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

SECOND REPORT.

BY

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The preliminary report on the Block 6 manuring experiment which appeared in the last issue of the Quarterly Journal can now be augmented by a more detailed consideration of a new series of measurements.

Heights were recorded on December 17th 1929, following the same system of classification as before, namely, taking a staff with 3 inch intervals marked and numbered serially, and using this for assigning each tree to its class number.

Before discussing these measurements, it will be necessary to present the history as regards rainfall, since this has undoubtedly been the ruling factor in growth. It may be recalled that the soil is very porous and sandy, so that the young plants suffer badly during dry weather. The diagram shown in Figure I indicates the weekly totals of rainfall since Block 6 was planted. The figures actually refer to the gauge at the Laboratory, which is some 8 miles from the Experiment Station. These figures had to be used, since figures at the Experiment Station were not available for the first part of the period. As shown in another note in this issue there can be no doubt that the figures used give an accurate idea of the seasonal variations, although the totals differ considerably.

The period since planting falls into five distinct intervals. (1) The wet planting season lasting until the end of December 1928. This was followed by (2) very dry weather in January, February and part of March. April and May form (3) a second wet interval followed again by (4) a long dry interval which broke at the end of September with the onset of (5) the next planting season. The measurements here described were taken at a time when the second manuring, as well as the third wet period, would have had time to produce marked results.

It was remarked in the first report that the size distribution curve showed a curious flatness. In this second series the reason for this result emerges more clearly. A closer analysis reveals that the curves show prominent peaks indicating that the trees fall into several distinct groups. The separation between these groups has been increased by the further period of growth. They can be traced in the first series but were not distinct enough at that time to cause comment. As an instance, the distribution curve for the control

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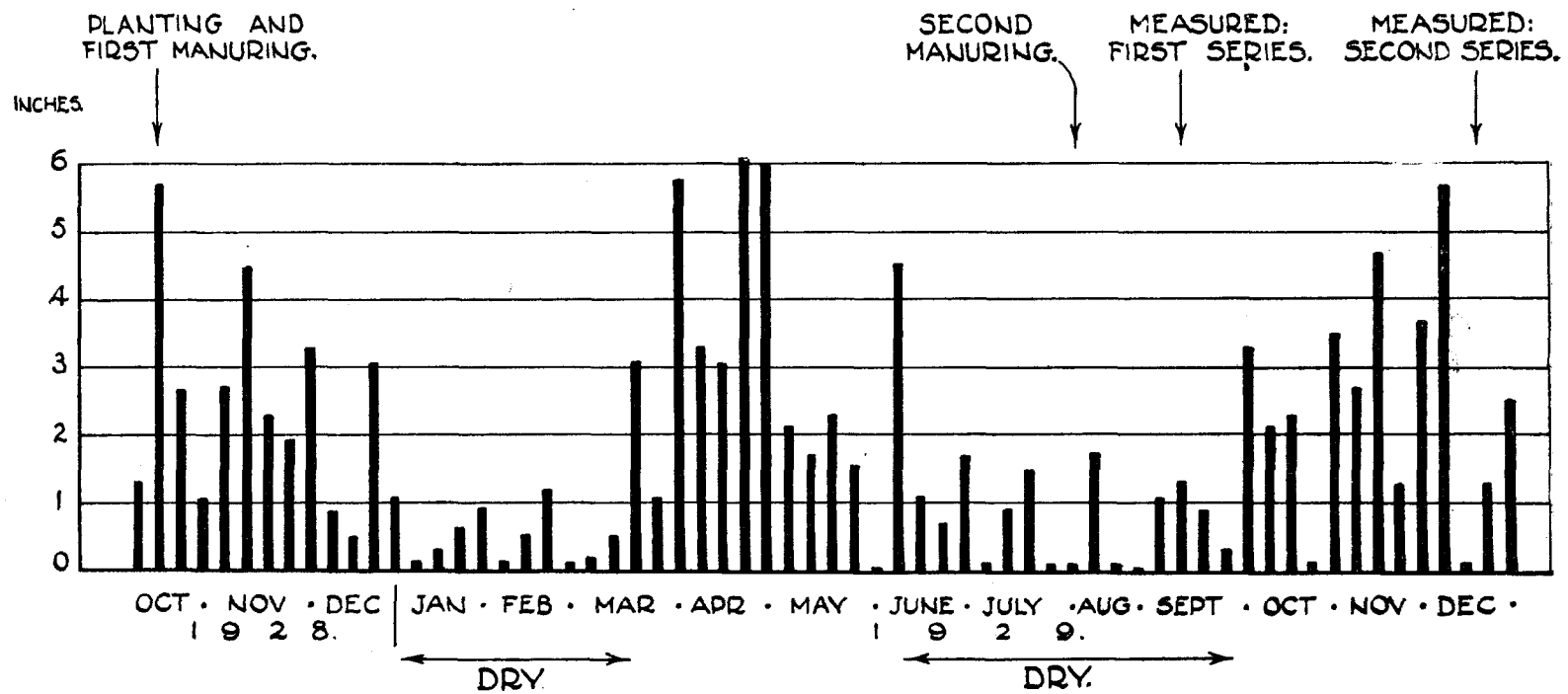

Fig: 1.

RAINFALL — WEEKLY TOTALS.

plots A is shown in Figure 2 in continuous line. There are three distinct groups having mean values of 2 ft. 9 ins., 6 ft. 6 ins. and 9 ft. 6 ins. respectively. It is suggested that these groups have been formed as a result of the retardment of growth during dry seasons acting differentially upon the trees according to size. Such an explanation involves the supposition that there is a critical size (of the tree in general and of the root in particular) beyond which the tree largely escapes the effect of drought, but below which there is definite retardation. Then the largest group will correspond to those trees which extended their root systems far enough during the actual planting season to escape in a large measure the checking influence of the ensuing dry period. The middle group would correspond to those trees which passed the critical stage during the second wet season, while the first group, which is common to all plots, represents those trees which even at the time of measurement had not passed the critical stage. The curve shown in broken line in Figure 2 shows similar groups for the D plots (which receive Nitrogen only).

Figure 3 is the distribution curve for the total population, which shows two distinct classes only, since the differences between plots due to manuring have caused the two larger groups to merge together. At the time of writing (January 1930) the division into two size classes is very noticeable to the eye and makes the stand of trees appear extraordinarily irregular.

A large number of stunted trees are affected with *Fomes Lignosus* and are being supplied. It remains to be seen from further examination to what extent disease and drought have been inter-related in keeping back the smaller class. When a stump is attacked before it has started vigorous growth, this fungus does not kill quickly but gives rise to a prolonged sickly stage accompanied by arrestment of growth. The groupings can therefore be subdivided, and such analysis gives rise to one or two very interesting inferences.

The smallest group containing the failures may be taken as below No. 9 (equals 2 feet). Very few of these were missing or dead, but no progress had been made after the first shooting. Their distribution among the various plots is as follows:—

Plots A—11, Plots B—23, Plots C—24, Plots D—16, Plots E—15, Plots F—20. These figures indicate that the control plots A had decidedly the smallest number of failures. An explanation of this would seem to be that the manuring rather increased the incidence of disease attack as affecting the plants immediately after planting. The causal organism would naturally be stimulated by the addition of the plant foods in the neighbourhood of the plant roots. It should be noted that 20 failures in one set of plots only represent about 4 per cent. of the trees.

The next group might be called the " stagnant class," that is, those trees which have not yet (or only recently) started to 'get away'

DISTRIBUTION CURVES.

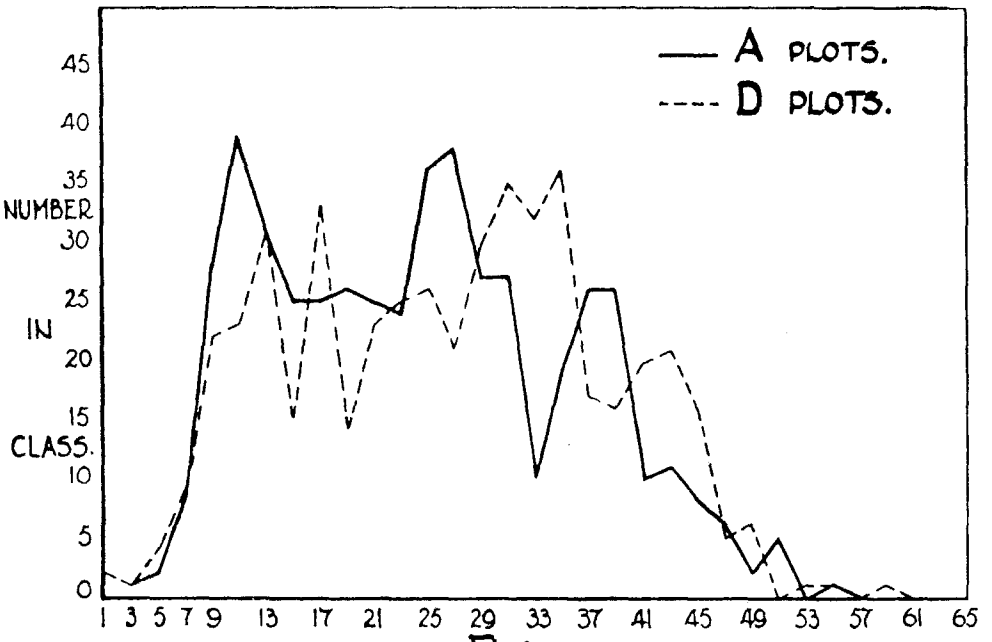

Fig: 2.

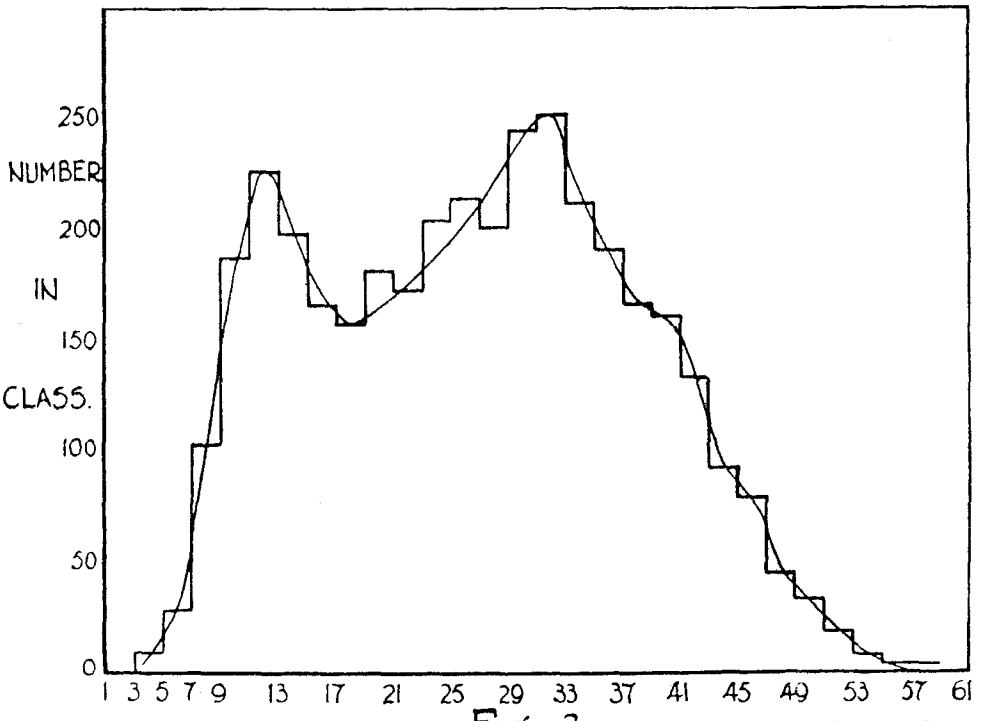

Fig: 3.

as regards growth. Taking the upper limit of this class at number 19 we have the following total numbers between 9 and 19. Plots A—148, Plots B—108, Plots C—129, Plots D—124, Plots E—129, Plots F—105.

The figure for the control plots A is the greatest, although it was the least in the last group. Expressed in a different way this signifies that the number of escapes from the 'stagnant class' for all manured plots is greater than for the control. The average size of tree in this sub-group were, for different treatments, as follows:—

A—3.4 ft. B—6.0 ft. D—3.6 ft. E—3.4 ft. F—3.6 ft. Here it is the B plots (dung) which stand out from the rest. The greater average height for this plot is accompanied by a less distinct splitting off of this class from the other: but the inference is legitimate that young plants struggling against a heavy handicap (root disease, etc. in conjunction with drought) make better headway when an organic fertiliser has been given than they do under treatments from chemical fertilisers.

Leaving the main size group for the moment we may next deal with the 'most favoured' or largest class, which may be supposed to be composed of those trees which established themselves thoroughly in the season of planting. They are almost 50 per cent. larger than the main group. The separation from the main group is most distinct for the A, B and D plots and the mean size attained runs in that order, namely A—9′6″, B—10′3″, D—11′0″. This order also corresponds to the amount of nitrogen received. For the C, E and F plots, the splitting off of this class is not to be remarked. The division at this point is attributed to the effects of the first dry season, separating two groups, one of which broke away in the planting season and the other in the next wet season. There is therefore an indication of some drought-resistant effect in treatments C, E and F which is absent from A, B and D. This must be something other than nitrogen, and the constituent which C, E and F received in common was superphosphate. Part of the action might be attributed to the calcium in this fertiliser. We have evidence that this element is far more deficient than phosphorus as regards availability in this particular soil. That this distinction between these two groups of plots is not due to chance is confirmed by the fact that when the plots were taken grouped into 'rows' and 'columns' (each group of six then having one plot of each treatment) none of the distribution curves showed a splitting off at the largest group.

Taking the main size group and estimating the mean size from the curves, the following values are obtained:—

A 6′6″ B 7′6″ C 8′0″ D 8′8″ E 8′0″ F 7′9″

This comparison is possibly the best that can be derived from the figures as expressing the effect which is to be expected from the manures without the exceptional disturbing effects which have already

been discussed. It represents a benefit of from 15 to 20 per cent. which is of the same order as the increase remarked in the " most favoured " class. As the later analysis will show, the results when referred to grand totals are less than this, being weighted by what is in effect an unresponsive class. It may be remarked that the increases are for one year only, and that future benefits may be expected, at least for some time, to accrue according to "compound interest" rather than "simple interest" laws.

TABLE I.

Height totals for plots according to position in field.

						Totals.
E 2028	A 1979	B 1949	F 2340	D 2265	C 2250	12811
F 1961	B 1807	D 1894	E 2261	C 2707	A 2260	12890
D 2342	E 1983	A 1906	C 1893	F 2170	B 2725	13019
C 1748	F 1925	E 1924	A 1867	B 2306	D 2614	12379
A 1848	D 1946	C 2273	B 2107	E 2329	F 2227	12730
B 2112	C 1801	F 2296	D 2104	A 2358	E 2316	12987
Totals 12034	11441	12242	12572	14185	14392	76816

TABLE II.

Height totals for plots according to treatments.

A	B	C	D	E	F
1979	1949	2250	2265	2028	2340
2260	1807	2707	1894	2261	1961
1906	2725	1893	2342	1983	2170
1867	2306	1743	2614	1924	1925
1848	2107	2273	1946	2329	2227
2358	2112	1801	2104	2316	2296
Totals 12218	13006	12667	13165	12341	12919

In Table I is given the results of the census expressed as the totals of the height numbers for each plot, the positions in the table corresponding to the positions in the field. It is evident that the two series of plots nearest the road, which correspond to the two columns on the right of the table, are in a favoured position relative to the rest. Table II gives the data of Table I re-arranged according to treatments.

The mean values for each treatment from Table II can be expressed as percentages, as follows:—

A 100 B 107.1 C 103.6 D 107.9 E 105.8 F 105.9

The total effect so expressed is not large. It remains to test its significance. The discussion of the analysis of variance for the "Latin-square" layout, followed in this experiment, is given by Dr. R. A. Fisher in his book " Statistical Methods for Research Workers." Applying the calculation to the above figures (without reference to any small disturbing effects the "mixed" nature of the population may have on the plot totals) we obtain the following table.

TABLE III.

	Degrees of Freedom	Sum of Squares
Rows ...	5	45,526
Columns ...	5	1,185,623
Treatments ...	5	91,312
Remainder ...	20	843,593
	35	2,166,055

This gives a standard error of 3.9 per cent. for the experiment. The differences shown for the effects of manuring are between one and two times the standard error. Thus, although every treatment appears to show an increase, the level of significance is low.

Since this record is one of a series, and will, therefore, receive further light from later developments, it is not proposed at present to examine this set of measurements more exhaustively.