BLOCK 6.—MANURING EXPERIMENT, R.R.I. EXPERIMENT STATION.

THIRD REPORT.

Part I. Third Series of Measurements. January, 1931.

BY

C. Falconer Flint.

In the two reports (1) (2) already published on the Block 6 manurial experiment, the first described the lay-out of the experiment and presented a set of height measurements taken 11 months after planting, while the second considered in much greater detail a second series of height measurements taken 14 months after planting and interpreted the data by reference to a detailed rainfall chart covering the period of growth.

It is the purpose of this paper, as the first part of the third report, to present a series of girth measurements taken 2¼ years after planting. Details of the lay-out and the fertiliser applications are given in order to make this third report complete in itself. For the sake of brevity and clearness, the information is tabulated wherever possible.

The essential details of the experiment are summarised in Table I. The plots are situated on an area of flat sandy soil which has a dark well-humified colour to a considerable depth.

TABLE I.

Size and form ...	A 40 acre square.
Lay-out ...	Divided into 36 square plots, 6 plots being assigned to each of 6 treatments A, B, C, D, E and F.
Distribution of treatments ...	Indicated in Table IX, the top of the table being the north.
Planting distance ...	22 ft. × 22 ft.
Number of trees per plot ...	81, exclusive of guard rows.
Date of planting ...	October, 1928 (Stumps).

At the time of making the girth measurements (January 1931), soil samples were taken and submitted to the usual routine analysis for the purpose of record and to afford some basis of comparison for other workers on the same problems. The figures are given in Table II which is self explanatory. Two samples were taken from the same hole on each control plot, at 0-4 inches and 12-16 inches respectively. These were compounded to give one top-soil sample and one sub-soil sample for laboratory examination.

TABLE II.

Results of analysis of composite top-soil and sub-soil samples prepared from A plots.
(All figures except pH values given as percentage of weight of oven-dry soil).

	Top soil	Sub-soil
Sand ...	84	82
Silt ...	5	5
Clay ...	11	13
Loss on ignition ...	5.6	4.5
Carbon ...	1.57	
Nitrogen ...	0.082	
pH (electrometric, on soil suspension) ...	4.3	4.5
pH (colorimetric, on 1 :5 water extract) ...	5.4	
pH (colorimetric, on 10% KNO_3 1 :3 extract) ...	4.2	4.4
Potassium (in 1 :1 H.Cl extract) ...		0.007
Magnesium do. ...		0.016
Calcium do. ...		0.010
Phosphate do. ...		0.0018
Phosphate (in 1 :5 water extract)...	0.000018	
Colour (Ridgway's book of standards)—wet ...	Olive Brown.	Light Brownish olive.
Colour (Ridgway's book of standards)—dry ...	Light drab.	Isabella colour (light).

Table III gives particulars of the manurial applications up to the time of writing. Column headings indicate the nutritional programme assigned to each of the groups of 6 plots. Group A are controls. Table IV shews approximately the total amounts of plant foods given per tree.

TABLE III.

The manurial treatments and details of dates of application and amounts per tree.

Descriptive number.	Date of application.	Number of months after planting	B plots.	C plots.	D plots.	E plots.	F plots
			Organic.	Complete Inorganic.	Nitrogen only.	Nitrogen and Phosphate.	Phosphate and Potash.
1st.	October 1928.	At planting	$4\frac{1}{2}$ lbs. matured cow dung.	$\frac{3}{8}$ oz. Sulphate of potash. $\frac{3}{8}$ oz. "20/20 Ammophos."	$\frac{3}{4}$ oz. Ammonium sulphate.	$\frac{1}{2}$ oz. Ammonium sulphate. $\frac{1}{4}$ oz. Double superphosphate.	$\frac{1}{2}$ oz. Sulphate of potash. $\frac{1}{4}$ oz. Double superphosphate.
2nd.	July 1929.	9	$6\frac{3}{4}$ lbs. matured cow dung.	$2\frac{1}{2}$ oz. "Nitrophoska"	$1\frac{1}{8}$ oz. nitrate of soda. $1\frac{1}{8}$ oz. Ammonium sulphate.	$2\frac{1}{4}$ oz. "20/20 Ammophos".	$1\frac{1}{8}$ oz. Sulphate of potash. $1\frac{1}{8}$ oz. Double superphosphate.
3rd.	March 1930.	17	20 lbs. matured cow dung.	12 oz. Nitrophoska"	10 oz. Ammonium sulphate.	10 oz. "20/20 Ammophos".	4 oz. Sulphate of potash. 4 oz. Double superphosphate.
4th.	Septr. 1930.	23	← 3rd application repeated. →				
5th.	March 1931.	29	← 3rd application repeated. →				

TABLE IV.

Total ounces (approx.) of plant food applied per tree up to the end of the 4th manuring.

	B	C	D	E	F
Nitrogen ...	4.0	4.5	4.8	3.7	—
Phosphate (as $'PO_4$) ...	0.4	5.9	—	6.1	5.0
Potassium (as K′) ...	1.4	5.0	—	—	3.9

The girth measurements were made at a height of 2 feet from the ground with a pair of wooden callipers designed like a large screw spanner, but with the lower jaw sliding freely on the shaft, graduated to read directly inches of girth in terms of the diameter to which it is applied.

Table V gives details of the number of trees omitted from measurement, for reasons directly due to root disease. Since in the majority of cases less than the full number of 81 trees could be measured in a plot, totals for each plot were corrected on a basis proportional to this figure and are here quoted only after correction :—

TABLE V.

Shewing details of numbers of trees measured; guard rows were not measured.

Theoretical number of trees to be measured ...	2,916
Number actually measured ...	2,831
Too small for measurement (recent supplies) ...	63
Trees missing (soil treated for disease and awaiting supplies) ...	16
Trees dying of root disease ...	4
Trees dead due to root disease ...	2

Table VI shews the corrected girth totals for each of the six different treatments including controls. Table VII gives these same figures expressed as a percentage of the mean, and indicates the extent of the difference between respective manurial treatments and control. When supplemented by the figure for standard error, obtained as will presently be indicated, Table VII expresses the result of the experiment represented by this series of measurements.

TABLE VI.

Girth totals for groups of 6 plots, arranged according to treatment.

A.	B.	C.	D.	E.	F.	Grand total.
2,892.	3,216.	2,983.	3,027.	2,846.	2,885.	27,849.

Mean, per group of 6 plots, 2,974.8

TABLE VII.

Girth totals per group of 6 plots, arranged according to treatments and expressed as a percentage of the mean figure per group of 6. The lower row of figures shews deviations from the figure for the A control plots :—

A. Control.	B. Organic.	C. Complete inorganic.	D. N only	E. N & P.	F. P & K.
97.2	108.1 +10.9	100.3 +3.1	101.7 +4.5	95.7 -1.5	97.0 -0.2

Standard error 1.96 per cent.

It will be seen that only the treatment with cow dung and that with inorganic nitrogen without phosphate or potassium give a significant girth increase, when the criterion is the conventional test of differing from the control figure by more than twice the standard error.

Table VIII gives the frequency data.

TABLE VIII.

Frequency data for the 2,831 trees measured.

Girth classes, in inches.	Number of Trees.
0 — 0.5	2
0.6 — 1.1	35
1.2 — 1.7	46
1.8 — 2.3	38
2.4 — 2.9	42
3.0 — 3.5	62
3.6 — 4.1	122
4.2 — 4.7	209
4.8 — 5.3	267
5.4 — 5.9	361
6.0 — 6.5	408
6.6 — 7.1	446
7.2 — 7.7	314
7.8 — 8.3	184
8.4 — 8.9	124
9.0 — 9.5	88
9.6 — 10.1	32
10.2 — 10.7	29
10.8 — 11.3	14
11.4 — 11.9	5
12.0 — 12.5	2
12.6 — 13.1	1

The frequency curve is remarkably smooth and shews little evidence of a mixed population. Its peak is sharp but slightly bent towards the region of highest readings giving a gentle concavity on this side above what should be the point of maximum inflection. A slight hump distorts the curve in its first few points, as can be seen from the table, but although this indicates the presence of trees which do not belong to the normal population, their effect on the final result would be so small that their elimination from the experiment was not attempted. This hump is the only feature that suggests the second or "stagnant" class that was of such prominence in Haines's first two series of measurements, but probably represents the biggest of the trees planted as supplies to replace deaths from root disease.

Examination of the frequency data was held to justify an analysis of variance for the application of the tests of significance described by R. A. Fisher (3).

TABLE IX.

Deviations of girth totals for plots from a working mean of 500, arranged according to position in the field.

							Totals.
	E −22	A +26	B +49	F −17	D −24	C + 6	+ 18
	F −34	B +54	D + 8	E −42	C −62	A −25	−101
	D +14	E −24	A −51	C −56	F −51	B + 5	−163
	C +68	F +30	E −41	A −21	B +24	D −40	+ 20
	A + 5	D +21	C −12	B +37	E −27	F −46	− 22
	B +47	C +39	F + 3	D +48	A −42	E + 2	+ 97
Totals.	+78	+146	−44	−51	−182	−98	−151

Table IX is, in effect, a diagram of the experimental lay-out (the north being at the top of the table) and gives deviations of the girth totals for each plot from a working mean of 500. In Table X the figures have been employed to give the analysis of variance, from which follows the test of the significance of the experiment and the calculation of the standard error used in Table VII.

TABLE X.

Shewing analysis of variance, test of significance and calculation of standard error.

	Degrees of freedom	Sum of squares.	Mean squares.	$\frac{1}{2}\log_e$ (mean square.)
Rows ...	5	11,810.8	2,362.16	1.5811
Columns ...	5	7,264.4	1,452.88	1.3381
Treatments ...	5	15,413.1	3,082.62	1.7143
Error ...	20	11,301.4	565.07	.8659
Total ...	35	45,789.7		

Comparing treatment with error, the Z value is 0.8484 while the 1 per cent. point is 0.7058. The experiment is therefore significant.

The Standard error (total of 6 plots) is the square root of $565.07 \times 6 = 58.22$; or 1.96 per cent. of the mean girth per group of 6 plots.

DISCUSSION OF RESULTS.

From a consideration of Table VII, the following points emerge :—

(1) A total of 51 lbs. of matured cow dung (B plots) applied in increasing quantities at four specified times has given a 10.9 per cent. girth increase which is statistically highly significant. The dung was estimated to contain 4 ozs. nitrogen, 0.4 ozs., phosphate and 1.4 ozs. of potassium.

(2) Application of 4.8 ozs. of nitrogen in inorganic form without phosphate or potassium (D plots) gave only a 4.5 per cent. increase, which is also statistically significant.

(3) A mixed inorganic fertiliser (C plots), similarly applied and totalling a similar weight of nitrogen accompanied by comparable amounts of phosphate and potassium, gave only a 3.1 per cent increase, which is hardly significant.

(4) Similar applications (E plots) of rather less nitrogen and nearly twice as much phosphate show a depression in rate of girth increase, but this is not significant.

(5) The application of phosphate and potassium (F plots) was without effect.

Considering first, without reference to statistical significance, the groups receiving inorganic fertilisers, viz. C, D, E and F, nitrogen would seem to be the chief manurial requirement. The presence of a relatively large amount of phosphate seems to more than cancel the effect of a nitrogen dressing, though the addition of potash would appear to balance the depressing effect of the phosphate, both when nitrogen was added and when it was omitted. Since nitrogen and potassium were not given together in the absence of phosphate, this point cannot be checked nor can the existence of a potash deficiency be adequately tested.

As the B plots, which received nitrogen and more than three times as much potassium as phosphate, gave more than twice the increase furnished by a similar weight of inorganic nitrogen only, this might be considered as evidence in favour of the compensation of phosphate depression by potassium and the existence of a positive potassium response. It would, however, be more generally held that since the elements were applied in a bulky organic manure rich in bacterial life, the argument is invalidated.

In connection with the apparent depressing effect of phosphate on the girth increase of the young rubber, it may be remarked that reference has been made by this Division on several occasions to a depression of yield of mature rubber following phosphate dressings There is evidence (4) that water soluble phosphates only are implicated, and in this experiment phosphates were all given in the water soluble form.

The figure 0.18 parts per million of phosphate in the soil water extract (Table II) is a very usual one on Malayan rubber soils and, taken in conjunction with the sandy nature of the soil, indicates an adequate and sufficiently available supply.

The term "acid soluble potassium" conveys no evidence of availability.

According to results and observations discussed by Salter (5) and previous workers, the wide carbon-nitrogen ratio (19 :1) suggests that the nitrogen reserves, which are low in any case, would not be easily available for plant growth, and that the soil would therefore show a marked response to nitrogen dressings.

The cow dung, apart from its own nitrogen content liberated by micro-organic decomposition, should also be considered as an application of useful bacteria in a medium on which they could continue to thrive when it is dispersed in the surface soil. Thus, as the introduction of many points of persistent infection, an application of farm-yard manure might be expected greatly to assist the decomposition of nitrogen reserves in a soil in which a sluggish micro-organic population made availability low. On this soil type the superior efficacy of cow dung over inorganic nitrogenous fertilisers in promoting the girth increase of young rubber is therefore attributed to a dual effect—its nitrogen content *per se,* and its microbiological effect as a bacterial culture in rendering more easily available the soil nitrogen reserves.

Girth has an important economic aspect in determining the age at which an area can be brought into tapping. It must be emphasized that the effects to date of the treatments are of such low magnitude as to be without economic value; but if the trees maintained the same acceleration of growth as in the B plots, they could probably be brought into tapping a year earlier than control plots as a result of the manuring. Two factors have, however, to be considered. Firstly, the difficulty of securing large supplies of farm-yard manure (a difficulty which might be met from the preparation of artificial farm-yard manure from cover crops); secondly, rubber trees probably have a maximum rate of growth which may be attained but which cannot be exceeded by supplying fertility deficiencies. The second factor tends to destroy any promise of a continued acceleration of girth increase on Block 6, for there is evidence that in the presence of other limiting factors the maximum rate of growth has already been nearly achieved.

Part II. Fourth Series of Measurements. May, 1931.

BY

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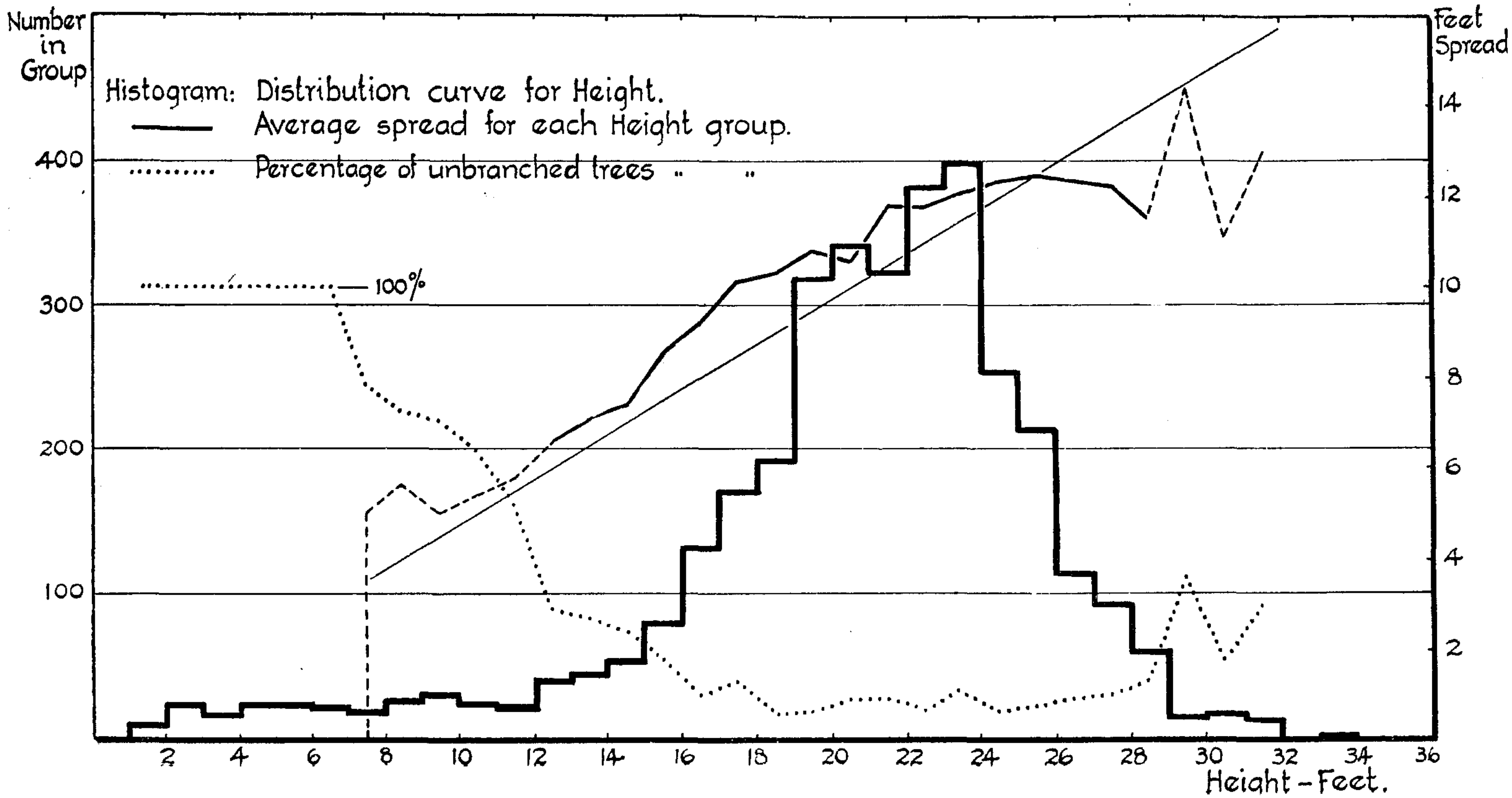
The fourth series of measurements on Block 6 were carried out when the trees were just over two and a half years' old from the time of planting. Direct measurements of height with a bamboo scale were made and, owing to the change in form which branching had produced, an additional measurement of spread was made by means of a cross piece attached to the vertical scale. Readings were made as before to the nearest three inches.

It was found convenient to use field glasses in making the records, as this allowed the observer to stand some distance from the tree and so reduce the elevation of the line of sight to comfortable proportions.

The frequency curve for the height records was first examined, and the result is shewn in the diagram as a histogram for groups of 1 foot interval. The main part of the curve is approximately normal in form, although still bi-modal as in the case of the height measurements taken a year earlier, and it trails off at its lower end into groups of very small trees. These can be definitely eliminated as a special class of "casualties", being mainly supplies that have replaced trees lost by disease, lightning or other causes. All entries of height of 12 feet or under were considered to be in this special class and were rejected in the calculations for the normal population which are described later.

Measurements a year earlier had shewn two groups of trees with modes (i.e. most frequent height) at about 3 feet and 8 feet respectively; this separation was attributed to a "barrier" to growth produced by periods of drought acting on trees below a critical size, and so retarding a group small in size separated from the vigorously growing group. It is apparent that nearly all trees have now passed this critical point and are growing vigorously. The separation can still be noticed, however, in the two modal values at 20 feet and 23 feet, but the difference is obviously vanishing, shewing the capacity of the delayed trees to catch up to the others that were favoured early. A large proportion of the trees must have made quite ten times as



Number in Group
Feet Spread
Histogram: Distribution curve for Height.
Average spread for each Height group.
Percentage of unbranched trees " "
100%
400
300
200
100
14
12
10
8
6
4
2
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36
Height - Feet.

much growth (in height alone) during the last year as they made during the first.

Before proceeding further it will be necessary to decide upon some convention as to the method of combination of the readings for spread and height in order to give the best index for total growth. Hevea trees of mixed origin have a very varied manner of branching. At the stage now under discussion the trees have forms varying from a tall stem without branching (so called "bottle-brush" shape) to a dense dome of leaves formed by many branches radiating in all directions. Discrimination as to the number of branches was impossible in view of the large number of entries to be dealt with; and it was thought desirable to adhere to the conception of branch length, which would still represent " linear " growth in a fashion comparable with the earlier measurements of height, rather than to reduce spread to an expression of area (or volume). It was decided also, in the absence of more detailed knowledge, that it would be fair to give about equal weight to the two entries for height and for spread in combining them to a single figure. On examination of a few of the figures it was found that, on an average, twice the spread was nearly equal to the height; so the conception of an average tree was evolved having the form of a single vertical shoot and four equal branches. The total (linear) growth could then be expressed as height plus twice the spread of the tree, and this convention was adopted for combining the double entries and arriving at total growth.

The validity of this convention derives some support from an examination of the average spread of trees of the same height, using the groups which had been formed for the height frequency curve. The result of these calculations is shewn on the diagram as a curve in full line. The straight line shews the locus of those values of spread which, multiplied by two, would exactly equal the height. The calculated averages are in the main a little in excess, but follow the assumed relationship fairly well. The curve falls off toward the higher values, which expresses the fact that among the taller trees there has been some tendency to make height at the expense of spread, probably associated with late branching.

Unbranched trees, which had no entry for spread, were separately accounted for, and the dotted curve in the diagram shews the percentage which they formed in each group. Up to 7 feet height they form the whole of the group, but entries for spread begin at that point and steadily reduce the percentage of unbranched trees until at a height of 16 feet an almost constant value is reached. This value represents the proportion of trees of the distinct bottle-brush habit. It remains constant through the more numerous groups, but naturally increases again in the highest groups. For the average tree we may conclude that branching develops during the stage between

7 and 16 feet in height. Hence nearly the whole normal stand has entered the branched stage, since trees under 12 feet have been excluded from the normal population.

The "casualty" class, containing trees of 12 feet and under (and including blanks also), forms 9.5 per cent. of the total. The incidence is related to location in the field but not to the treatments which the plots have received. This is indicated in Table XI in which the total casualties have been taken in three different ways, viz. for groups of six plots according to treatment, and according to position in rows taken in two directions at right angles. The latter are distinguished as "rows" and "columns" as derived when the figures have been set out in a tabular plan of the plots.

TABLE XI.

INCIDENCE OF "CASUALTY" GROUP.

		Treatments.	*Rows.*	*Columns.*
A	...	46	36	61
B	...	41	47	35
C	...	49	47	52
D	...	47	45	35
E	...	47	46	52
F	...	48	57	43

The first row of plots with the low figure 36 is bounded by a road, while the column with the high figure 61 forms the extreme edge of the Block next the jungle. Both are in the line of movements of labour going from one part of the estate to another, and the reflection is suggested whether some difference may have been caused by the traffic going through the rubber in one case and not in the other. It is not likely that root disease from the jungle edge could be blamed at this stage.

The Pathological Division survey for *Fomes lignosus,* made at about the same time as the measurements under discussion, gave a figure of 6.0 per cent. for the incidence of this disease, including all trees shewing external mycelium as well as trees attacked or killed.

Table XII shews the values of mean growth for the plots calculated in the manner already described. The figures are expressed in feet; the first figure is the average height for the plot, the second is twice the average spread, while the third, in heavy type, is the sum of these two as used for the analysis of total growth.

Where trees are unbranched this indicates a definite habit rather than mere poor development, and it gives too little weight to their value for total growth if the spread entry is treated as zero. A very low conventional value for spread was therefore assumed and used in the calculations for these cases.

TABLE XII.

E	A	B	F	D	C
21.69	22.90	22.74	20.81	21.28	21.67
22.07	21.94	23.68	18.94	19.09	20.32
43.76	**44.84**	**46.42**	**39.75**	**40.37**	**41.99**
F	B	D	E	C	A
21.43	22.88	21.55	20.72	20.59	20.61
20.10	22.88	22.22	20.70	18.93	18.41
41.53	**45.76**	**43.77**	**41.42**	**39.52**	**39.02**
D	E	A	C	F	B
23.10	21.41	20.62	20.96	20.80	21.72
20.42	21.21	20.33	16.82	18.05	18.74
43.52	**42.62**	**40.95**	**37.78**	**38.85**	**40.46**
C	F	E	A	B	D
23.71	22.38	20.60	21.29	21.26	19.76
27.22	21.61	21.14	18.84	21.19	19.04
50.93	**43.99**	**41.74**	**40.13**	**42.45**	**38.80**
A	D	C	B	E	F
22.27	24.89	22.12	22.85	20.78	20.64
25.59	23.96	22.10	20.64	20.21	19.13
47.86	**48.85**	**44.22**	**43.49**	**40.99**	**39.77**
B	C	F	D	A	E
23.52	22.75	21.78	22.26	20.09	20.18
23.57	23.66	21.64	20.36	18.99	20.66
47.09	**46.41**	**43.42**	**42.62**	**39.08**	**40.84**

Examination of the table shews that differences are closely connected with position in the Block. It is easy to draw an entirely plausible fertility contour map on the basis of the figures, which is a fair test to shew the relationship between location and growth. This conclusion is also borne out statistically by the analysis of variance in Table XIII which shews that by far the greater part of variance can be attributed to location.

TABLE XIII.

ANALYSIS OF VARIANCE.

	Degrees of freedom.	*Sum of squares.*	*Mean squares.*
Rows ...	5	44.35	8.87
Columns ...	5	200.60	40.15
Treatments ...	5	39.08	7.81
Error ...	20	55.52	2.78
Total ...	35	339.55	

Standard error (6 plots)=4.07 or 1.6 per cent.

The standard error of the experiment for a group of six plots is 1.6 per cent, which gives considerable accuracy for judging results. The errors for the first two series of measurements were much higher (about 4 per cent), but it must be remembered that those series did not show a proper conformity to the normal population curve.

If the plots having the same treatment are grouped together and the average growth is compared with the control as 100, we get the following figures :—

A	B	C	D	E	F
100.0	105.4	103.7	102.3	99.9	98.4

As on each previous occasion, the B plots receiving a complete organic fertiliser (dung) shew the best growth. None of the effects are large; indeed, the only other result that can be regarded as significant is that for the C plots receiving a complete inorganic fertiliser. The results are rather surprising, since there have been five separate applications of fertilisers, and as an example of the amounts given [see Part I Table III] it may be stated that the E plots had received a total of well over 2 lbs. of "Ammophos 20/20" per tree. The amounts of plant nutrients given with the dung (as conventionally reckoned) are known from later analyses to have been smaller than in the other cases where chemical fertilisers were given,—especially in regard to phosphates and potash.

The simplest conclusion seems to be that the reserves in this virgin soil have so far proved, for all practical purposes, quite adequate for the growth of Hevea and have needed no assistance from outside sources. Thus the fears which were early expressed as to the poorness of the site are not being confirmed, and the disappointing results in the first months may safely be attributed to exceptionally dry weather acting in a situation abnormally sensitive to drought (i.e. young trees in an open well-drained soil). Conventional analysis tables of rubber soils are difficult of interpretation unless depth of soil is taken into account. In the present case, as in others which we have examined, great depth of weathered mineral material having easy drainage is compensating for the low figures for plant nutrients shewn by a conventional analysis of the usual acid extract of the soil. This point of view does not affect the nitrogen question however, and this may assume greater importance when the newly exposed surface soil loses the supplies associated with the humus.

The outstanding feature for emphasis is the way in which growth has evened itself as soon as the first critical stages were passed and the trees were vigorously established. The promise of some marked differences, which previous measurements suggested, has not been fulfilled. The moral is an important one and warns one to discount hasty conclusions based on early differences, which are the more easily observed when the plants are small.

Comparing the two series of measurements here reported, it seems that girth may prove a more sensitive criterion of growth than a combination of height and spread. This is fortunate, for not only is the girth measurement more direct and more easy to perform but it also concerns that part of the tree which is the focus of interest—the future tapping area.

Summary.

Two series of measurements of young rubber are reported for a manuring experiment on a new clearing; one analyses girth measurements at two years old, while the other discusses the height and spread measurements at two and a half years. None of the differences are large enough to be of practical importance, but significant effects have been produced by dung in both cases. In addition, girth was improved where nitrogen alone was given and total growth was improved by a complete chemical fertiliser, but none of the other figures are significant.

Part of the growing period has been much affected by drought and the lack of result from fertilisers might be directly associated with this in some way. Alternatively, it might be explained by the newly cleared soil having sufficient reserves for normal tree growth, rendering additions almost superfluous up to the present stage. The progress of the experiment will presently resolve these uncertainties.

References.

1. W. B. Haines. 1929. Block 6. Manuring Experiment, R.R.I. Experiment Station. First Report. *Quart. Journ. Rubber Research Inst. of Malaya,* Vol. **I,** No. 4.
2. W. B. Haines. 1930. Block 6. Manuring Experiment, R.R.I. Experiment Station. Second Report. *Ibid,* Vol. **II,** No. 1.
3. R. A. Fisher. "Statistical Methods for Research Workers." 3rd edition, 1930. Oliver and Boyd, London.
4. C. F. Flint. 1930. *Annual Report. Rubber Research Inst. of Malaya,* p. 49.
5. F. J. Salter. 1931. The carbon-nitrogen ratio in relation to the accumulation of organic matter in soils. *Soil Science,* Vol. **XXXI,** No. 6, p. 413.