SOME NOTEWORTHY FEATURES OF THE "INITIAL FLOWERING" PATTERN IN A COCONUT PLANTATION

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INTRODUCTION

Of the more important morphological characters currently used in studies on coconut — such as height, leaf production and stem girth in the very young stages of growth; 'flowering' in the intermediate stages; and the yield of copra in the adult stages; — the character 'flowering' can be considered the most important because it is supposed to give the earliest indications of the economic performance of the adult palm. In this respect Liyanage[1] and Abeywardena have shown that the character 'flowering' is highly correlated with the yield of copra, and also suggested that early flowerers tend to be high-yielders.

In view of its importance, more attention has been directed by the author recently towards the study of the statistical distribution of this character in general and also examining the adequacy of the statistical indices used in the past for the specification of this character in experimental plots. This paper will discuss certain noteworthy features in the flowering phase of a coconut plantation as revealed by these studies.

MATERIAL FOR STUDY

The data for these studies were obtained from the flowering records of five experimental blocks of the Coconut Research Institute of Ceylon planted at different times under different soil and climatic conditions — namely: (1) Fertilizer experiment on young palms at Ratmalagara Estate planted in December 1948. (2) Fertilizer cum cover crop experiment on under-planted young palms at Letchemy Estate planted in October 1939. (3) Selection experiment at Ratmalagara Estate planted in November 1939. (4) A block consisting of seedlings from Tall × Tall artificially pollinated nuts, planted in December 1955 at the Isolated Seed Garden (a jungle clearing at Ambekelle) and (5) The plots of the replanting experiment where the old palms had been removed prior to planting — planted at Bandirippuwa Estate in May 1950.

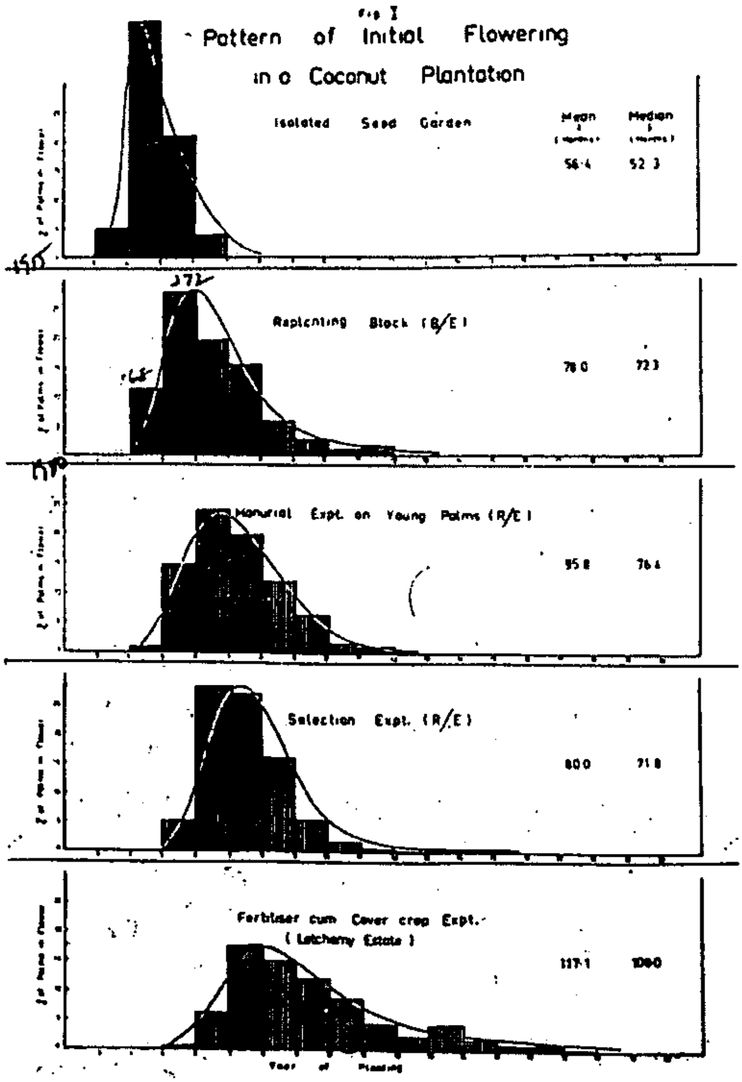
DEFINITION OF "FLOWERING"

Flowering, in this context, refers to the emergence of the first inflorescence (or flower) in a coconut palm; the flowering phase refers to that period in a plantation within which the initial flowering of all the palms in the plantation takes place; and what we mean by studying the flowering character in coconut is none other than studying its 'earliness' of flowering — the term 'earliness' being used in a relative sense.

According to this definition of flowering, an obvious measure of this character is given by the period between the date of transplanting of the seedling and the date of emergence of the first inflorescence; and this period we generally refer to as the flowering period.

THE "INITIAL FLOWERING" PATTERN OF A COCONUT PLANTATION

Fig. 1, shows the typical flowering patterns for certain new plantations and also an under-plantation.



(*a*) New plantation

The flowering phase of a new coconut plantation generally ranges from about the fifth year of planting to about the 14th year. At the commencement of the flowering phase, the rate at which palms come into flower is pretty slow; then there is a gradual quickening of this rate; and after about the 8th year there is again a lowering of the rate until about the 14th year when almost all palms in the plantation would have flowered.

(*b*) **Under-plantation**

The flowering phase of an under-plantation invariably lags behind due to competition from the old stand. In this case, flowering commences about the sixth year from planting and is not complete until about the 20th year. However the character of the flowering phase described earlier — namely, the rate of coming into flower being slow at first, then fast and then slow again applies equally well to an under-plantation.

This shows that the fundamental distribution of the character, initial flowering period, is uni-modal in form and is similar whether it be a new plantation or an under-plantation. Fig. 1, also stresses that the curves are strongly a-symmetrical.

Table I, gives the essential statistics i.e. median, mean, standard deviation and the coefficient of variation in respect of the flowering period for these coconut plantations.

TABLE I

PLANTATION		*MEAN (months)*	*MEDIAN (months)*	*S.D. (months)*	*C.V. (months)*
NEW PLANTATION	(1) SELECTION EXPERIMENT R/E				
	(*a*) Selected Palms ..	78.13	72.86	16.47	21.08
	(*b*) Unselected Palms ..	80.98	75.29	16.00	19.76
	(2) FERTILIZER EXPT.: R/E				
	(*a*) With Phosphates ..	78.78	72.61	16.41	20.83
	(*b*) Without Phosphates ..	101.67	95.00	20.81	20.47
	(3) RE-PLANTING EXPT. B/E	77.99	72.25	17.68	22.67
	(4) ISOLATED SEED GARDEN AMBEKELLE ..	56.37	52.33	7.51	13.32
UNDER-PLANTATION	(5) FERTILIZER — COVER CROP EXPERIMENT, LETCHEMY ESTATE ..	117.10	108.00	29.93	25.56

The statistics in the Table are self-explanatory. However the wide disparity between the mean and the median may be noted as indicative of the a-symmetry referred to earlier.

NON-NORMAL DISTRIBUTION OF THE FLOWERING PERIOD

Any quantitative index selected as a variable for study in respect of an experiment, has sometime or other to be subjected to the analysis of variance. Therefore the study of the statistical distribution of such a variable, must necessarily anticipate an important requirement of this method of analysis — namely, the requirement that the variable subjected to it must be distributed Normally. However, for this purpose it will not be necessary to adopt rigorous mathematical methods by way of identifying the distribution of the variable as a particular type in the Pearsonian system and thereby estimating its parameters. It will suffice if we restrict ourselves to a much simpler assessment of the distribution curve provided it will eventually lead to a suitable transformation which shall render the distribution Normal.

The shape of the cumulative curves shown in Fig. 1, suggests that the distribution of the flowering period belongs to the family of the uni-modal type of curves of which the Normal distribution is also one. Therefore by calculating the moment coefficients β_1 and β_2, we can ascertain whether this distribution is Normal, and if not Normal, to what extent and in what direction it departs from Normality. The Normal distribution has the following properties;

$$\beta_1 = 0$$
$$\beta_2 = 3$$

where $\beta_1 = \dfrac{\mu_2^3}{\mu_3^2}$ and $\beta_2 = \dfrac{\mu_4}{\mu_2^2}$: μ_2, μ_3 and μ_4 being the 2nd, 3rd and 4th central moments of the distribution.[3]

Table II, below gives the moment coefficients for the flowering period in respect of these different plantations grown at different periods of time.

TABLE II

Moment Coefficients of the Flowering Period

PLANTATION		β_1	β_2
NEW PLANTATION	(1) SELECTION EXPERIMENT: R/E		
	(*a*) Selected Palms	2.08	6.50
	(*b*) Unselected Palms	2.75	7.89
	(2) FERTILIZER EXPERIMENT: R/E		
	(*a*) With Phosphates	2.97	7.30
	(*b*) Without Phosphates	0.90	3.29
	(3) RE-PLANTING EXPERIMENT: B/E ..	0.96	3.95
	(4) ISOLATED SEED GARDEN: AMBEKELLE ..	0.83	4.26
UNDER-PLANTATION	(5) FERTILIZER — COVER CROP EXPERIMENT LETCHEMY ESTATE	1.22	3.69

The β_1 and β_2 coefficients indicate that the flowering period departs strongly from Normality. All five curves are decidedly positively skewed and sharp-peaked and this is confirmed by the highly significant t — values (Table III) obtained in tests[4] of significance for departure from Normality in respect of the coefficients shown in Table II.

TABLE III

t — Values

PLANTATION		*t — Values* β_1	β_2
NEW PLANTATION	(1) SELECTION EXPERIMENT: R/E		
	(*a*) Selected Palms	14.38**	12.07**
	(*b*) Unselected Palms	18.78**	16.66**
	(2) FERTILIZER EXPERIMENT: R/E		
	(*a*) With Phosphates	21.81**	15.82**
	(*b*) Without Phosphates	6.59**	1.05
	(3) REPLANTING EXPERIMENT: B/E ..	4.95**	2.46**
	(4) ISOLATED SEED GARDEN: AMBEKELLE ..	5.08**	3.85**
UNDER-PLANTATION	(5) FERTILIZER — COVER CROP EXPERIMENT: LETCHEMY ESTATE	10.92**	3.10**

Note:—In the selection experiment and Fertilizer experiment, the statistics have been worked out seperately for the treatments which have shown statistical significance, in order to avoid any contention that the skewness may be the result of differential treatment.

A NOTEWORTHY FEATURE IN THE COMPARATIVE PATTERN OF FLOWERING IN RESPECT OF TWO TREATMENTS (OR PLOTS) IN AN EXPERIMENTAL BLOCK

The observation that the flowering period is positively skewed applies equally well to any single treatment in an experiment. Within each treatment, the latter 50 per cent of the palms take a much longer time to complete the initial flowering than the first 50 per cent. However a curious feature is observed when we compare the cumulative flowering patterns in respect of two treatments in an experiment. It is observed that the extent of the delaying effect (or skewness) varies according to whether the flowering phase of the plot commenced early or/late.

Table IV (overleaf) gives the cumulative proportion of palms in flower in two treatments with respect to each of three independent plantations.

TABLE IV

Cumulative Proportion of Palms in Flower

(*a*) Letchemy Estate

YEAR OF PLANTING	*Cumulative % of Palms in Flower TREATMENT*	
	O	*NK*
7th (July 1946)	6.7	8.9
8th (,, 1947)	23.9	27.2
9th (,, 1948)	37.8	42.8
10th (Dec. 1949)	55.0	53.9
11th (,, 1950)	66.1	66.7
12th (,, 1951)	73.3	68.9
13th (,, 1952)	75.6	72.2
14th (,, 1953)	82.2	75.6
15th (,, 1954)	85.0	78.3
16th (,, 1955)	87.2	80.6
17th (,, 1956)	88.3	83.3
18th (,, 1957)	89.4	83.9

(*b*) Ratmalagara Estate

YEAR OF PLANTING	*Cumulative % of Palms in Flower TREATMENT*	
	N_0	N_2
5th (Dec. 1953)	0.9	3.1
6th (,, 1954)	16.0	30.6
7th (,, 1955)	43.2	57.4
8th (,, 1956)	73.8	75.9
9th (,, 1957)	87.7	84.8
10th (,, 1958)	95.4	89.2
11th (,, 1959)	96.6	91.4
12th (,, 1960)	97.5	92.3

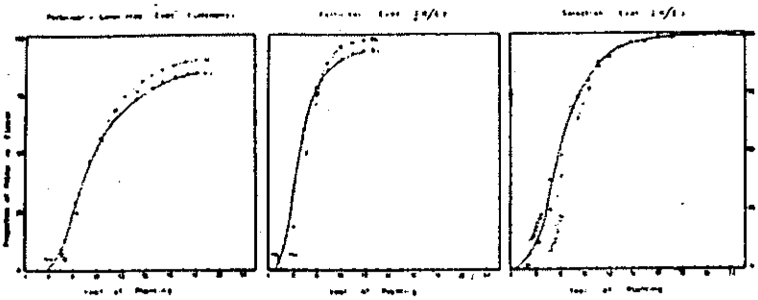
(*c*) Ratmalagara Estate

YEAR OF PLANTING	*Cumulative % of Palms in Flower TREATMENT*	
	Selected	*Unselec.*
5th (Dec. 1944)	12.9	5.0
6th (,, 1945)	43.4	34.1
7th (,, 1946)	71.7	68.1
8th (,, 1947)	89.5	87.8
9th (,, 1948)	94.8	95.3
10th (,, 1949)	97.6	97.5
11th (,, 1950)	98.6	98.2
12th (,, 1951)	99.3	98.9
13th (,, 1952)	100.0	99.0
		100.0

Fig. II, below gives the corresponding graphs.

Fig. II

Comparative Flowering Patterns



In Fig. II (*a*), we observe that in the early years, the N.K. plots are superior from the points of view of the number of palms in flower; but in the latter stages, the zero plots are obviously completing their flowering phase earlier than the NK plots. This same property of 'First shall be the last and last shall be the first' is clearly evidenced in Fig. II (*b*). In Fig. II (*c*) too, the same tendency is observed although not so clearly probably due to the fact that the initial handicap in respect of 'selected' palms is too large to be compensated fully by whatever cause that is responsible for the above feature.

This feature of experimental plots during the initial flowering phase has to be borne in mind in the statistical analysis and interpretation of data in respect of the flowering period. A certain treatment which turned out to be favourable in the early stages may show up as unfavourable during the latter stages purely by virtue of this inherent feature described above.

A MATHEMATICAL TRANSFORMATION FOR 'NORMALISING' THE DISTRIBUTION OF THE FLOWERING PERIOD

As stated earlier, it is necessary that any statistical variable should be 'normally' distributed if the analysis of variance is to be valid. Therefore the flowering period which we have found to be positively skewed has to be made to conform to the Normal distribution through some mathematical transformation. In this situation the logarithmic transformation appears to be suitable, and the adequacy of this transformation can be verified by computing the β_1 and β_2 coefficients for the transformed data.

Table V, gives the β_1 and β_2 coefficients for the untransformed data as well as the transformed data.

TABLE V

Moment Coefficients for Transformed Data

PLANTATION		β_1		β_2	
		Untransformed	*Transformed*	*Untransformed*	*Transformed*
NEW PLANTATION	(1) SELECTION EXPT.: R/E				
	(a) Selected Palms	+2.08	—0.28	6.50	3.83
	(b) Unselected Palms	+2.75	—0.15	7.89	4.37
	(2) FERTILIZER EXPT.: R/E				
	(a) With Phosphates	+2.97	+0.02	7.30	3.23
	(b) Without Phosphates ..	+0.90	—0.17	3.29	3.74
	(3) RE-PLANTING EXPT.: B/E ..	+0.96	—0.21	3.95	3.12
	(4) ISOLATED SEED GARDEN: AMBEKELLE	+0.83	—0.18	4.26	4.94
UNDER-PLANTATION	(5) FERTILIZER COVER CROP. EXPT. LETCHEMY ESTATE ..	+1.22	+0.02	3.69	2.76

It is clear that the log-transformation has brought these coefficients sufficiently close to the theoretical values (namely zero and 3 for β_1 and β_2) to warrant our acceptance of this transformation as suitable under most conditions.

However, it may be that under certain circumstances, this transformation may be too drastic, as in the case of the replanting experiment or the block at Isolated Seed Garden and a less drastic transformation such as the 'square root' may be suitable. But such perfect 'normalising' is not called for because we are really dealing with means or totals of plots of 16 – 18 palms and therefore any slight 'A-normality' that may still remain after the log — transformation gets corrected — a fact that has been established in Statistical Theory in respect of sampling distribution of parameters.

DISCUSSION

The tendency on the part of the flowering period to be positively skewed seems to be a universal feature in coconut. Five plantations grown in different environments have shown the same pattern. Further the fact that the initial flowering phases of these plantations covered different periods of time reasonably excludes a possible explanation that this feature is the result of a coincident weather pattern — for instance a situation such as favourable weather during the first half of the flowering phase followed by unfavourable weather during the latter half.

The skewness may be explained through a generally accepted phenomenon in plant communities. The skewness indicates that the palms that flowered during the latter half of the phase have taken relatively too long a time to be explained out through the 'Normal curve of errors'. These palms invariably have had to put up with certain inhibitory factors which the early flowerers were relatively free from. But what could be these inhibitory factors that operate half-way in the flowering phase?

A coconut plantation constitutes a plant community living on a limited quantum of nutrients and soil moisture — a 'closed economy', as it were, with a 'free for all' distribution system. In such a system, one can conceive of the younger palms (namely those which are yet to flower) suffering through competition from the bearing palms whose demands are necessarily much higher — the latter being the palms that flowered in the first half of the flowering phase.

It may also be that whatever attention the plantation received from time to time by way of fertilizers, have not been sufficient to compensate for the depletion of nutrients brought about by the growing plantation in the early stages. With the result that the palms that remain to flower in the second half, according to the natural order of events, may be at a disadvantage in having to depend on a relatively depleted environment for their nourishment.

The earlier explanation for skewness through 'competition from the relatively more exacting bearing palms', helps also to explain the second feature of the flowering phase that the plots which commence the flowering phase early finish it late. Here again it may be suggested that, at a particular point of time, the plot which commences the flowering phase early has, relatively more bearing palms to compete with the palms yet to flower as compared with a plot which commences the flowering phase later; and consequently the palms which are yet to flower in the former plot faces stiffer competition as compared with the palms yet to flower in respect of the latter plot, where fewer bearing palms are offering competition — hence the curious feature noted in the comparative patterns of initial flowering in respect of two treatments.

Due to these reasons, one feels reasonably justified in accepting that the positive skewness in the statistical distribution of the flowering period is an inherent feature of the flowering phase of a coconut plantation grown under sub-optimum conditions; and also that at least one of the causes may be 'competition'.

SUMMARY

(i) Due to the importance of the flowering character in studies on coconut, the need for a more rigorous specification of its statistical distribution is being stressed.

(ii) The flowering patterns of some new plantations and an under-plantation are described. The flowering phase of the under-plantation lags behind due to competition from the old stand of palms.

(iii) The positive skewness in the distribution of the flowering period is shown as an inherent feature in a coconut plantation grown under sub-optimum conditions. It is suggested that this tendency on the part of the late flowerers to be unduly late is the result of competition from early flowerers and probably also due to the depletion of nutrients in the early stages.

(iv) It is shown that an experimental plot which commences the flowering phase early will complete the phase later. It is suggested that this feature too is the result of competition of a relative nature. This has to be borne in mind in the interpretation of flowering data.

(v) The flowering period is shown to follow the Log-Normal distribution approximately. Therefore it is recommended that data in respect of the flowering period be transformed to logarithms prior to analysis of variance.

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