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NEPS IN COTTON YARNS AS RELATED TO VARIETY, LOCATION, AND SEASON OF GROWTH
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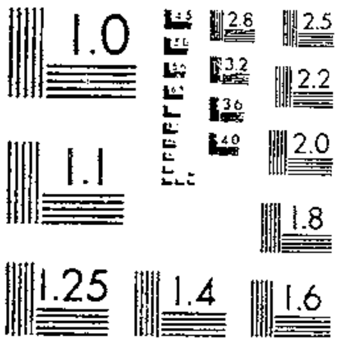

MICROCOPY RESOLUTION TEST CHART
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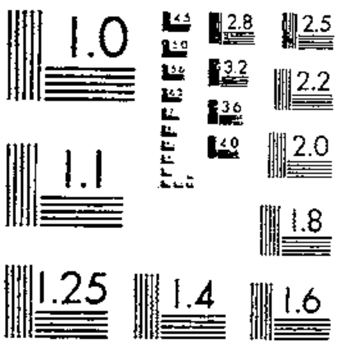

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NATIONAL BUREAU OF STANDARDS-1963-A

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Neps in Cotton Yarns as Related to Variety, Location, and Season of Growth[1]

By NORMA L. PEARSON, *cotton technologist, Division of Cotton and Other Fiber Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration*

CONTENTS

SUMMARY

Neps have always been a source of trouble in the manufacture of cotton yarns and cloth. Their occurrence in appreciable numbers detracts from the general appearance of yarn and cloth products and lowers their quality, especially if they are to be dyed. Neps may also interfere with economical spinning and may possibly have some influence on yarn strength. It is particularly necessary that cotton and other fibrous war fabrics be high in quality and be produced with minimum waste of time, effort, and substance.

Different lots of yarn may vary greatly in neppiness. These variations have been attributed to the influence of several different factors, but there is little exact information as to the extent of such influence.

To determine the extent to which neppiness in cotton yarn varies with variety, location, and season and the extent to which these variations can be explained by variations in fiber length, fiber weight per inch, and percentages of thin-walled fibers and large motes, the neps were counted in 50-yard samples of 22s yarn, representing 2 series for each of 16 varieties grown at 8 locations for 3 successive years (1935–37).

Variety, location, and season and their interactions affected significantly the number of neps in yarn made from the cotton. The effect of variety was greatest. The tendency for varieties to show a differential response to the effect of location and of season was not so great

[1] Submitted for publication March 1944. This study is a part of the regional variety investigation conducted jointly by the Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, and the Cotton and Fiber Branch, Office of Distribution, War Food Administration. Acknowledgment is made to the agricultural experiment stations of South Carolina, Mississippi, Arkansas, Louisiana, Oklahoma, and Texas for providing the samples that made these studies possible.

as their tendency to rank about the same from station to station or from year to year.

There was a significant general tendency for the number of neps in yarn to increase with increases in fiber length, decreases in fiber weight per inch, and increases in percentage of thin-walled fibers.

Varietal differences in neppiness may be accounted for to a significant extent by heritable differences in fiber length and in fiber weight per inch, and to a questionable extent by the percentage of thin-walled fibers when each property is considered separately. The combined influence of these three properties accounts to a considerable extent for the varietal differences in yarn neppiness. Beta coefficients, however, show that fiber length ranks first in importance, with weight per inch nearly as important, but that the percentage of thin-walled fibers by itself accounts for little of the varietal differences in neppiness. Varieties having a high percentage of large motes tend to be neppier than those having a low percentage.

The effect of location on neppiness cannot be accounted for by station differences in any one of the three fiber properties, though a small degree of station variance may be accounted for if the three properties are considered together. Station differences in neppiness, however, follow closely station differences in the percentage of large motes. Large motes may not be directly related to nep formation, but their relative number in seed cotton may possibly indicate the nep-forming potentialities of the lint.

Differences in the number of neps in yarn representing the different years can be attributed to some extent to yearly differences in maturity of the fibers, expressed either in weight per inch or in percentage of thin-walled fibers.

A fairly large part of the varietal variance in neppiness and much larger parts of the station and yearly variance remain unexplained. It is possible that the solution of the problem may be found in some other fiber or lint properties that vary with variety and respond in a very marked degree to factors that vary with location and season.

EFFECT OF NEPS IN YARNS

In connection with the war program it is very important that certain fabrics be high in quality and that they be produced with as little waste in time, effort, and substance as possible. Any information that will further these ends is desirable.

This bulletin presents information regarding some of the factors that affect the occurrence of one of the quality-determining elements of cotton yarn—namely, neps.

Neps are small knots of tangled cotton fibers.[2] Their formation is dependent upon manipulation, and consequently they are not found in unpicked cotton.[3] But they do occur in varying numbers in ginned lint and in all the products of the processes through which the raw cotton passes in the manufacturing of yarn.

The occurrence of neps in any abundance in yarn and consequently in the cloth manufactured from it is considered a serious problem in

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[2] PEARSON, N. L. NEPS AND SIMILAR IMPERFECTIONS IN COTTON. U. S. Dept. Agr. Tech. Bul. 396, 18 pp., illus. 1933.

[3] PEARSON, N. L. DO NEPS OCCUR IN SEED COTTON? Cotton Ginners' Jour. 7 (6): 5-6, 17. 1936.

quality. Neps detract from the general evenness of the yarn [4] and appear as specks or irregular places in the woven fabric. If the cloth is to be dyed they present an additional and more serious problem. Most neps are composed entirely of thin-walled fibers or at least contain some of these fibers.[5] Thin-walled fibers absorb less dye than those that are thick-walled; consequently, neps appear in certain types of dyed cloth as light specks against the surrounding darker background.[5] Such cloth is considered very inferior in quality to evenly dyed fabrics.

Neps that are closely incorporated in the yarn produce weak places, for the fibers must pass around these knots; as a result, the close fiber association that gives strength to cotton yarn is broken. It is thought also that much of the breakage or "ends down" that occurs in spinning may be due in part to the presence of neps.

Yarns spun from different lots of cotton may vary considerably in neppiness. In general, these variations have been attributed in part to differences in fiber length, fiber weight per inch, and the percentage of thin-walled fibers. Moreover, neppiness has been considered to vary with variety and with environment. Since there is little exact information as to the extent to which these various factors influence yarn neppiness, a study of neps was made in connection with that part of the regional cotton variety study [6] concerned with cotton spinning and related fiber studies [7] to ascertain the extent to which neps in yarn might vary with variety, location, and season of growth of cotton, and to what extent these differences might be explained by varietal, locational, and seasonal variations in fiber length, fiber weight per inch, and percentage of thin-walled fibers.

MATERIALS AND METHODS

The materials studied were yarn and seed-cotton samples representing 2 series for each of 16 varieties grown at 8 locations for 3 successive years (1935–37).[8]

The code numbers for the 16 varieties given in the accompanying list are used instead of dots in the scatter diagrams (figs. 1, 2, 3, and 4).

Code Numbers and Varieties

1. Acala (Rogers).
2. Arkansas 17.
3. Cleveland (Wannamaker).
4. Cook 912.
5. Delfos (Missdel) 4.
6. Deltapine 11.
7. Dixie Triumph 759.
8. Farm Relief 2.
9. Half and Half.
10. Mexican Big Boll.
11. Qualla.
12. Rowden 40–2088.
13. Startex 619.
14. Stoneville 5.
15. Triumph (Oklahoma) 44.
16. Wilds 5.

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[4] CAMPBELL, M. E. STANDARDS FOR APPEARANCE OF COTTON YARN. U. S. Dept. Agr. Market. Serv., 8 pp., illus. 1940. [Processed.]

[5] See footnote 2, p. 2.

[6] BARRE, H. W. NATURE AND SCOPE OF THE COOPERATIVE REGIONAL VARIETY STUDIES WITH COTTON. (Paper presented before the Amer. Soc. Agron., New Orleans, La., Nov. 22–24, 1939.) Bur. Plant Indus., Soils, and Agr. Engin., 5 pp. 1939. [Processed.]

[7] CAMPBELL, M. E. PRELIMINARY REPORT OF COTTON SPINNING AND RELATED FIBER STUDIES: IN CONNECTION WITH THE REGIONAL VARIETY SERIES CROPS, 1935 AND 1936. (Paper presented before Amer. Soc. Agron., New Orleans, La., Nov. 22–24, 1939.) Agr. Market. Serv., 26 pp., illus. 1939. [Processed.]

[8] There were 766 spinning lots instead of 768 ($16 \times 2 \times 8 \times 3$), since in two instances replicate spinning samples were composited. To facilitate analysis, two 50-yard samples of yarn were examined for these composited lots, in order to have an equal number of observations for all varieties. The degrees of freedom used for the total in the final analysis, however, is 766–1, or 765.

Locations of Varietal Studies

Florence, S. C.	Baton Rouge, La.
Stoneville, Miss.	Stillwater, Okla.
Marianna, Ark. (upland).	College Station, Tex.
Marianna, Ark. (delta).	Lubbock, Tex.

The study was made on 22s yarns, as 22 counts were the only ones common to all lots. A 50-yard sample was examined, a yard at a time, for each of the 766 spinning lots (except for the 2 composited samples, for each of which 100 yards were examined), and the neps were removed by means of tweezers and counted.[9] The yarn was not untwisted, except where definite bulges occurred; consequently, only those neps were counted that were actually on the surface or, if closely incorporated, were large enough to form a bulge. Neps smaller than the diameter of the yarn and closely incorporated with it would be missed. It is not illogical, however, to assume that the number of neps missed in the different lots would be proportional to the total number present.

It must be emphasized that only one type of small imperfection is being considered—true neps, which are small knots of fibers entangled with sufficient tightness to make a structure definite enough to be separated from the yarn with tweezers and remain a knot. Particles with attached fibers from either seeds or motes, loose clumps of thin-walled fibers, bits of foreign matter, and other imperfections are not included in this discussion.[10]

Data representing the number of neps in the 50-yard samples of yarn and data representing fiber length (upper quartile fiber length), fiber weight per inch, and percentage of thin-walled fibers of the corresponding lint samples[11] were subjected to variance and covariance analyses. In addition, an attempt was made to ascertain whether certain differences in yarn neppiness might be explained by differences in the percentage of large motes occurring in the seed cotton, assuming either that large motes are an important source of nep-forming fibers or that the relative number of large motes occurring in a seed cotton is indicative of the nep-forming potentialities of its lint. The mote-percentage data were obtained by counting the number of motes in 1,000 seed samples (1,000 seeds and motes) of seed cotton.

VARIATIONS IN YARN NEPPINESS

Considerable variation in neppiness was found among the 766 samples of yarn. Averages showed that the yarns representing the different varieties, locations, and years differed strikingly and in some cases very consistently (tables 1 and 2); and variance analysis of the data indicated that many of these differences were very significant (table 3).

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[9] The nep counts were made by Mary Butler, junior botanist, Bureau of Plant Industry, Soils, and Agricultural Engineering.

[10] See footnote 2, p. 2.

[11] The fiber data and samples of yarn were supplied by the Fiber and Spinning Laboratory of the Cotton and Fiber Branch, of the Office of Distribution, War Food Administration, located at College Station, Tex., and operated cooperatively by the Bureau of Plant Industry, Soils, and Agricultural Engineering and the Agricultural and Mechanical College of Texas.

TABLE 1.—*Average number of neps in 50-yard samples of 22s yarn for 2 series for each of 16 varieties grown at 8 locations for 3 successive years* [1]

Variety	Location [2]								Year [3]			Average [4]
	Florence, S. C.	Stoneville, Miss.	Marianna, Ark.		Baton Rouge, La.	Stillwater, Okla.	College Station, Tex.	Lubbock, Tex.	1935	1936	1937	
			Upland	Delta								
Acala (Rogers)	53.2	51.3	47.5	38.0	62.2	62.7	38.7	33.5	39.4	59.9	45.9	48.4
Arkansas 17	32.3	33.5	33.3	20.7	45.3	71.5	27.8	26.3	30.6	44.9	34.5	36.3
Cleveland (Wannamaker)	15.0	10.3	12.8	7.7	21.3	31.5	11.8	8.0	5.7	18.6	20.1	14.8
Cook 912	26.2	26.0	26.5	18.3	32.0	36.7	22.3	16.8	32.5	22.4	21.0	25.6
Delfos (Missdel) 4	34.5	24.7	25.5	20.2	48.2	56.7	41.2	25.5	31.0	35.8	36.9	34.6
Deltapine 11	27.7	22.2	31.2	16.2	40.0	57.8	23.7	14.8	18.9	42.1	26.6	29.2
Dixie Triumph 759	19.2	13.2	10.5	10.2	25.8	30.0	14.7	10.7	9.2	17.0	23.3	16.8
Farm Relief 2	27.7	28.7	33.0	18.0	32.2	50.0	30.7	16.3	16.9	37.5	34.3	29.6
Half and Half	13.5	12.8	15.7	10.5	22.0	25.8	13.7	7.7	6.8	25.0	13.9	15.2
Mexican Big Boll	42.7	37.2	26.3	20.8	43.8	63.8	31.5	22.3	39.5	37.3	31.4	36.0
Qualla	34.7	23.5	23.2	14.2	47.2	44.7	22.3	18.2	14.6	33.0	37.9	28.5
Rowden 40-2088	20.5	17.0	19.5	16.2	25.5	40.7	15.7	12.0	9.0	26.6	26.6	20.8
Startex 619	15.8	13.7	11.5	8.8	22.8	36.2	14.5	12.3	9.1	24.4	17.3	16.9
Stoneville 5	21.8	21.7	23.0	13.2	31.5	49.3	19.0	13.2	13.9	30.9	27.5	24.1
Triumph (Oklahoma) 44	18.5	17.3	14.7	15.2	26.8	37.2	16.0	12.5	9.8	26.4	23.1	19.8
Wilds 5	95.5	80.5	96.3	61.7	130.2	94.7	89.2	58.5	84.4	99.0	84.9	89.4
Average [5]	31.2	27.7	28.2	19.3	41.0	49.3	27.0	19.3	23.2	36.4	31.6	30.4

[1] Least significant difference between—

	5-percent level	1-percent level
Variety means	2.1	2.7
Station means	1.5	1.9
Year means	.9	1.2

[2] Means of 6 observations.
[3] Means of 16 observations.
[4] Means of 48 observations.
[5] Stations, means of 96 observations; years, means of 256 observations.

TABLE 2.—*Average number of neps in 50-yard samples of 22s yarn, for varieties grown at 8 locations for 3 successive years* [1]

Location	Year [2]			Average
	1935	1936	1937	
Florence, S. C	35.3	27.0	31.2	31.2
Stoneville, Miss	28.7	28.1	26.2	27.7
Marianna, Ark.:				
Upland	19.8	37.1	27.7	28.2
Delta	16.8	20.4	20.7	19.3
Baton Rouge, La	31.8	41.2	50.1	41.0
Stillwater, Okla	19.3	82.2	46.4	49.3
College Station, Tex	20.2	34.5	26.4	27.0
Lubbock, Tex	13.7	20.4	23.8	19.3
Average [3]	23.2	36.3	31.6	30.3

[1] Least significant difference between—

	5-percent level	1-percent level
Year means	0.9	1.2
Station means	1.5	1.9

[2] Means of 32 observations: 16 varieties × 2 series.
[3] Means of 256 observations: 16 varieties × 8 locations × 2 series.

VARIETAL VARIATIONS

Varietal differences were the most striking. The average number of neps in 50 yards of yarn for the 16 varieties ranged from 14.81 for Cleveland to 89.44 for Wilds (table 1). In general, varietal means (average of 48 observations) should differ by at least 2.73 neps per 50 yards of yarn for a high degree of significance. Thus Wilds is significantly more neppy than all the other 15 varieties, and Cleveland is significantly less neppy than all but Dixie Triumph, Half and Half, and Startex.

TABLE 3.—*Results of analysis of variance of (1) the number of neps in 50-yard samples of 22s yarn, for 2 series for each of 16 varieties grown for 3 successive years at 8 locations; and (2) the same data and those of fiber weight per inch, upper quartile length, and percentage of thin-walled fibers for the corresponding lint sampes, and the percentage of large motes in corresponding seed-cotton samples for 7 locations (Stillwater, Okla., omitted)*

Source of variance	8 locations		7 locations					
				Mean square [2]				
							Percentage of—	
	Degrees of freedom [1]	Mean square [2] neps	Degrees of freedom [3]	Neps	Weight per inch	Upper quartile length	Thin-walled fibers	Large motes
Total	765	815	670	488	41.8	0.0145	44.3	3.91
Varieties	15	**16,026	15	**14,474	**1,388.1	**.5778	**620.3	**30.08
Stations	7	**10,186	6	**5,317	**284.1	**.0623	**1,176.4	**99.25
Years	2	**11,320	2	**2,559	**630.7	**.0030	**52.4	**136.70
Blocks within stations	8	49	7	*54	**5.8	**.0061	*17.1	1.01
Varieties × years	30	**556	30	**531	**13.2	**.0012	**40.3	**2.41
Varieties × stations	105	**228	90	**199	**5.5	**.0006	**19.5	**1.20
Years × stations	14	**4,122	12	**953	**158.1	**.0327	**307.6	**49.28
Years × blocks within stations	16	26	14	30	**7.8	**.0017	**18.0	**1.43
Varieties × years × stations	210	**131	180	**101	**3.7	**.0004	**19.3	**1.32
Error	358	27	314	27	2.0	.0002	8.1	.83

[1] In two instances replicates were composited, thus reducing the degrees of freedom from the expected 767 to 765.

[2] * = Significant; ** = highly significant.

[3] With Stillwater, Okla., omitted, there remained one instance of replicates being composited, making the degrees of freedom 670 instead of the expected 671.

Although the effects of varieties, locations, and years upon the number of neps in cotton clearly dominate the study as a whole, differential response to location and season was established (table 3). These differential responses may be partly explained by the fact that certain varieties are more limited than others in adaptation. For instance, Delfos yarns are relatively much more neppy when the variety is grown at College Station or Lubbock, Tex., than when grown at Stoneville, Miss. Most varieties have many more neps when grown at Stillwater, Okla., than at any other location except Baton Rouge. The increase, however, is not proportional for all varieties. Acala yarns for Stillwater are relatively less neppy than for all other locations. This is true also for Wilds.

LOCATIONAL AND SEASONAL VARIATIONS

Environmental effects (locational and seasonal) as opposed to hereditary or varietal influences may have a significant influence upon the nep-forming potentialities of a cotton (tables 1, 2, and 3). Taken as a whole, the place where the cotton was grown had a very decided influence upon the neppiness of yarn, though the effect is not so marked as for variety. Some stations behaved much more consistently than others. Cottons grown at Marianna, Ark. (delta land), and at Lubbock, Tex., were consistently the least neppy, and those grown at Baton Rouge, La., tended to be very neppy.

The over-all effects of location and season are exaggerated by the very bad conditions that prevailed at Stillwater in 1936. Cottons for that location and year were poor in quality and the yarns very neppy. When the data for each year are analyzed separately, the importance of location in 1936 far exceeds that of variety, whereas in 1935 and 1937 variance due to variety exceeds that due to location (table 4). If Stillwater is omitted from the 1936 data, the mean square for stations becomes 2,076.80, a figure more consistent with those of 1935 and 1937; and when the Stillwater data are omitted from all 3 years in the combined analysis (table 3), the station variance ranks second and yearly variance third.

TABLE 4.—*Analyses of variance of the number of neps in 50-yard samples of 22s yarn for 16 varieties grown at 8 locations in 1935, 1936, and 1937*

Source of variance	Degrees of freedom [1]	Mean square [2]		
		1935	1936	1937
Total	255	517	815	430
Varieties	15	**6,454	**6,338	**4,340
Stations	7	**1,019	**12,786	**3,724
Blocks within stations	8	23	*53	27
Varieties × stations	105	**165	**185	**141
Error	120	34	23	24

[1] The number of degrees of freedom for 1936 and 1937 were 254 for total and 119 for error. See footnote 8.
[2] * = Significant; ** = highly significant.

VARIATIONS IN YARN NEPPINESS AS RELATED TO VARIATIONS IN FIBER PROPERTIES AND THE PERCENTAGE OF LARGE MOTES

Each fiber property considered differed significantly with variety, location, and season (table 3). Variety has by far the greatest influence on length, with station and year rank second and third, respectively. For weight per inch, the influence of variety ranks first, year second, and location third; and for the percentage of thin-walled fibers. the effect of location is first, variety second, and year third. In other words, length and weight per inch are primarily varietal characteristics, whereas the degree of secondary wall development, as expressed by the percentage of thin-walled fibers, although associated to some extent with variety, is primarily the result of the effect of location.

It is possible that the figure representing the percentage of thin-walled fibers in a cotton may not necessarily represent the relative number of important nep-forming fibers. Although all types of fibers may be found in neps, the thin-walled are found most abundantly and seem to form the basis for entanglement. And of the thin-walled type, those having the thinnest walls appear to be those that tangle most readily.[12]

[12] See footnote 2, p. 20.

The figure representing the percentage of thin-walled fibers in a cotton,[13] however, does not take into account variations in secondary wall development within the group classed as thin-walled. Thus it is possible for two cottons to have the same percentage of thin-walled fibers and yet to differ greatly in the percentage of very thin-walled ones. On the same basis of reasoning it would be possible for two cottons to possess very different total percentages of thin-walled fibers and yet have a similar number of exceedingly thin-walled ones.

Fibers of all degrees of secondary-wall thickness may be found on what may be called mature seeds, so mature seeds may contribute thin-walled fibers to the ginned lint. Seed cottons may contain in varying numbers, however, large motes or immature seeds the fibers of which are long enough to be ginned. The fibers contributed by these large motes may possess varying degrees of wall development, but the majority are usually very thin-walled.

Since large motes would contribute at least some of the very thin-walled fibers, it was thought possible that the percentage of such motes might serve as an index to the number of very thin-walled fibers present in the lint and thus be related to the number of neps present in yarn. It is very possible, however, that the conditions that tend to produce many large motes may also tend to interfere with the wall development of the fibers on all seeds, and thus the importance of large motes may be due not so much to the fact that they are contributors of thin-walled fibers as to the fact that they indicate the maturity of the cotton as a whole.

Nevertheless, attempt was made to ascertain whether there is any relation between the numbers of large motes in the seed cotton and the numbers of neps in the yarn.

Variance analyses of the data representing the percentage of large motes in seed cotton indicated that the abundance of these motes may be attributed in very large measure to the effects of enviroment—either locational or seasonal (table 3). Certain varieties, however, tend rather consistently to produce more of this type of mote than others.

In making the covariance analyses, the data pertaining to Stillwater, Okla., for all 3 years were omitted, since the poor-quality cottons and yarns for 1936 would tend to give a distorted picture of what might generally be expected.

The results of variance analysis of nep data, omitting the Stillwater data, are little different from those obtained when the Stillwater data were included, except for the relative degree of variability due to season and to location (table 3). With Stillwater included, the variance due to years ranks second, that for stations third; and, when Stillwater is excluded, variance due to station is second and that for years is third.

Though covariance analysis, simple correlation coefficients were calculated for each source of variance to show the relation between neps in yarn and fiber length, fiber weight per inch, and the percentage of thin-walled fibers. Beta regression and multiple-correlation coefficients were calculated for variety, stations, and years taken as a

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[13] RICHARDSON, H. B., BAILEY, T. L. W., JR., and CONRAD, C. M. METHODS FOR THE MEASUREMENT OF CERTAIN CHARACTER PROPERTIES OF RAW COTTON. U. S. Dept. Agr. Tech. Bul. 545, 77 pp., illus. 1937.

whole. Since little in the way of significant simple correlation was found for the various interactions, no further calculations were undertaken for these sources of variance.

Correlation coefficients showing the relation between neps in yarn and the percentage of large motes in seed cotton were made for only a part of the different sources of variability.

GENERAL RELATIONSHIPS

For the data as a whole (672 observations)[14] there is a very significant tendency for the number of neps in yarn to increase as fiber length increases ($r=0.665$) and to decrease as weight per inch increases ($r=-0.664$) (table 5). The correlation coefficient representing the extent to which the percentage of thin-walled fibers is related to neppiness is small (0.363); nevertheless, because of the large number of degrees of freedom, it can be considered highly significant.

TABLE 5.—*Results of covariance analysis: Simple correlation coefficients representing the relation of neps to fiber length, to fiber weight per inch, and to percentage of thin-walled fibers, and the relationship among the 3 fiber properties for 2 series for each of 16 varieties grown at 7 locations for 3 successive years*

Source of variance	Simple correlation coefficients [1]						
	Neps and upper quartile fiber length	Neps and weight per inch	Neps and percentage of thin-walled fibers	Neps and percentage of large motes in seed cotton	Weight per inch and upper quartile fiber length	Percentage of thin-walled fibers and upper quartile fiber length	Weight per inch and percentage of thin-walled fibers
Total	**0.665	**−0.664	**0.363	----------	**−0.741	**0.172	**−0.587
Varieties	**.828	**−.837	*.501	*0.597	**−.906	*.534	**−.643
Stations	.248	.077	.058	**.944	.710	*−.854	**−.882
Years	−.870	−.980	.988	----------	.951	−.784	−.937
Blocks within stations	.509	*−.777	.577	----------	−.369	−.111	−.724
Varieties × stations	.152	−.133	.184	----------	**−.279	.049	**−.444
Varieties × years	−.028	−.220	*.425	----------	−.281	−.317	−.093
Years × stations	−.263	−.182	.498	----------	.144	−.480	**−.823
Years × blocks within stations	−.073	*−.814	.495	----------	.043	−.229	**−.694
Varieties × stations × years	−.098	−.028	−.099	----------	**−.298	.004	**−.311
Error	−.079	−.120	.146	----------	−.170	−.067	−.382

[1] *=Significant; **=highly significant.

VARIETAL RELATIONSHIPS

FIBER PROPERTIES

Differences among varieties in the neppiness of their yarns can be accounted for to a very significant degree by varietal differences in fiber length ($r=0.828$) or in weight per inch ($r=-0.837$) (table 5) (fig. 1). The correlation coefficient representing the degree of relationship between neps and fiber maturity (percentage of thin-walled fibers) is significant only at the 5-percent level ($r=0.591$). The scatter diagrams (fig. 1), moreover, indicate that a very large part of the correlation is due to the effect of the one variety, Wilds.

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[14] 672 50-yard samples, but 671 spinning lots.

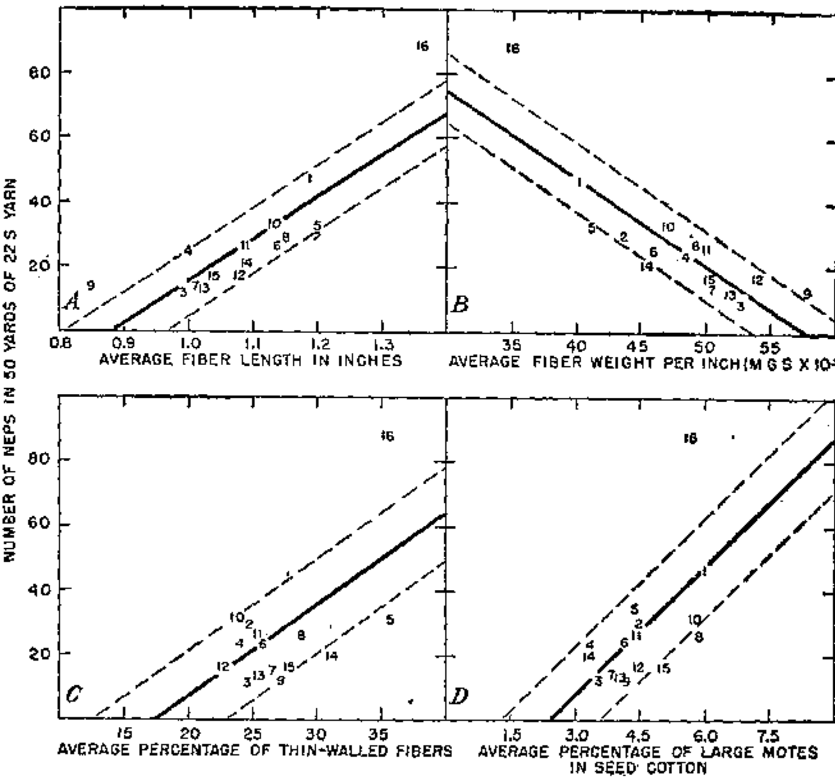

FIGURE 1.—Regression of the average number of neps in 50 yards of 22s yarn upon: *A*, The average upper quartile fiber length; *B*, the average fiber weight per inch; *C*, the average percentage of thin-walled fibers in the ginned lint; and *D*, the average percentage of large motes in seed cotton, for 16 varieties. Each plotted point is represented by the variety code number and is the average of 42 observations (2 series × 7 locations × 3 years). Regression equations—fiber length: $E=-116.15+130.98X$, *S. E. E.* $=10.79$, $r=0.828$; fiber weight per inch: $E=156.25-2.70X$, *S. E. E.* $=10.50$, $r=-0.837$; percentage of thin-walled fibers: $E=-49.68+2.83X$, *S. E. E.* $=14.94$, $r=0.591$; percentage of large motes: $E=-31.12+13.10X$, *S. E. E.* $=15.41$, $r=0.597$.

There are very important relations among the fiber properties themselves. With an increase in length of fiber for varieties there is a decided decrease in weight per inch ($r=-0.906$). Weight per unit length is influenced by fiber diameter and the thickness of the fiber wall. This decrease in weight per inch possibly represents to an undetermined extent a decrease in fiber diameter, that is, the fibers of long-fibered cottons are smaller in diameter than those of short-fibered cottons and therefore weigh less per unit length. Moreover, with a decrease in weight per inch there is an increase in the percentage of thin-walled fibers, as would be expected ($r=-0.643$). Also there is a decided tendency for the varieties possessing the longer fibers to have the greater number of thin-walled fibers ($r=0.534$). This is a very interesting trend, but it should not be concluded that the tendency is universal, as it may be simply a characteristic of these particular varieties.

The combined effect of the three fiber properties accounts for a highly significant amount ($R=0.858$) of the varietal variation in neppiness (table 6).

TABLE 6.—*Results of covariance analysis: Beta regression coefficients and multiple correlation coefficients with standard error of the estimate for neps in yarn as related to fiber and seed-cotton properties for 16 varieties at 7 locations for 3 successive years*

Source of variance	Beta regression coefficients			Multiple correlation coefficients (R)	Standard error of estimate
	Neps and upper quartile fiber length	Neps and fiber weight per inch	Neps and percentage of thin-walled fibers		
Variety	0.418	−0.380	0.124	**0.858	10.65
Station	1.190	.753	1.738	.674	7.77
Year	−.008	−.280	.060		

**=Highly significant.

The beta regression coefficients (table 6) show that for varieties the effect of length is first in importance and weight per inch second, there being actually very little difference in the relative importance of the two. Here, weight per inch may mean, to some extent at least, fiber diameter, since in the calculation of the beta regression coefficients some of the differences in weight per inch due to differences in the extent of secondary wall deposition, as represented by the percentage of thin-walled fibers, have been eliminated. Percentage of thin-walled fibers ranks third, but in comparison with the other two fiber properties this cannot by itself account for any appreciable varietal differences in neppiness.

LARGE MOTES

The tendency for the varieties having the greatest number of large motes to produce the neppiest yarn is significant (table 5). As in the case of the percentage of thin-walled fibers, however, a large part of this correlation is due to the effect of the one variety, Wilds (fig. 1). The omission of Wilds, however, in the case of thin-walled fibers leaves little in the way of correlation, whereas in the case of mote percentage considerable correlation would be left, as indicated by the scatter diagram (fig. 1).

There is no significant tendency for the cotton with the greatest number of thin-walled fibers to have the greatest number of large motes. This is interesting in view of the suggestions that were made earlier—that the single figure representing the percentage of thin-walled fibers is not sufficient to represent the nep-forming fibers in the line, and that the percentage of large motes in a seed cotton might be indicative of the number of nep-forming fibers present in the ginned lint.

Although there is no significant tendency for seed cotton with a high percentage of large motes to yield lint with a high percentage of thin-walled fibers, the varieties with a low weight per inch tend to have more motes than those with a greater fiber weight per inch. This is what would be expected if the abundance of large motes indicates the extent of secondary wall development. But this relation is not so pronounced as the tendency for the varieties with the greatest weight per inch to be the most mature ($r=-0.643$). Since only 16 varieties are included, however, too sweeping conclusions should not be drawn from these results. The data do justify concluding that varietal differences in the percentage of large motes should be taken into consideration in attempting to explain varietal differences in neppiness.

REGRESSION OF WEIGHT PER INCH ON FIBER LENGTH

Since varietal differences in neppiness can be accounted for to a significant degree either by varietal differences in length of fiber, weight per inch, or percentage of thin-walled fibers, the differences that cannot be related to differences in these three properties are of particular interest. Scatter diagrams show that certain cottons are more or less neppy than their fiber length, weight, or percentage of thin-walled fibers would indicate (fig. 1). Both Half and Half and Wilds (shown by Codes 9 and 16) are too neppy for their length and for their weight per inch. Delfos and Stoneville (Codes 5 and 14) are less neppy than can be accounted for by their weight per inch and percentage of thin-walled fibers. Wilds, Acala, and Mexican Big Boll (Codes 16, 1, and 10, respectively) are much more neppy than their percentage of thin-walled fibers would indicate.

Since varietal differences in weight per inch and length account for such a high percentage of varietal differences in neppiness, and since these two properties are themselves highly correlated, it might be logical to assume that, other things being equal, neppiness would tend to follow the average regression of weight per inch on length. Varieties that deviate considerably from the regression line would be expected to have more or less neps than cottons of similar length, depending upon whether their weight per inch is greater or less than that expected. If the deviation is not accompanied by a marked difference in neppiness, some other factor would have to be sought to explain the behavior. If cottons possess about the average weight per inch and length relationship but are more or less neppy than varieties of equal length, explanation of their neppiness might be found in the percentage of thin-walled fibers or of large motes, or might be attributed to some unknown factor or factors.

These interrelationships were shown by plotting for variety means on several different charts the regression of weight per inch on length. Instead of using dots to locate the points representing the weight per inch-length relationship, the variety code numbers were placed on one chart, the average number of neps per 50 yards of yarn on a second, the percentage of thin-walled fibers on a third, and the percentage of large motes on a fourth (fig. 2). This procedure was followed for variety means as a whole, for varieties at each station and within each year, and for the varieties within each year at the different stations. Because of space limitations only the charts for the total and for one station are represented here (figs. 2 and 3).

For the total, several varieties have greater or less weight per inch than would be expected from their length (fig. 2). It does not follow in all cases, however, that cottons the fibers of which are of too light weight for their length are neppier than cottons of equal length, or that cottons the fibers of which weigh too much for their length are less neppy than cottons of similar fiber length. Inconsistencies cannot be explained as a general rule by differences in the percentage of thin-walled fibers, but some inconsistencies can be explained by assuming that the percentage of large motes is an indication of the number of nep-forming fibers in the lint.

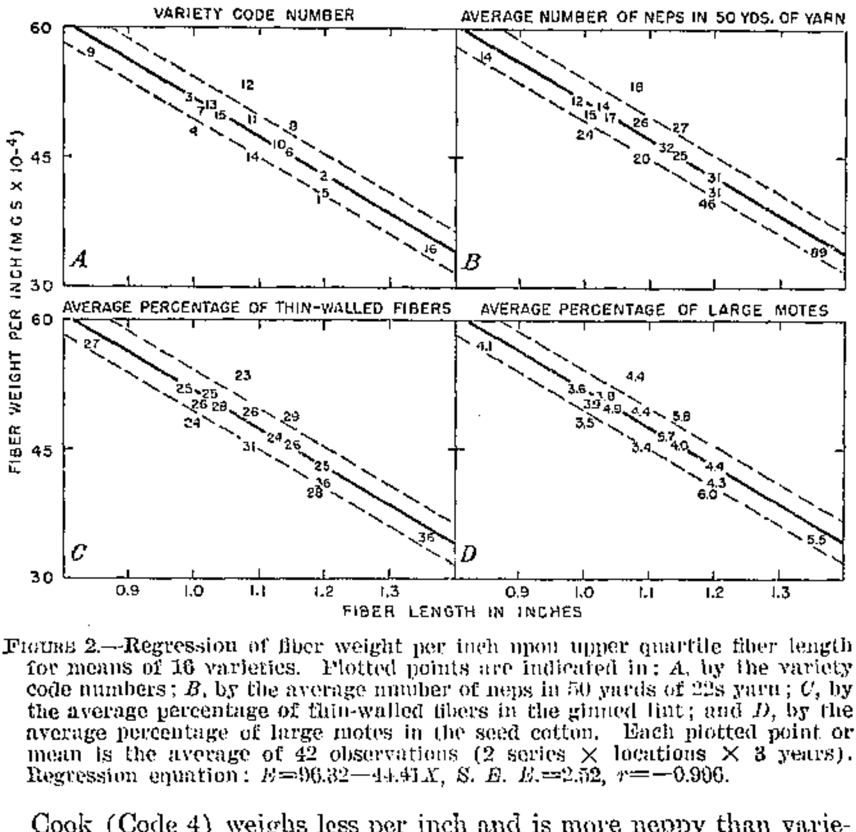

FIGURE 2.—Regression of fiber weight per inch upon upper quartile fiber length for means of 16 varieties. Plotted points are indicated in: *A*, by the variety code numbers; *B*, by the average number of neps in 50 yards of 22s yarn; *C*, by the average percentage of thin-walled fibers in the ginned lint; and *D*, by the average percentage of large motes in the seed cotton. Each plotted point or mean is the average of 42 observations (2 series × locations × 3 years). Regression equation: $E=96.32-44.41X$, *S. E. E.*=2.52, $r=-0.906$.

Cook (Code 4) weighs less per inch and is more neppy than varieties of about equal length. This tendency to have fibers relatively light in weight was shown markedly, however, in 1935 and 1936 only, and in both years Cook tended to have yarn neppier than that of cottons of equal length. In 1937 its weight per inch was not greatly different from that of cottons of about equal length, and it was about as neppy as these cottons. It behaved consistently in 1935, showing at all stations a tendency to be lighter in fiber weight and more neppy than cottons of equal length. It was much more variable in 1936 and 1937.

Rowden (Code 12) in general tends to have a much greater weight per inch than cottons of equal length, particularly Qualla and Stoneville (Codes 11 and 14). On the whole, especially in 1936 and 1937, at most of the stations it might be considered to be more neppy than would be expected from its fiber weight. The behavior cannot be explained on the basis of the percentage of thin-walled fibers nor consistently by the percentage of large motes.

Farm Relief (Code 8) generally weighs more per inch than cottons of similar length and is neppier in some cases. It usually has a large number of large motes and a rather high percentage of thin-walled fibers, despite its relatively high weight per inch, either or both of which might explain its neppiness.

Acala (Code 1) is about the same length as Arkansas (Code 2) and Delfos (Code 5). It has many more neps than either of these varieties but differs appreciably in weight per inch from Arkansas only. According to the percentage of thin-walled fibers, Delfos would be expected to be much neppier than Acala. Acala usually has more large motes than Delfos; it is possible, therefore, that Delfos, although it has a large total number of thin-walled fibers, has less very thin-walled ones than Acala and consequently is less neppy.

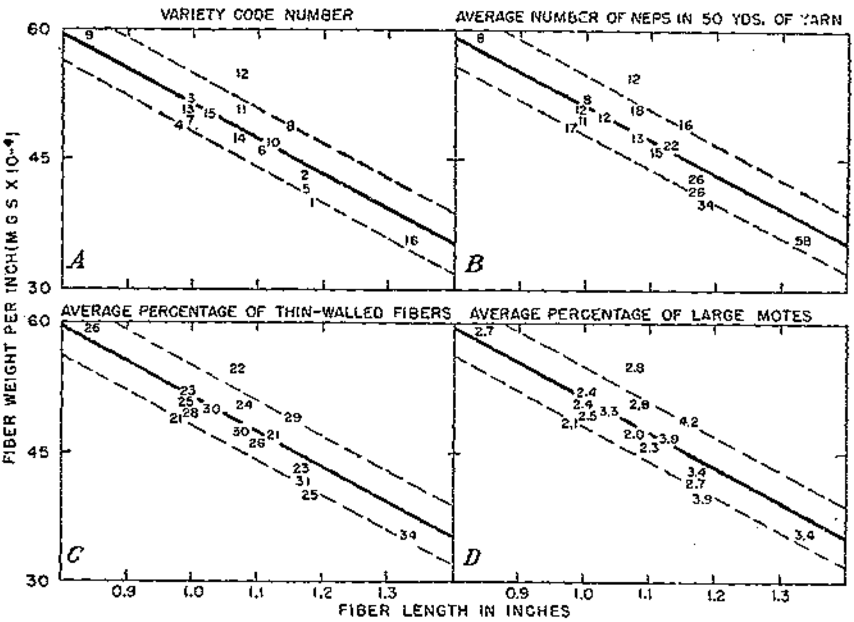

FIGURE 3.—Regression of fiber weight per inch upon upper quartile fiber length for 16 varieties at 7 locations, one location only being shown. Plotted points are indicated in: *A*, by the variety code numbers; *B*, by the average number of neps in 50 yards of 22s yarn; *C*, by the average percentage of thin-walled fibers in the ginned lint; and *D*, by the average percentage of large motes in the seed cotton. Each plotted point or mean is the average of 6 observations (2 series × 3 years). Regression equation: $Y=92.10-40.57X$, *S. E. E.*=3.50, $r=-0.806$.

Mexican Big Boll (Code 10) has about an average length-weight per inch relationship, yet at all stations in 1935 it had more neps than Deltapine (Code 6), Farm Relief (Code 8), or Stoneville (Code 14). Mexican Big Boll usually has a large number of large motes, but this characteristic was shown in all years and so cannot alone explain its unusual neppiness in 1935.

Stoneville (Code 14) is less neppy on the whole than its weight per inch and percentage of thin-walled fibers would indicate. It produces few large motes; its thin-walled fibers, therefore, may be largely those having considerable wall deposition. Nevertheless, it is less neppy than would be expected from available data.

Apparently there is some varietal characteristic not yet understood that affects the nep-forming possibilities of the different varieties and that is subject to modification by seasonal and locational factors. Through variance and covariance analyses it is possible to remove from the data relating to neps, fiber length, fiber weight per inch, and percentage of thin-walled fibers all the variance except that due to varietal differences and that ascribed to error. After this is done, and the varietal mean square for neps is adjusted to compensate for varietal differences in fiber length, weight per inch, and percentage of thin-walled fibers, the differences among the variety means are still highly significant. This indicates that though a considerable degree of varietal differences in neppiness of yarns may be accounted for on the basis of varietal differences in fiber length, fiber weight per inch, and percentage of thin-walled fibers, there is still considerable varietal variation for which other factors must be responsible. Such factors may include: Percentage of exceedingly thin-walled fibers, fiber diameter, uniformity of the various fiber properties, and the amount of fuzz ginned off into the lint.

Locational Relationships

FIBER PROPERTIES

Although significant differences exist among the station means for neps as well as for all three fiber properties (table 1), station differences in yarn neppiness cannot be accounted for by differences in fiber length, fiber weight per inch, or the percentage of thin-walled fibers taken individually (nonsignificant correlations, table 5). Length was not expected to be a factor, since station differences in length are relatively small. It was thought, however, that station differences in neppiness might be related to the maturity of the cotton representing the different stations, reflected either in differences in weight per inch or in the percentage of thin-walled fibers, but this did not prove to be the case.

Although the three fiber properties taken separately explain little if any of the station variation in neppiness, the combined effect of the three, as indicated by the size of the multiple correlation coefficient, explains somewhat more (table 6). Apparently the interrelationships among the fiber properties are such that taken as a whole they can account for some of the station differences in neppiness. The beta regression coefficients indicate that the percentage of thin-walled fibers is the most important of the three properties in this respect (table 6).

It is of considerable interest that environmentally induced responses result in correlations among the fiber properties themselves that are significant or nearly so (table 5). With an increase in fiber length for location there is an increase in weight per inch. The same trend is shown by the negative correlation between length and percentage of thin-walled fibers, the longer cottons being the more mature. In other words, the environmental conditions that tend to produce long fibers also tend to produce well-matured ones, and vice versa, whereas exactly the reverse relationships exist among varieties.

It was thought that perhaps for the stations the cottons of the poorest quality, as far as fiber length and weight per inch together are concerned, would be the neppiest, but this was not true. In figure 4 the station data for 8 of the varieties are presented. Since it would be impracticable to show clearly the results for all 16 varieties, 8 were selected throughout the range of fiber length, and the regression of weight per inch upon fiber length was plotted, using the average number of neps for the variety-station means to locate the position showing the relation between these two fiber properties. Within each variety, the stations show a fairly definite trend, the weight per inch tending to increase as length increases; that is, the locational factors that tend to produce long fibers tend also to favor normal secondary wall development and vice versa. No tendency was noted for the shorter and more immature (lighter) cottons to be neppier than the longer and more mature (heavier) ones.

LARGE MOTES

There is a very definite tendency for the stations producing seed cottons with the greatest number of large motes to be those having the neppiest yarns ($r=0.944$, table 5). Correlation between the percentage of large motes in the seed cotton and the percentage of thin-walled fibers in the lint or the fiber weight per inch, however, is not significant. The exact way in which the large motes are related to the number of neps in the yarn cannot be judged from these data, but it is evident that their occurrence is related either directly or indirectly in a very significant manner to the nep-forming potentialities of the seed cotton.

Seasonal Relationships

FIBER PROPERTIES

The differences in the neppiness of yarns representing the different years cannot be explained to any significant degree by yearly differences in fiber length, fiber weight per inch, and percentage of thin-walled fibers. The correlation coefficients are large, but because of the single degree of freedom none of them can be considered significant (table 5). Within individual varieties and stations, however, an increase in neppiness from one year to another is accompanied to a significant degree by a decrease in weight per inch or an increase in the percentage of thin-walled fibers. That is, with an increase in immaturity, expressed either in weight per inch or as percentage of thin-walled fibers, there is an increase in neppiness. Many of the differences in weight per inch and percentage of thin-walled fibers, however, as well as the differences in the number of neps, are very small.

Although the negative correlation between fiber length and number of neps is not significant it is of interest. The correlation coefficients indicate that certain environmental conditions that vary with seasons may produce shorter and more immature cottons than those of other years; and since the more immature cottons tend to be the neppier, it follows that the shorter cottons should also be the neppier.

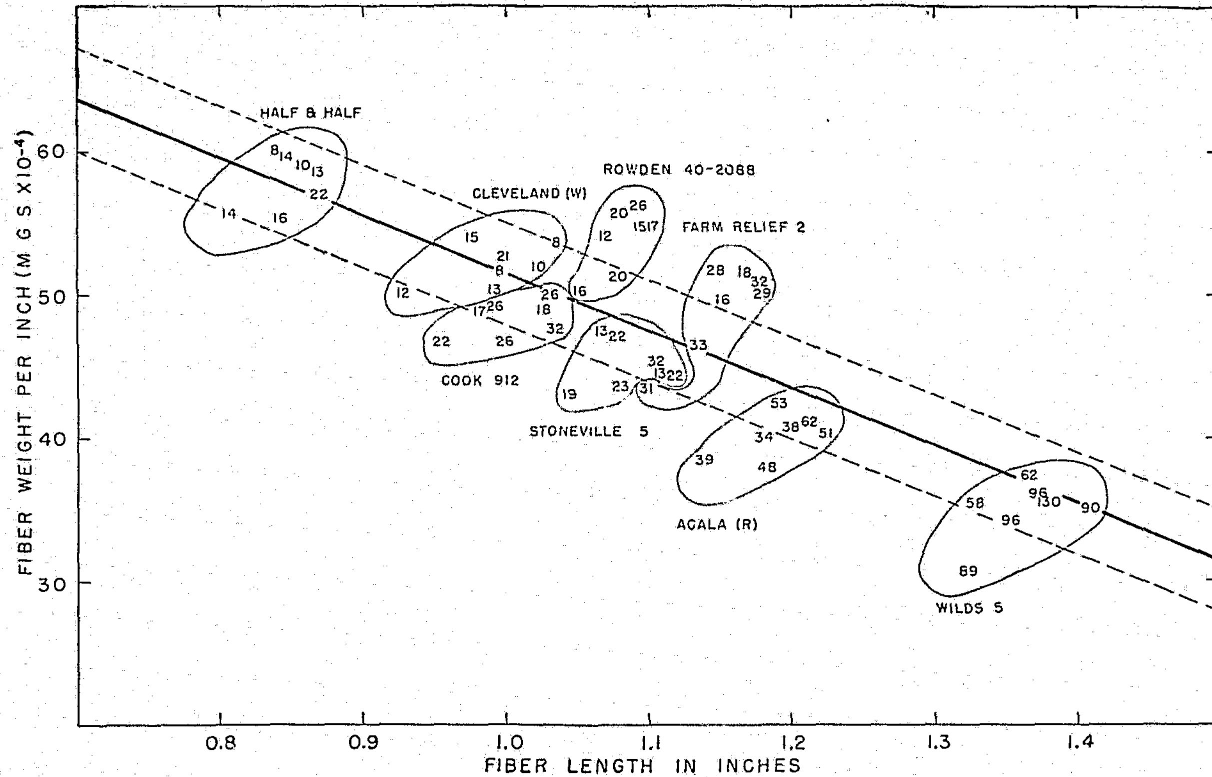

FIGURE 4.—Regression of fiber weight per inch upon upper quartile fiber length for 8 varieties at 7 locations. Each plotted point is indicated by the average number of neps in 50 yards of 22s yarn for a variety at a particular location and is the average of 6 observations (2 series $\times$ 3 years). Regression equation: $E=92.10-40.57X$, $S.\ E.\ E.=3.50$, $r=-0.806$.

LARGE MOTES

Differences in neppiness of yarn representing the different years were not related to differences in mote percentages of the seed cottons.

INTERACTION RELATIONSHIPS

The simple correlation coefficients representing the extent to which variations in neppiness associated with the various interactions can be explained by variations in the three fiber properties are, with one exception, nonsignificant. In general, therefore, variations in neppiness attributed to the differential response of variety to the effect of location and of year, to the effect of location as modified by the effect of year, or to the differential effect of location during the different seasons upon the cottons as a whole cannot be accounted for by variations in fiber length, fiber weight, or the percentage of thin-walled fibers (table 5).

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