1.5	—	—
7064 ..	30s	5.0	22.5	3.0	45.5	11.0	4.0	9.0	—	—	—
7064 ..	20s	8.5	16.5	0.5	52.0	9.0	2.5	7.0	2.5	1.5	—
7198 ..	40s	3.0	14.5	5.0	61.0	9.0	1.0	5.5	0.5	—	0.5
7365 ..	30s	5.0	38.5	1.5	45.0	4.0	1.0	3.0	1.0	1.0	—
7365 ..	24s	3.5	13.0	1.0	56.0	9.5	4.5	7.0	—	4.5	1.0
7365 ..	20s	3.0	25.0	2.5	48.0	10.0	2.0	6.5	1.0	1.0	1.0
6875 ..	30s	6.0	14.0	11.5	41.5	15.0	3.5	6.5	1.0	0.5	0.5
6615 ..	30s	12.5	20.0	2.0	56.0	3.5	1.0	2.0	2.5	—	0.5
7290 ..	20s	5.0	29.0	1.0	52.5	3.5	2.0	4.5	2.0	0.5	—
7206 ..	20s	2.5	17.5	2.5	57.5	11.0	2.5	5.0	2.0	—	—
7288 ..	20s	8.0	23.0	2.0	49.5	5.5	0.5	7.0	4.0	0.5	—
7927 ..	16s	7.5	16.0	3.0	42.0	19.5	4.0	7.0	—	—	1.0
7522 ..	16s	5.0	6.0	1.0	46.5	7.5	3.0	9.0	18.0	3.0	1.0
7508 ..	12s	4.0	9.0	2.0	52.5	6.0	1.5	10.0	13.0	2.0	—
7771 ..	10s	6.5	18.5	1.0	23.5	33.0	8.0	3.5	3.0	—	3.0
7776 ..	8s	6.5	17.5	4.5	54.5	9.0	1.0	3.5	—	2.0	1.5
7776 ..	6s	10.5	11.0	4.5	42.5	16.5	4.5	5.0	1.5	—	4.0
Mean ..		6.0	18.0	3.1	49.5	10.1	2.6	6.1	2.7	1.2	0.7
		+0.572	+1.566	+0.571	+1.682	+1.523	+0.407	+0.518	+0.977	+0.326	+0.230

TABLE IV

Mean number of fibres in various types of neps

Sample No.	Counts	Fibre-Neps				Seed coat fragments			Leaf bits, etc.		
		Matted fibres	Entangled fibres			Ma- ture fuzz	Half mature fuzz	Imma- ture fuzz	Leaf bits	Jute fibres	Wild silk fibre
			Imma- ture fibres over 90%	Ma- ture fibres over 50%	Mixed fibres						
1	2	3	4	5	6	7	8	9	10	11	12
7355 ..	40s	44	41	22	33	66	47	63	—	40	—
7355 ..	30s	31	39	32	34	56	56	40	6	36	10
7355 ..	20s	52	44	20	39	97	34	49	35	31	—
7064 ..	40s	61	50	41	45	73	60	85	49	—	—
7064 ..	30s	72	36	33	30	77	109	117	—	—	—
7064 ..	20s	45	49	32	33	106	62	85	52	24	—
7198 ..	40s	51	42	50	46	58	98	107	38	—	9
7365 ..	30s	65	49	30	41	92	49	78	30	65	—
7365 ..	24s	41	36	25	33	78	60	58	—	25	5
7365 ..	20s	55	38	27	32	104	40	58	14	22	27
6875 ..	30s	55	59	32	39	75	81	65	20	10	—
6615 ..	30s	42	45	29	36	56	53	55	38	—	15
7290 ..	20s	58	58	37	40	63	107	65	66	73	—
7206 ..	20s	45	58	33	48	84	124	147	47	—	—
7288 ..	20s	67	55	20	38	101	175	109	33	82	—
7927 ..	16s	39	32	30	28	52	80	54	—	—	6
7522 ..	16s	28	28	40	27	49	42	62	24	25	18
7508 ..	12s	38	36	35	28	61	67	60	25	37	—
7771 ..	10s	59	34	29	32	76	78	73	32	—	6
7776 ..	8s	50	39	29	30	61	33	71	—	21	21
7776 ..	6s	43	41	27	33	56	46	44	26	—	17
Mean ..		50	43	31	35	73	71	74	33	38	13
		+2.538	+1.960	+1.581	+1.323	+3.930	+7.638	+5.842	+3.772	+6.102	+2.539

TABLE V

Mean length of fibre pieces in various types of neps (mm.)

Sample No.	Counts	Fibre-Neps				Seed coat fragments			Leaf bits, etc.		
		Matted fibre	Entangled fibres			Ma-ture fuzz	Half mature fuzz	Imma-ture fuzz	Leaf bits	Jute fibres	Wild silk fibre
			Imma-ture fibres over 90%	Ma-ture fibres over 50%	Mixed fibres						
1	2	3	4	5	6	7	8	9	10	11	12
7355 ..	40s	2.6	2.5	5.0	3.4	1.4	2.7	2.5	—	3.5	—
7355 ..	30s	2.9	3.0	3.9	3.5	2.6	0.5	2.8	1.0	3.1	4.0
7355 ..	20s	2.8	2.4	3.8	3.3	1.7	2.0	1.4	3.0	3.9	—
7064 ..	40s	2.4	2.4	3.2	2.8	2.1	2.1	1.8	2.7	—	—
7064 ..	30s	3.0	2.5	3.3	2.9	2.5	3.0	2.4	—	—	—
7064 ..	20s	3.3	3.3	6.0	3.5	2.4	3.0	2.8	3.6	3.0	—
7198 ..	40s	2.2	1.8	3.2	2.7	1.5	1.5	1.5	4.0	—	3.0
7365 ..	30s	2.7	3.1	4.0	3.5	1.9	1.5	2.2	3.5	5.0	—
7365 ..	24s	2.4	2.0	4.5	2.7	2.2	2.4	2.2	—	3.0	2.0
7365 ..	20s	3.1	2.7	4.2	3.2	2.2	2.2	2.1	5.0	2.5	3.5
6875 ..	30s	2.0	2.8	3.3	2.8	1.7	2.0	1.7	3.5	4.0	—
6615 ..	30s	2.5	2.5	3.8	3.4	2.7	2.5	2.7	3.8	—	2.0
7290 ..	20s	2.5	3.1	3.0	3.4	2.3	2.5	2.3	3.5	4.0	—
7206 ..	20s	2.2	2.1	3.4	2.6	1.6	1.6	2.0	3.8	—	—
7288 ..	20s	2.1	2.0	2.8	2.0	1.0	1.0	1.4	2.1	3.0	—
7927 ..	16s	2.3	3.2	3.8	3.9	1.9	1.6	2.1	—	—	3.0
7522 ..	16s	2.3	2.8	5.0	3.3	2.7	2.8	2.8	2.9	3.8	2.0
7508 ..	12s	3.1	3.3	4.8	3.5	3.0	2.7	2.7	3.0	3.5	—
7771 ..	10s	2.9	3.1	3.5	2.9	2.5	2.7	2.3	2.8	—	1.3
7776 ..	8s	2.7	3.1	4.3	3.4	2.3	2.5	2.3	—	2.5	1.0
7776 ..	6s	3.0	2.9	3.9	3.1	2.1	2.7	2.2	3.0	—	1.8
Mean ...		2.6	2.7	3.9	3.1	2.1	2.2	2.2	3.2	3.4	2.4
		+0.081	+0.100	+0.172	+0.094	+0.109	+0.147	+0.097	+0.223	+0.194	+0.307

TABLE VI

Maturity percentages of fibres in neps
(M-H-I)

Mature-Half-mature-Immature

Sample No.	Fibre neps					Seed coat fragments			Leaf bits, etc.		
	Counts	Matted fibre	Entangled fibres			Mature fuzz	Half mature fuzz	Immature fuzz	Leaf bits	Jute fibres	Wild silk fibre
			Immature fibres over 90%	Mature fibres over 50%	Mixed fibres						
1	2	3	4	5	6	7	8	9	10	11	12
7355	40s	5- 2-93	3-1-96	63-13-24	18-12-70	86- 1-13	7-68-25	4 3-93	—	11- 3-86	—
7355	30s	1- 0-99	2-1-97	67- 9-24	20-10-70	70- 9-21	1-99- 0	3- 3-94	0- 0-100	15-11-74	90-10- 0
7355	20s	4- 2-94	3-2-95	57-14-29	21-11-68	90- 2- 8	12-73-15	10-10-80	29-46-25	13-12-75	—
7064	40s	11-10-79	3-1-96	67- 4-29	14-13-73	83- 3-14	9-76-15	4 2-94	8-14-78	—	—
7064	30s	3- 0-97	3-1-96	61-16-23	15-14-71	92- 2- 6	5-85-10	2- 1-97	—	—	—
7064	20s	4- 2-94	3-1-96	81- 0-19	15-15-70	96- 1- 3	5-93- 2	3- 4-93	1- 3-96	8-10-82	—
7198	40s	8- 5-87	2-2-96	70-11-19	23-13-64	76- 6-18	10-82- 8	4 5-91	76-11-13	—	56-22-22
7365	30s	1- 1-98	2-1-97	79- 9-12	13-10-77	79- 2-19	0-100-0	3- 1-96	6-17-77	10-36-54	—
7365	24s	9- 4-87	3-2-95	54-12-34	15-11-74	88- 3- 9	9- 78-13	4 2-94	—	18-10-72	22-22-56
7365	20s	4- 1-95	2-2-96	64-17-19	15- 9-76	78- 4-18	18-73- 9	4 2-94	31-35-34	18- 0-82	14- 5-81
6875	30s	5- 3-92	3-1-96	69-10-21	20-14-66	87- 2-11	14-83- 3	4 7-89	12- 8-80	50- 0-50	—
6615	30s	5- 2-93	2-2-96	63- 9-28	13-16-71	43-10-47	7-46-47	7-11-82	17-11-72	—	0- 0-100
7290	20s	1- 1-98	2-2-96	74-10-16	13-13-74	77- 5-18	1-93- 6	3- 2-95	8- 2-90	0-11-89	—
7206	20s	5- 1-94	5-1-94	59-17-24	18-14-68	86- 5- 9	3-89- 8	2- 5-93	9-15-76	—	—
7288	20s	3- 1-96	3-2-95	65- 8-27	20-12-68	92- 0- 8	6-86- 8	2- 2-96	11- 8-81	15-12-73	—
7927	16s	5- 6-89	3-2-95	63- 8-29	15-12-73	83- 3-14	2-90- 8	2- 4-94	—	—	23- 8-69
7522	16s	8- 6-86	2-2-96	80- 2-18	16-15-69	72-11-17	9-80-11	10- 4-86	16-17-67	25-15-60	3- 3-94
7508	12s	3- 3-94	2-3-95	59-21-20	13-14-73	87- 5- 8	8-68-24	5- 6-89	11-15-74	21- 9-70	—
7771	10s	2- 0-98	2-2-96	100- 0- 0	15- 8-77	89- 2- 9	4-87- 9	5- 3-92	11-31-58	—	88- 6- 6
7776	8s	3- 1-96	3-1-96	59-15-26	18-13-69	76- 4-20	0-85-15	2- 3-95	—	5-13-82	53- 8-39
7776	6s	10- 2-88	2-1-97	67-14-19	18-13-69	78- 5-17	16-72-12	2- 7-91	10-19-71	—	57-11-32
Mean		5- 3-92	3-1-96	68-10-22	16-13-71	81- 4-15	7-81-12	4 4-92	16-16-68	16-11-73	40-10-50

TABLE VII
Some miscellaneous data

Sample No.	Counts	Percentage of loose fibres on seed coat bits, etc.	Mean weight per seed coat or leaf fragment 10 ⁻⁵ gm	Mean weight per all fibre neps 10 ⁻⁵ gm	Mean fibre weight 10 ⁻⁶ gm	Observed mean number of fibres in a nep	Calculated mean number of fibres in a nep	Apical ends per fibre nep
1	2	3	4	5	6	7	8	9
7355	40s	24.1	2.9	1.02	1.67	37	24	—
7355	30s	25.0	2.6	1.32				
7355	20s	23.7	3.7	1.32				
7064	40s	22.3	3.4	1.08	1.49	40	28	—
7064	30s	19.7	3.1	1.14				
7064	20s	18.7	3.9	1.44				
7198	40s	30.5	3.5	1.60	1.26	45	50	—
7365	30s	20.3	3.7	1.72	1.90	45	27	—
7365	24s	23.9	2.2	—				
7365	20s	21.1	2.3	—				
6875	30s	26.2	4.3	—	—	—	—	—
6615	30s	25.2	2.9	1.84	1.79	38	33	—
7290	20s	28.0	4.0	—	—	—	—	—
7206	20s	20.3	5.4	1.15	1.22	50	38	—
7288	20s	31.5	3.3	—	—	—	—	—
7927	16s	21.7	3.6	2.14	2.04	30	30	—
7522	16s	30.3	4.2	1.73	1.85	27	29	5.4
7508	12s	23.3	4.2	1.77	1.87	30	27	6.5
7771	10s	45.2	4.6	2.30	2.43	36	33	5.5
7776	8s	38.1	3.5	2.18	2.22	34	31	6.2
7776	6s	31.4	4.6	2.18				
Mean		26.2	3.6	1.62				6.16
		+1.425	+0.174	+0.107				+1.212

TABLE VIII

Name of cotton	Sample No.	Counts	Neps per yard	Neps per gramme	% proportion of short and long fibres	% proportion of short and long fibres x % immaturity	% proportion of long fibres	% proportion of long fibres x % immaturity (x)	Calculated values of Neps per yard. Equation $Y = .9197x - .1440$	Calculated values of Neps per yard. Equation $Y = .3347x + .2230x^2$	Calculated values of Neps per yard. Equation $Y = 1.0008x + 0.3142$
1	2	3	4	5	6	7	8	9	10	11	12
<i>Standard Indian cottons (1944-45)</i>											
1. Jayawant	7908	40s	0.35	25.9	12.2	1.220	11.0	1.100	0.87	0.53	—
2. Gadag	7873	34s	0.50	31.5	7.9	0.790	6.0	0.600	0.41	0.38	—
3. Surat	7962	30s	1.20	66.7	15.8	3.792	14.3	3.432	3.01	2.74	—
4. Wagad	7968	14s	0.10	2.6	6.5	1.560	5.2	1.248	1.00	0.60	—
5. Jarila	7787	30s	0.90	50.0	9.8	1.176	7.9	0.948	0.73	0.47	—
6. Sind Sudhar (Roller ginned) ..	8059	40s	1.20	88.9	41.6	2.496	40.2	2.412	2.07	1.47	—
7. Sind Sudhar (Saw ginned) ..	8056	40s	2.00	148.2	34.9	2.094	33.1	1.986	1.68	1.08	—
8. Sind American M4 (Roller ginned)	8094	34s	1.35	85.0	27.3	2.457	25.3	2.277	1.95	1.34	—
9. Sind American M4. (Saw ginned)	8091	34s	0.75	47.2	28.1	2.529	26.4	2.376	2.04	1.44	—
10. Sind N.R.	8084	8s	0.10	1.5	2.3	0.046	0.7	0.014	—	0.33	—
11. Punjab American 4F.	7837	30s	0.50	27.8	5.0	1.650	3.2	1.056	0.83	0.51	—
12. Punjab American L.S.S.	7863	40s	0.65	48.2	9.3	1.767	7.2	1.368	1.11	0.66	—
13. Mollisoni	7862	10s	0.10	0.2	2.8	0.168	1.1	0.066	—	0.33	—
14. V. 434 (Akola)	7821	30s	0.65	36.1	12.2	0.976	10.9	0.872	0.66	0.45	—
15. Umri Bani	7726	30s	0.90	50.0	9.2	1.288	7.7	1.078	0.85	0.52	—
16. Gaorani	7829	40s	0.65	48.2	7.2	0.720	5.7	0.570	0.38	0.37	—
17. Cambodia, Co. 2... .. .	7973	34s	0.90	56.7	18.6	6.138	16.7	5.511	Not included	—	—
18. Nandyal	7947	40s	0.90	66.7	15.7	2.198	14.2	1.988	1.68	1.09	—
19. Hagari	8001	34s	0.80	50.4	9.4	1.316	8.0	1.120	0.89	0.54	—
20. Koilpatti	8139	20s	0.90	33.3	6.3	1.323	4.3	0.903	0.69	0.46	—
<i>Present samples</i>											
Co. 3-6	7064	40s	6.20	459.3	40.6	5.278	39.0	5.070	4.52	5.73	5.39
Buri 107	7198	40s	5.00	370.4	25.7	4.883	24.2	4.598	4.08	4.75	4.92
199F.	7206	20s	5.80	214.8	30.8	6.468	29.4	6.174	5.53	8.43	6.49
Gaorani 6	7355	30s	0.80	44.4	10.8	0.972	9.0	0.810	0.60	0.43	1.12
Jarila	7365	24s	0.80	35.6	7.8	0.936	5.2	0.624	0.43	0.38	0.94
Wagad 8	7508	12s	0.80	17.8	6.2	1.116	3.8	0.684	0.48	0.39	1.00
Wagotar 4-1	7522	16s	1.00	29.6	4.0	1.000	2.2	0.520	0.33	0.36	0.83
35/1	7771	10s	0.50	9.3	4.1	0.246	1.9	0.114	—	0.33	0.43
36/5b	7776	8s	0.20	3.0	2.9	0.203	1.1	0.077	—	0.33	0.39
Seg. 403-3	7927	16s	1.20	35.6	7.6	0.608	5.9	0.472	0.29	0.35	0.79

TABLE IX

Types of Neps 1	Grey cloth				Bleached cloth			
	Incidence % 2	Mean No. of fibres 3	Mean maturity % 4	Mean length (mm) 5	Incidence % 6	Mean No. of fibres 7	Mean maturity % 8	Mean length (mm) 9
<i>Fibre neps:</i>								
(i) Matted neps	6	34	1- 1-98	1.3	—	—	—	—
(ii) Entangled fibre neps ..	29	57	38-12-50	2.8	48	43	20- 9-71	2.6
<i>Seed coat neps*:</i>								
(i) with mature fuzz	42	50	82- 4-14	2.6	42	55	80- 7-13	2.0
(ii) with half mature fuzz ..	10	52	11-75-14	2.3	4	55	14-73-13	1.5
(iii) with immature fuzz ..	8	60	9-7-84	2.5	2	112	1- 1-98	4.0
<i>Rest:</i>								
(i) Leaf bits	2	10	37-26-37	3.0	—	—	—	—
(ii) Jute fibres	3	10	74-13-13	1.7	4	26	23-14-63	2.2
(iii) Wild silk fibres.. .. .	—	—	—	—	—	—	—	—

* The seed-coat fragments were absent from bleached cloth, but in their stead there were fuzz neps.

TABLE X
Neps at various stages of yarn manufacture.

Material 1	Total weight (gm.) 2	Weight of fibrous part (gm.) 3	Neps		Seed and leaf bits		Motes	
			Neps per gramme 4	Total Neps columns 3 × 4 5	Per gramme 6	Total columns 6 × 2 7	Per gramme 8	Total columns 8 × 2 9
Raw cotton	3,628.8	3,628.8	419	1,520,467	142	515,290	8	29,030
Blowroom wastes:—								
Horizontal Opener	166.6	84.04	294	24,708	399	66,473	70	11,662
Crighton Opener	56.7	35.48	210	7,451	351	19,902	69	3,912
Scutcher Opener	74.4	15.53	453	7,035	400	29,760	75	5,580
Total				39,194 or 2.6%		116,135		21,154 or 72.9%
Invisible loss	97.5	—	—	—	—	—	—	—
Card Wastes:—								
Licker-in-fly	39.0	39.00	238	9,282	1,269	49,491	—	—
Strip plus cylinder and doffer	248.1	248.10	684	169,700	85	21,089	—	—
Total	682.3			178,982 or 11.8%		186,715 or 36.2%		
Card web	2,946.5	—	391	1,152,082 or 75.7%	14	41,251 or 8.0%	—	
Balance				150,209 or 9.9%		287,324 or 55.8%		7,876 or 27.1%
30s yarn			233					
40s yarn			311					
44s yarn			326					

APPENDIX II

PLATE I



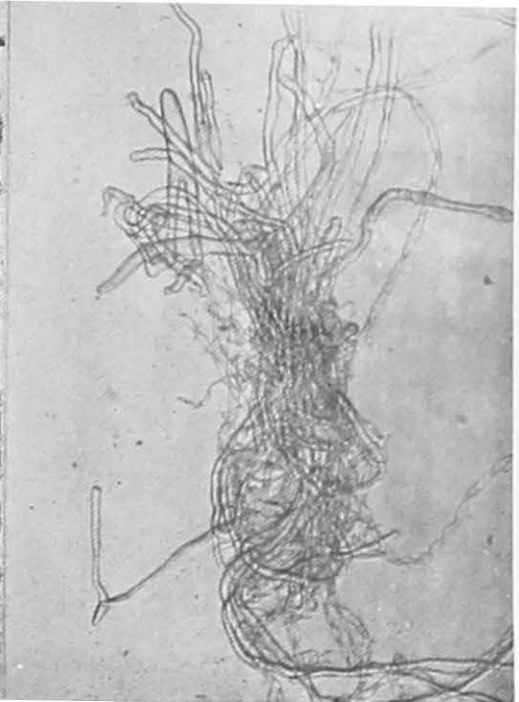
1. Matted fibre-nep $\times 100$



2. Immature fibre-nep $\times 100$

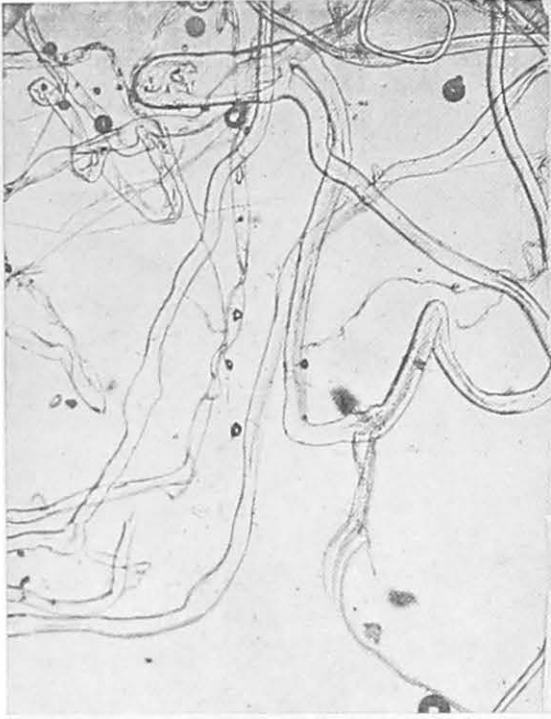


3. Mature fibre-nep $\times 100$

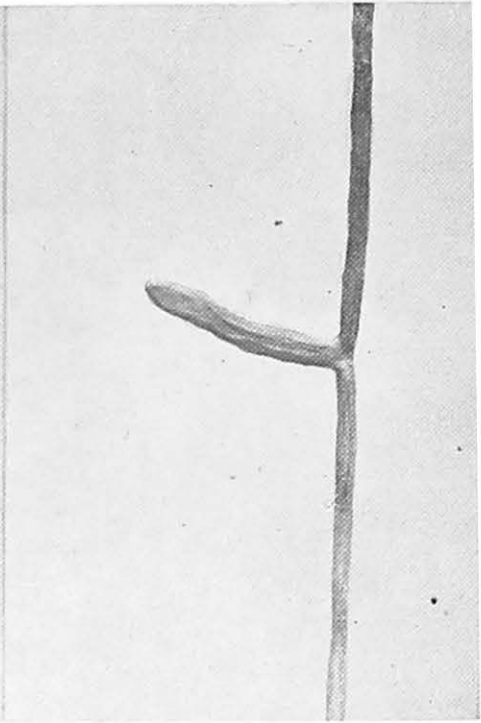


4. Mixed fibre-nep $\times 50$

PLATE II



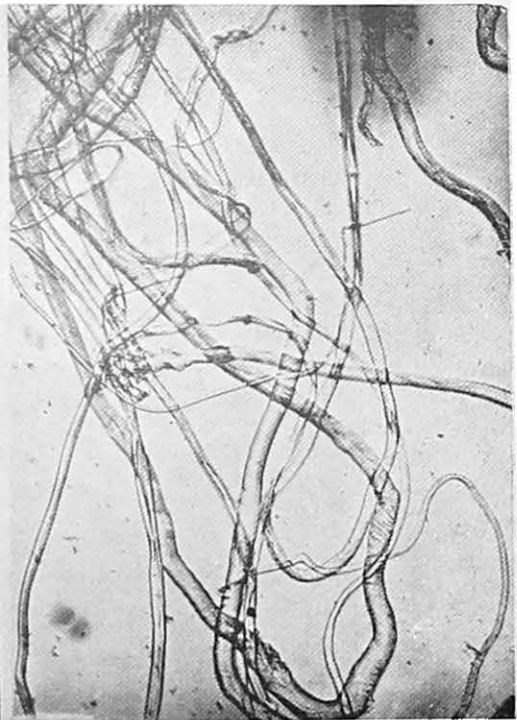
1. Spurred and kinked fibres in a nep $\times 100$



2. A long spur in cotton fibre $\times 100$

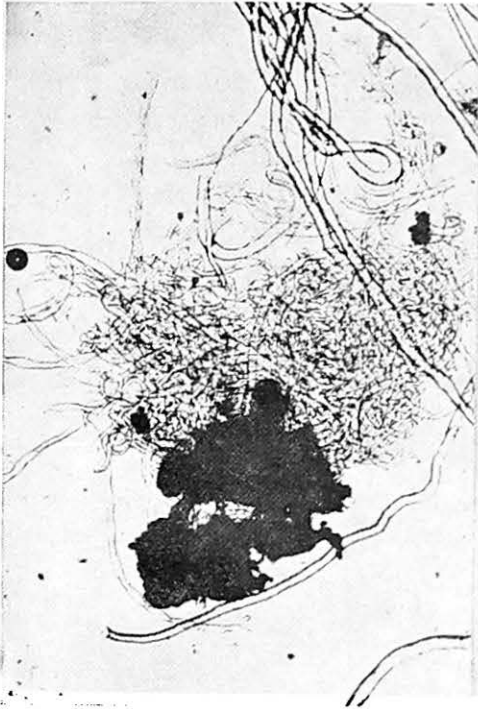


3. Damaged cotton fibre pieces in a nep $\times 100$



4. Apical ends in a nep $\times 100$

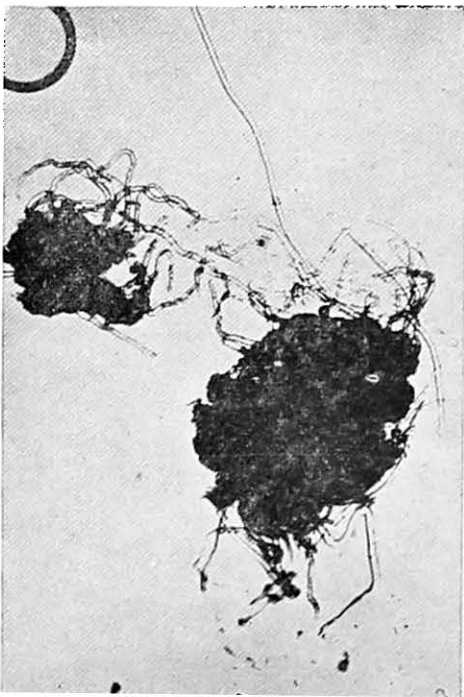
PLATE III



1. Seed-coat with immature fuzz $\times 50$



2. Seed-coat with half mature fuzz $\times 50$

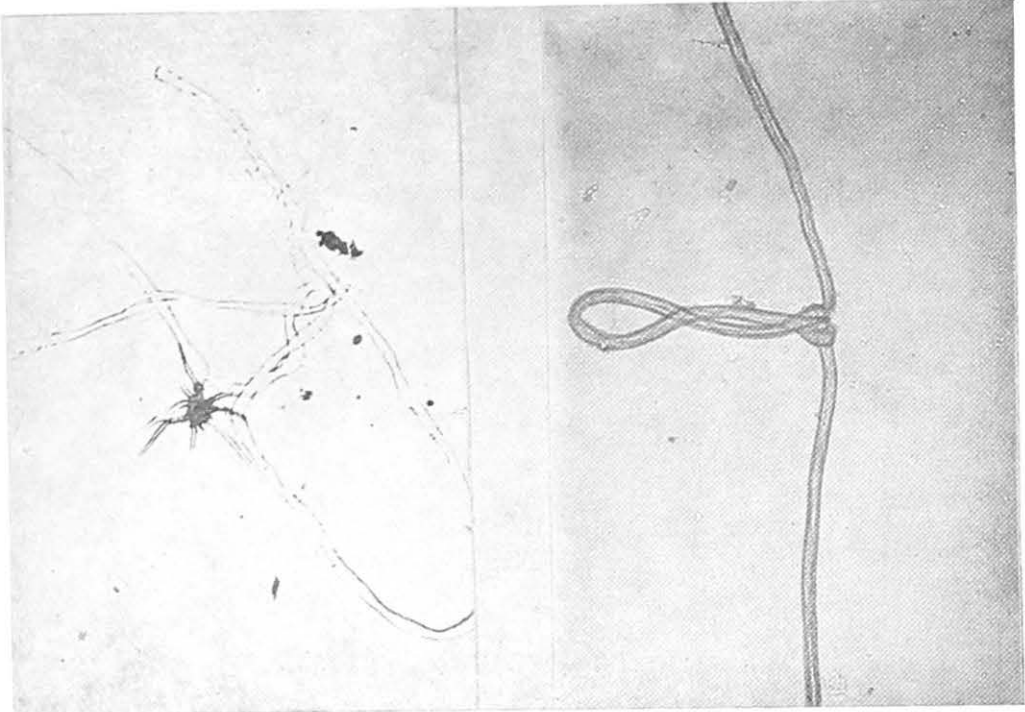


3. Seed-coat with mature fuzz $\times 50$



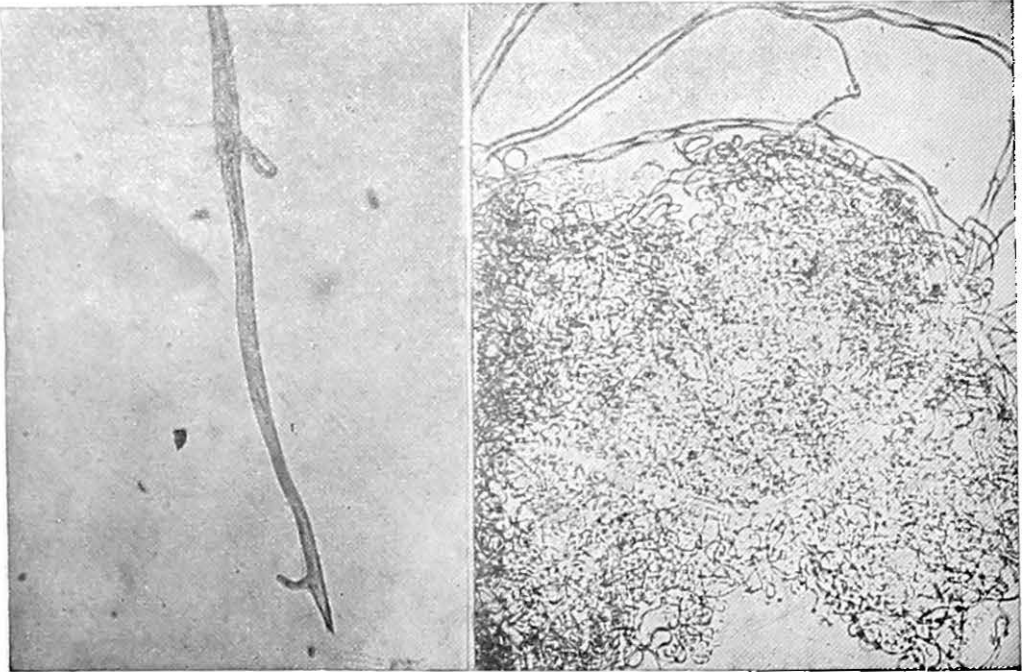
4. Leaf bit $\times 50$

PLATE IV



1. Stellate leaf hair entangled with fibres $\times 50$

2. A knotted cotton fibre $\times 50$



3. A cotton fibre with two branches $\times 100$

4. Wild silk fibre-nep $\times 50$

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