STUDIES ON BIENNIAL BEARING TENDENCY IN COCONUT

2. A MINIMUM PLOT SIZE FOR COCONUT

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In the previous issue of this series (Abeywardena '62) wherein the author made a quantitative assessment of bienniality in coconut, it was shown that the biennial rhythm is a significant feature in coconut yields, although the intensity of biennial fluctuations is not of such a magnitude as to arouse much concern in commercial circles. However it was feared that this tendency might still give rise to difficulties in the statistical evaluation of experimental data in coconut and a further examination of the data was suggested with a view to verify these biometrical implications.

In a coconut plantation, during any particular year, there are some trees in the "on" phase of bienniality and some in the "off" phase—the expected value of the ratio of "on" to "off" phase palms being fifty fifty, provided there is no spurious reversal of phase due to the weather (Abeywardena '62). In the subsequent year, the trees change their phase as a result of bienniality. The palms which were in the "on" phase in the previous year get into the "off" phase and palms which were in the "off" phase get into the "on" phase. As a result of this change of phase, a comparison of individual tree yields *vis-a-vis* some treatment effect, becomes awkward and of doubtful value.

To take a simple case, suppose there are two palms A and B in opposite phases of bienniality and giving almost identical yields in alternate years (Fig. 1).

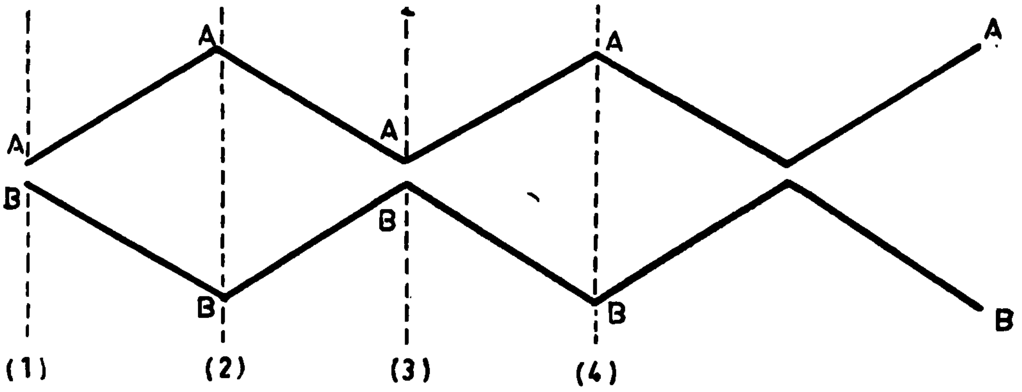

Fig. 1 Yields of 2 palms (A & B) in opposite phases of bienniality

Suppose an experiment is conducted on these two trees in a certain year (i.e. position (1)), when the trees give almost identical yields. A is given a certain dummy treatment and B left as a control. But the fact that the treatment given to A is a dummy is kept a secret from us by the experimenter. Their yields are noted in the subsequent year (i.e. position (2)), and we proceed to understand the effect of the treatment given to A, on the basis of the relative yields in position (2). If one interprets the treatment effect unconscious of the biennial rhythm, the conclusion would-be that the treatment given to A has a very beneficial effect. Alternatively the experiment may have started in the subsequent year i.e. the treatment would have been applied in position (2), when the tree A gave a higher yield than the tree B; and the treatment effect is judged by the relative yields in position (3). What is our interpretation on this latter experiment? It would be argued that palm A, which was the superior palm prior to the application of the treatment, has shown a depression, while control palm B, the inferior one, has shown an upward trend. Therefore if we dēbit A for the upward trend of the control B, which is quite the legitimate thing to do, there is an *a priori* argument for the conclusion that the treatment given to A is highly depressing. But the experimenter is aware that the treatment was a dummy and therefore would challenge the interpretations in both instances. The palms have merely changed their phase due to bienniality and any difference shown in subsequent yields is due purely to the biennial rhythm.

This is a statement of the problem in its simplest and most obvious form and meant only to indicate the biometrical issue arising out of bienniality. However so far as this Institute is concerned, such difficulties in the interpretation of data were not experienced, because the plot size in our experiments, consequent to the recommendation by Pieris and Salgado (1937), has not been below 16 palms. Of course when they proposed 16-18 palm plots for coconut experiments, they were guided by the one objective of securing a reasonably low *error*, and the prospect of eliminating biennial tendencies was probably furthest from their minds. But, incidental to their decision to have large plots, we have been free from the disturbing effects of bienniality—a situation which is simple to understand. In a coconut plantation, the "on" and "off" phase palms are randomly distributed in the field (Abeywardena unpublished). Therefore when mean (or total) yields of clusters of palms are involved, the biennial effect must necessarily even out to some extent or other—the more so as the plot size increases. Accordingly a solution for any biometrical issues arising from bienniality is readily available in the use of large—sized plots.

But in the case of plantation crops, economic considerations weigh heavily against the use of large-sized plots. The tendency, in fact, now-a-days is to discredit the once popular concept of an optimum plot size based on "uniformity trials" (Pearce 1953), and to recommend relatively smaller plots supported by increased replication and/or calibration (Pankajakshan 1958, Pearce 1953 and Jones 1962). But this alternative of smaller plots, whatever its merits and demerits from the point of view of improving the "precision" of the experiment, does not, at any rate, offer relief from disturbances arising from the biennial rhythm. Therefore, for crops which show a biennial rhythm, we are obliged to re-entertain the idea of a minimum plot size. This will be the minimum plot size which will ensure the near elimination or at least a reasonable control of the vitiating effects of bienniality.

In this paper, it is proposed to examine to what extent the biennial rhythm ceases to assert itself as the plot size is increased, and what could be considered a reasonable plot size for coconut *vis-a-vis* bienniality.

MATERIAL AND METHODS

The same data as were used in Part 1 of this series, have been used in this study—namely the individual palm nut records of a block of 300 palms maintained under a uniform system of management by the Botanist's Division of the Coconut Research Institute of Ceylon.

The index of bienniality employed in this study is the one suggested in "alternative method II" of the previous paper of this series. The relevant extract regarding this index is reproduced below so as to make this paper independent of any reference to the previous paper.

"The individual tree yields are ranked in either descending or ascending order, but in the same order, for all the years. Whatever effect the weather has on a particular years' crops, will necessarily operate in the same direction on all the palms, though not necessarily to the same extent due to a possible interaction between the yield capacity of a palm and its responsiveness to a particular stimulus. This latter interaction, if present, is only slight and may be ignored. Therefore if a biennial rhythm is present, one can expect the ranks to agree more in alternate years than in adjacent years because a tree that is in the "on" phase in a particular year will be in the "off" phase in the adjacent year and in the "on" phase in the subsequent year. If then we calculate the rank correlation coefficients (Spearman's) for every pair of adjacent years and every pair of alternate years, the coefficients for the alternate years should generally be higher than those for the adjacent years".

"Suppose there are m such coefficients (x_1, x_2 . . . . . .x_m) for alternate years and n coefficients (y_1, y_2 . . . . . . y_n) for adjacent years. These coefficients are combined into a single ordered series and ranked from 1 (the lowest) to m + n (the highest). For reasonably high values of m and n (as in this particular case where $m = 17$ and $n = 18$), T, the rank sum of x's may be assumed to be distributed normally with expectation $= m(n + n + 1)/2$ and variance $= mn(m + n + 1)/12$ (Sibuya 1961)".

This rank sum T can be used as a sensitive index of bienniality because it increases when bienniality is high and decreases when low—the maximum value (T_{max}) for complete bienniality being given by $m(m + 2n + 1)/2$ and the expected value for absence of bienniality being given by $\mu = m(m + n + 1)/2$.

Accordingly, in order to estimate a minimum plot size which will reasonably eliminate complications due to bienniality, the palms are grouped into clusters or plots of varying sizes ranging from (say) 1 to 16 palms. The biennial index T is calculated on the plots as units for each of these varying plot sizes, in the same manner as was done earlier for individual palms as units. Having obtained the T values, one could examine the T values plotted against plot size (or obtain mathematically a functional relationship between T and plot size) with a view to determine the minimum plot size which will ensure a reasonal reduction of disturbances caused by bienniality.

RESULTS

The biennial index (T value) calculated on the lines indicated above for varying plot sizes are given in Table 1. Odd numbers are avoided as, in practice, plots do not have odd number of plants.

TABLE 1

T values for varying plot sizes

Size of Plot (No. of palms)	*T—value*
1	405
2	375
4	364
6	359
8	351
10	335
12	346
14	335
16	350

A histogram showing the dimensions of the T value at different plot sizes is given in Figure 2 and a curve has been superimposed to show the probable relationship. The size of plot is not a continuous variable because it cannot refer to a plot size of (say) 4·6 palms. Therefore one cannot, strictly speaking, depict the relationship between T value and plot size by means of a continuous curve. This has been done here merely to indicate how the T value decreases with increasing plot size.

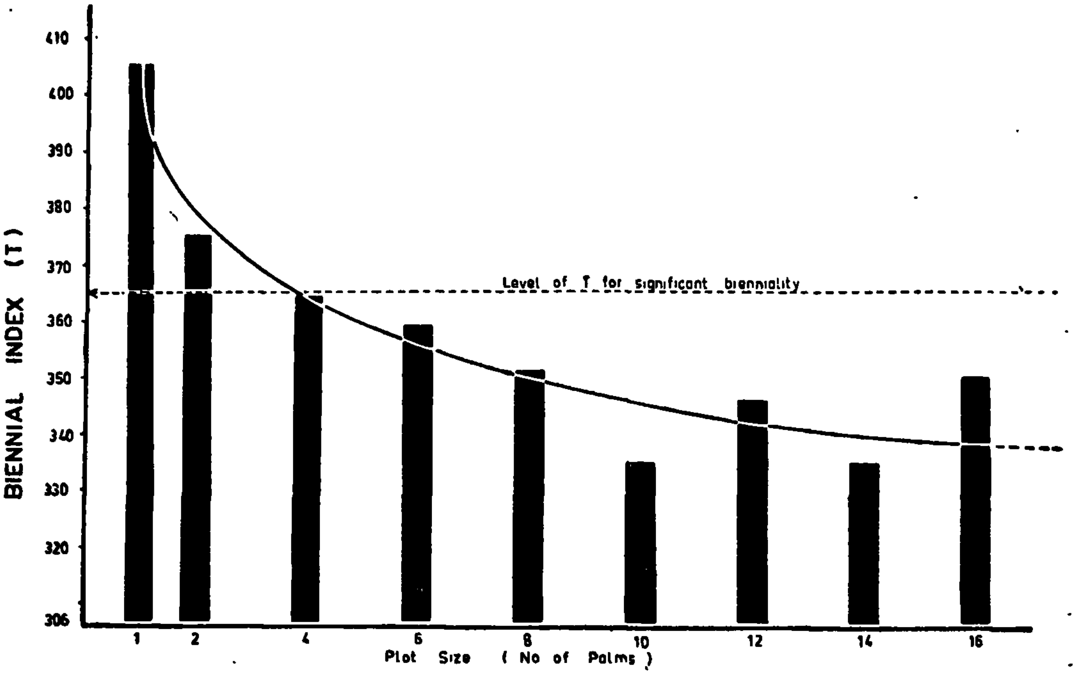

Fig 2. BIENNIALITY Vs. PLOT SIZE

The significant features indicated by this curve are:

(1) The bienniality reduces as the plot size is increased but after the plot size exceeds 8-10 palms, there appears to be no appreciable decreases.

(2) The plot size should be at least 4 palms if the biennial index is not to exceed the significant level and

(3) Even at the plot size of 16 palms, bienniality is not completely eliminated.

From the above it is reasonable to suggest that from the point of view of avoiding any significant bias in interpretation due to the biennial rhythm, the plot size for field experimentation on coconut should not be below 6 palms.

DISCUSSION AND SUMMARY

Plant species which are biennial in growth and cropping often present difficulties in the statistical interpretation of observations made on them; and these difficulties have been overcome usually by analysing the observations grouped over an even number of years.

In coconut however, at least so far as Ceylon is concerned, statistical analysis was done, as a rule, on single year's data, and no such difficulties were encountered. As explained earlier, this may be due to the fact that our plot size for experiments has been 16-18 palms and when the plot size is large, the biennial trend can be expected to annul itself due to the random occurrence of "on" and "off" phase palms in the field. Yet due to the fact that the current trend is to recommend smaller plot sizes for experiments—especially with regard to expensive plantation crops,—it was deemed necessary to assess the extent of bienniality at smaller plot sizes. This would enable one to ascertain how small a plot could be while still avoiding the complications of the biennial rhythm.

It may be argued that this is not quite necessary because even if there exists considerable bienniality at smaller plot sizes, one could always adopt the method of analysing an even number of years' data grouped together. But the latter method is very often not conducive to clear interpretation. In agronomic research especially, it is essential that the results of an experiment be understood against a particular environment such as (say) a certain specific range of weather conditions. Such clarifications are very often not possible if one were to combine two years' data. Therefore the use of large-sized plots (provided they are not prohibitively large) is the more reasonable approach to overcome disturbances arising from bienniality.

The present investigation suggests that 6 palms is a reasonable minimum plot size for coconut.

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