BIENNIAL TENDENCY AMONG COCONUT HYBRIDS- A STATISTICAL STUDY

By
LATHY K S

THESIS
submitted in partial fulfilment of the requirements
for the degree
MASTER OF SCIENCE IN AGRICULTURAL STATISTICS
Faculty of Agriculture
Kerala Agricultural University

Department of Statistics
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
Mannuthy Trichur

1989

DECLARATION

I hereby declare that this thesis entitled "BIENNIAL TENDENCY AMONG COCONUT HYBRIDS - A STATISTICAL STUDY" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Lathy K S

Manmuthy,
4 - 2 -1989.

LATHY, K.S.

CERTIFICATE

Certified that this thesis, entitled "BIENNIAL TENDENCY AMONG COCONUT HYBRIDS - A STATISTICAL STUDY" is a record of research work done independently by Kumari LATHY, K.S. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Saraswathi

Dr. (Mrs.) P. Saraswathi,
(Chairman, Advisory Board),
Associate Professor of
Agricultural Statistics,
(NARP-SR)
College of Agriculture,
Vellayani, Trivandrum.

Vellayani,
4-2-1989.

APPROVED BY:

Chairman:

Dr. (Mrs.) P. Saraswathi

Members:

Sri. R. Balakrishnan Asan

Sri. O. Abdul Rehman Kunju

Sri. K.P. Madhavan Nair

ACKNOWLEDGEMENTS

I wish to express my deep sense of gratitude and indebtedness to my guide and Chairman Dr. (Mrs.) P.Saraswathi, Associate Professor of Agricultural Statistics, College of Agriculture, Vellayani, for suggesting the research problem, expert guidance, continued support and constant encouragement rendered throughout the course of the research work and preparation of the thesis.

I owe my deep sense of gratitude to the members of my advisory Committee Dr. K.C. George, Professor of Statistics, Mr. K.L. Sunny, Assistant Professor, College of Veterinary and Animal Sciences, Mannuthy and Dr. V. Muraleedharan Nair, Professor of Agronomy for critically going through the entire manuscript and suggesting modifications.

I have great pleasure in recording my gratitude to my teachers.

I am grateful to Dr. K.P. Rajaram, Associate Director, RARS, Pilicode; Dr. R.R. Nair, Associate Director, RARS, Kumarakom; Prof. K. Sivasankara Pillai, CRS, Balaramapuram and Sri. S. Janardhanan Pillai, Associate Professor, Instructional Farm, Vellayani for providing me the necessary data required for the study.

My heartful thanks are also due to my friends for their help at all stages of the work. I am deeply indebted to my family members for their constant encouragement during the course of the study.

Grateful acknowledgement is made to the Kerala Agricultural University for the fellowship awarded to me during the course of study.

LATHI, K.S.

CONTENTS

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

CHAPTER IV

INTRODUCTION

CHAPTER-I

INTRODUCTION

Coconut palm is one of the most useful plants in the world. India is the third largest coconut producing country. 15 per cent of the area under coconut and 20 per cent of the production of coconut in the world is contributed by India. But the percapita availability of coconut in India is low, being 11 nuts per year. Coconut development in India has only a history of less than a century. The cultivation of coconut is confined only to the coastal areas of the country. 65 per cent of the total area under coconut in India is confined to the State of Kerala which accounts only 1.18 per cent of the total geographical area of India.

Biennial tendency is a common characteristic of coconut palm though it is not so high as in other fruit crops like apple, mango etc. The extent of bienniality in coconut was reported by many workers through some non-parametric approaches. It is always better to apply some parametric approach to test the significance of biennia-lity. A knowledge of the magnitude of bienniality in hybrid varieties of coconut will be helpful to design experiments on them using calibration techniques and also in analysing several years' yield data. It is a practice

to analyse even years' data suspecting biennielity. If the magnitude of biennial tendency is negligible the results based on individual years' data seems valid. A comparison of the magnitude of biennial tendency established through appropriate statistical tests will establish the severity of this tendency in west coast tall (WCT) as related to hybrid varieties of coconut. So the present study is aimed at the following objectives.

1. To measure the extent of biennielity among different hybrids and west coast tall.

2. To measure the intensity of crop fluctuations from year to year.

3. To test the significance of biennial tendency.

4. To study the influence of time trend.

5. To test the significance of time trend.

6. To examine the influence of treatments on biennial tendency.

REVIEW OF LITERATURE

CHAPTER-II

REVIEW OF LITERATURE

Perennial plants and fruit trees are in general far different from other crops. One special problem that needs attention in perennial species is that of their biennial or alternate fruit bearing tendency. One year the tree yields heavily, the next year the yield will be less, in a third year it returns to heavy yield and so on. According to Pearce (1953) most perennials are to some extent biennial in bearing and growth. Singh (1948) observed that trees which have acquired this biennial rhythm will carry a heavy crop in one year, called the 'on' year and very low or no crop in the next, called the 'off' year. This characteristic of high and low yields in the 'on' and 'off' years persist with great regularity. Sometimes it may be upset by some major climatic factor (Thampan, P.K., 1982; Anon., 1988).

The biennial tendency is extensively reported to be a common feature of fruit trees in both tropical and sub-tropical regions (Singh, 1948).

It was Hoblyn et al. (1936) who first devised a method to measure the biennial fruit bearing tendency in orchard crops. They proposed two factors 'B' and 'I' to

measure the extent of bienniality and the intensity of crop fluctuations from year to year.

Haldane (1958) commented on repeated biennial tendency. He felt that it is important to know if this is a sharply defined character, how it is inherited and whether it can be overcome by the use of fertilizers.

Shrikande (1957) and Pankajakshan (1960) have mentioned about the biennial tendency in coconut.

Singh (1961 a) studied the biennial bearing in mango and concluded that biennial habit of mango cannot be prevented neither by resorting to manuring, irrigation, pruning and control of pest, nor it is affected by vigour of varieties or the major climatic factor, rainfall and temperatures.

Singh (1961 b) observed that biennial bearing is governed by the timely production of new vegetative shoots in his studies on mango.

Abeywardena (1962) observed that 38.5 per cent of the coconut palms have significant biennial bearing tendency.

Satyabalan et al. (1968) studied the biennial bearing tendency of coconut through correlation studies and

found that the incidence of bienniality is high among poor yielders (giving less than 40 nuts per annum) and the percentage of such biennial bearers ranged from 73 to 93. This percentage was observed to be 17 to 40 among high yielders (giving over 80 nuts per tree per annum) and 39 to 57 among medium yielders (giving 40 to 86 nuts per tree per annum).

Webster (1939) has reported 40 per cent bienniality in oil palms, a species closely associated with coconut.

Abeywardena (1962) modified Hoblyn's method to estimate biennial tendency. He thought that the method given by Hoblyn (1936) was not adequate for perennial crops like coconut, which is highly influenced by weather factors. So he modified their method after adjusting for the effect of rainfall. He observed from his study that though biennial bearing tendency was a significant feature in coconut, the intensity of crop fluctuations was very low and hence of least concern in economic and commercial circles.

Coconut is a crop which is highly influenced by rainfall. The effect of rainfall on coconut has been investigated by Abeywardena (1966, 1968 and 1979). The crop will increase as the effective rainfall increases with the reservation that as one gets up to higher

rainfalls, the law of diminishing returns will operate. Abeywardena (1968) tried to forecast coconut yield using rainfall data. Crops in a locality can fluctuate with a wide range of as much as 40 per cent of the mean yield purely as a result of the fluctuations in the incidence of rainfall (Abeywardena, 1979).

Northwood (1967) has established correlation studies to estimate the biennial bearing tendency in cashew. The low correlation coefficient between years suggest a tendency towards alternate bearing.

Pearce and Urbanc (1967) considered various methods for the measurement of irregular and biennial phenomena in apple trees.

Marchetti, S. and Ughini, V. (1984) used a modified succession test in the evaluation of the degree of varietal susceptibility to alternate bearing in apple (Malus domestica). They used a mathematical method. It is based on a χ^2 technique, using a decrease in yield in the low bearing as against high bearing year arbitrarily fixed at 25 per cent as the threshold value in determing the expected value. Application of the method to 98 cultivars of 4 different types showed that it gave rapid and clear indication of individual varietal tendencies.

Pal et al. (1984) applied numerous treatments on mango to induce regular bearing. Although none of the treatments gave marked improvement, ethephon at 200 ppm + 0.1 per cent urea in one trial or at 400 ppm + 1 per cent urea in another trial, applied 5 times at 30 day (first trial) or 15 day intervals (second trial) gave the best results by inducing bearing in the 'off' years.

Das and Sahoo (1981) examined the effect of gibberellic acid (GA_3) and urea on the 'off' year shoots in Lanrga mango. GA_3 at 50 ppm + urea at 1 per cent, applied to trees in the 'on' year stimulated vegetative shoot growth, and increased the number of leaves and their area. These effects were considered promising for inducing fruit development in the following ('off') year.

Saraswathi (1983) has defined orthogonal contrasts to test the significance of biennial tendency and time-trend. Based on these contrasts she has derived appropriate tests of significance to detect bienniality and time-trend in coconut. The study established the fact that biennniality is a significant feature of coconut palms. The presence of biennniality was also tested by a non-parametric approach. This method also revealed the effect of biennniality but over estimated its presence. For the experimental data she has got 53 per cent of the

WCT palms as significantly biennial in bearing in the pre-experimental period, 52.5 per cent in the experimental period and 23.2 per cent in the post-experimental period.

The 'I' factor was found to be less than 30 per cent for 72 per cent of the palms in the pre-experimental period. Both in the experimental and post-experimental periods, the 'I' factor percentage has reduced to 20 per cent. During these periods 72 per cent of the palms showed an 'I' factor less than 20 per cent. This indicated the possibility of treatment effects in reducing the biennia-lity.

The tests of significance showed that biennial tendency was present during the pre-experimental and experimental periods and was absent during the post-experimental period. Biennial tendency was predominant at various levels of N and K and at higher levels of P. At 0.25 kg (per palm per year) level of P presence of bienniality has been established. Application of magne-sium at 0.5 kg per palm per year was also found to increase the biennial tendency.

MATERIALS AND METHODS

CHAPTER-III

MATERIALS AND METHODS

3.1. MATERIALS

The data utilised for this study were taken from Regional Agricultural Research Station, Pilicode; Regional Agricultural Research Station, Kumarakom; Coconut Research Station, Balaramapuram and Agricultural Instructional Farm, Vellayani in Kerala. Individual palm yields of different hybrids and West Coast Tall varieties of coconut were collected. The details about the data used for this study are given in the following Tables from 3.1.1 to 3.1.4.

3.2. METHODOLOGY

The biennial or alternate bearing tendency of perennials necessitates special considerations in their design and analysis. Coconut palm being a perennial exhibits biennial tendency. A knowledge of the magnitude of biennial tendency will be of much help in planning experiments with them.

Coconut palm which have acquired biennial rhythm will produce good yield in one year, called the 'on' year and poor yield in the alternate year, called the 'off' year. A rough idea of bienniality can be obtained from a

Table 3.1.1. Varietal distribution of palms

Regional Agricultural Research Station (RARS), Pilicode

Sl. No.	Variety	No. of palms	Period of availability of the data
1.	West Coast Tall (WCT)	169	1969 - 1984
2.	West Coast Tall x Chawghat Green Dwarf (WCT x CDG)	83	do.
3.	West Coast Tall x Ganga bondam (WCT x GB)	17	do.
4.	Natural Cross Dwarf (NCD)	10	do.
5.	Andaman Ordinary x Ganga bondam (AO x GB)	5	do.
6.	Laccadive Ordinary x Ganga bondam (LO x GB)	5	do.
7.	Laccadive Small x Ganga bondam (LS x GB)	5	do.
8.	Cochin China x Ganga bondam (CC x GB)	5	do.
9.	Java x Ganga bondam (Java x GB)	6	do.

Table 3.1.2. Varietal distribution of palms

Regional Agricultural Research Station (RARS), Kumarakom

Sl. No.	Variety	No. of palms	Period of availability of the data
1.	West Coast Tall (WCT)	243	1976-1987
2.	West Coast Tall x Andaman Dwarf (T x AD)	7	do.
3.	West Coast Tall x Laccadive Dwarf (T x LD)	7	do.
4.	West Coast Tall x Gangabondam (T x G)	7	do.
5.	West Coast Tall x Straight Settlement (T x SS)	9	do.

Table 3.1.3. Varietal distribution of palms

Coconut Research Station (CRS), Balaramapuram

Sl. No.	Variety	No. of palms	Period of availability of the data
1.	West Coast Tall (WCT)	198	1976-1987
2.	West Coast Tall x Orange Dwarf (T x D)	23	do.
3.	West Coast Tall x Gangabondam (T x GB)	18	do.
4.	West Coast Tall (Experimental palms)	109	do.

Table 3.1.4. Distribution of palms

Instructional Farm, College of Agriculture, Vellayani.

Sl. No.	Variety	No. of palms	Period of availability of the data
1.	Komadan	40	1981-1984

group of palms by plotting the average annual yield per palm against the years. If the palm exhibit biennial tendency the trend line will show 'peaks' and 'troughs' in alternate years. This characteristic is also affected by rainfall to a certain extent.

3.2.1. Non-parametric approach

The biennial effect can be examined by a non-parametric approach. Saraswathi (1983) has developed a method which requires a minimum of four years' yield data. If the yield in the second year exceeds the first year then a '+' sign is given, otherwise a '-' sign. In a four year period either a pair of '++' sign or '--' sign indicates the biennial habit of that palm. A pair of unlike signs '+-' or '-+' indicates the absence of bienniality during the period. If the yield data are available for n years, n being even, the magnitude of biennial tendency can be measured by a factor known as 'B' factor which measures the proportion of like signs in consecutive pairs (Saraswathi, 1983). With 'zn' years there will be 'n' like or unlike signs in n pairs of consecutive years. The probability of getting 0,1,2, ..., n like signs is given by the binomial distribution.

$$P_n(x) = {}^{n}C_x p^x q^{n-x}, \quad x = 0,1, \ldots\ldots, n$$

where p is the probability of getting x like signs in n pairs of consecutive years and q = 1-p. On the basis of an equiprobable hypothesis, the probability of like signs in any pair is $\frac{1}{2}$ if a group of palms are considered. Here $p = q = \frac{1}{2}$. The significant departure from the equiprobable hypothesis is tested by applying χ^2 - test of significance given by

$$\chi^2_{N-1} = (p - p^1)^2 / \frac{pq}{N}, \quad \text{where}$$

N is the sample size and $p^1 = P(X \geq x)$, is the observed proportion of palms showing like signs for x and above.

A second factor 'I' is used to measure the intensity of crop fluctuations from year to year (Saraswathi, 1983). This factor is defined as the ratio of the difference between successive yields to the sum of pair of successive yields. The value of 'I' ranges from 0 to 1 (or 0 to 100 per cent). Zero denotes equal crops in successive years and one (or 100 per cent) no crop at all in 'off' years.

3.2.2. Parametric approach

Tests of significance of biennial tendency are derived on the basis of several orthogonal contrasts (Saraswathi, 1983). Those contrasts involved terms of

biennial effect and time trend apart from random error component. If Y_{i1}, Y_{i2}, Y_{i3} and Y_{i4} are the yields of i^{th} palm in the first, second, third and fourth years respectively.

$$Y_{i1} = Y_i - \tfrac{3}{2}\lambda - \tfrac{1}{2}\delta + e_{i1}$$

$$Y_{i2} = Y_i - \tfrac{1}{2}\lambda + \tfrac{1}{2}\delta + e_{i2}$$

$$Y_{i3} = Y_i + \tfrac{1}{2}\lambda - \tfrac{1}{2}\delta + e_{i3}$$

$$Y_{i4} = Y_i + \tfrac{3}{2}\lambda + \tfrac{1}{2}\delta + e_{i4}$$

where Y_i is the expected yield of i-th palm, λ is the time trend effect, $|\delta|$ is the difference between the 'on' and 'off' year effect and e_{ij} is a random variable which is normally and independently distributed with expectation zero and variance σe^2. The contrasts were defined as

$$X_{i1} = \frac{1}{\sqrt{4}} (Y_{i1} - Y_{i2} - Y_{i3} + Y_{i4})$$

$$X_{i2} = \frac{1}{\sqrt{20}} (-Y_{i1} + 3\,Y_{i2} - 3\,Y_{i3} + Y_{i4})$$

$$X_{i3} = \frac{1}{\sqrt{20}} (-3\,Y_{i1} - Y_{i2} + Y_{i3} + 3\,Y_{i4})$$

$$X_{i4} = \frac{1}{\sqrt{4}} (-Y_{i1} - Y_{i2} + Y_{i3} + Y_{i4})$$

$$X_{i5} = \frac{1}{\sqrt{4}} (-Y_{i1} + Y_{i2} - Y_{i3} + Y_{i4})$$

The contrasts X_{11}, X_{12} and X_{13} are mutually orthogonal. X_{14} and X_{15} are not orthogonal to either X_{12} and X_{13}. The contrast X_{13} is orthogonal to Y_{11} and X_{12} but not orthogonal to X_{14} and X_{15}. Substituting the values of Y_{11}, Y_{12}, Y_{13} and Y_{14}

$$X_{11} = \frac{1}{\sqrt{4}} (e_{11} - e_{12} - e_{13} + e_{14})$$

$$X_{12} = \frac{1}{\sqrt{20}} (4\delta - e_{11} + 3 e_{12} - 3 e_{13} + e_{14})$$

$$X_{13} = \frac{1}{\sqrt{20}} (10\lambda + 2\delta - 3 e_{11} - e_{12} + e_{13} + 3 e_{14})$$

$$X_{14} = \frac{1}{\sqrt{4}} (4\lambda - e_{11} - e_{12} + e_{13} + e_{14})$$

$$X_{15} = \frac{1}{\sqrt{4}} (2\lambda + 2\delta - e_{11} + e_{12} - e_{13} + e_{14})$$

The contrast X_{11} is independent of both time trend and biennial effect but subject to random error component. X_{12} is influenced by biennial effect but free from time trend; X_{14} is affected by time trend but free from biennial effect; X_{13} and X_{15} are influenced by both time trend and biennial effect. Biennial effect will be positive or negative depending upon the year of starting being 'off' or 'on' year.

3.2.2.1. Test of significance of biennial tendency

The contrasts X_{11} and X_{12} are orthogonal.

$E\left(\frac{1}{n}\sum_{i} X_{11}\right) = 0$ and $E\left(\frac{1}{n}\sum_{i} X_{12}\right) = \frac{4}{20}\delta$

The expectation of $\frac{1}{n}\sum_{1}^{n} X_{12}^2$ involves biennial effect and random error component and free from time-trend effect. To test the significance of biennial tendency, the null hypothesis can be stated as,

$$H_0: \delta = 0$$

and the alternate hypothesis

$$H_1: \delta \neq 0$$

The ratio given by

$$F_1(n,n) = \frac{\sum_{1}^{n} X_{12}^2 / n}{\sum_{1}^{n} X_{11}^2 / n}$$

is distributed as the conventional F with $n_1 = n$ and $n_2 = n$ degrees of freedom. This provides a test of significance of biennial effect when the time-trend effect is absent.

3.2.2. Test of significance of time-trend effect in presence of biennial effect

The contrast X_{13} is orthogonal to X_{11} and X_{12}. X_{13} is affected both by time-trend effect λ and biennial effect δ. By considering X_{11}, X_{12} and X_{13} a test of λ involving δ can be derived. The null hypothesis for this can be stated as

$$H_0: \lambda = 0$$

and the alternate hypothesis

$$H_1: \lambda \neq 0$$

The ratio given by

$$F_2\,(n,2n) = \frac{(\sum_1 X_{13}^2)/\,n}{(\sum_1 X_{12}^2 + \frac{3}{2}\sum_1 X_{11}^2)/2n}$$

is distributed as F with $n_1 = n$ and $n_2 = 2n$ degrees of freedom. This provides the test of significance of time-trend ' λ ' in presence of biennial effect ' δ '.

3.2.2.3. Test of significance of time-trend in the absence of biennial tendency

The contrasts X_{14} and X_{15} are orthogonal to X_{11} but not orthogonal to X_{12} and X_{13}. A test of significance of time-trend effect ' λ ' independent of the biennial effect can be derived by using the contrast X_{14}. The null hypothesis for this can be stated as

$$H_0: \lambda = 0$$

and the alternative hypothesis

$$H_1: \lambda \neq 0$$

The ratio given by

$$F_3\,(n,n) = \frac{(\sum_1 X_{14}^2)\,/\,n}{(\sum_1 X_{11}^2)\,/\,n}$$

is distributed as conventional F with $n_1 = n$ and $n_2 = n$

degrees of freedom and provides a test of significance of time-trend independent of the biennial effect.

3.2.2.4. Test of biennial tendency in presence of time-trend

The contrasts X_{15} is orthogonal to contrasts X_{11} and X_{14} and involves both λ and δ. A test of biennial tendency ' δ ' in presence of time-trend ' λ ' can be derived by considering the contrasts X_{15}, X_{11} and X_{14}. The null hypothesis

$$H_0: \delta = 0$$

against the alternative hypothesis

$$H_1: \delta \neq 0$$

The ratio $F_4\ (n, 2n) = \dfrac{(\sum_1 X_{15}^2)\ /n}{(\frac{3}{2} \sum_1 X_{14}^2 + \frac{3}{2} \sum_1 X_{11}^2)\ /\ 2n}$

follows a F - distribution with $n_1 = n$ and $n_2 = 2n$ degrees of freedom. This ratio can be used to test the significance of biennial tendency ' δ ' in presence of time-trend ' λ '.

The above tests developed by Saraswathi (1983) were utilised to test for the significance of biennial tendency and time-trend.

RESULTS AND DISCUSSION

CHAPTER-IV

RESULTS AND DISCUSSION

The magnitudes of biennial tendency and time-trend were estimated and tested by the methods described in Chapter III and the results are presented in Section 4.1 to 4.5.

4.1. Yield data from RARS, Pilicode

The data used for the study refers to 169 palms of WCT, 83 palms of WCT x CDG, 5 palms each of AO x GB, LO x GB, LS x GB and CC x GB, 17 palms of WCT x GB, 10 palms of NCD and 6 palms of Java x GB. A visual idea of the biennial habit of the coconut palm may be observed from an examination of the trends of the annual yields over years (vide Fig. 4.1). If the trend shows an increase and decrease in behaviour alternatively over years then this is a clear evidence of bienniality over time. As such biennial tendency exists among these palms, though the magnitude of tendency differ among the various varieties. The fluctuations in yield over years are also subjected to rainfall. Coconut is a palm which is highly influenced by rainfall. The annual rainfall (in mm) and the average yield per palm (in nuts) from 1969 to 1994 are given in Table 4.1.1. The average yield of WCT palms

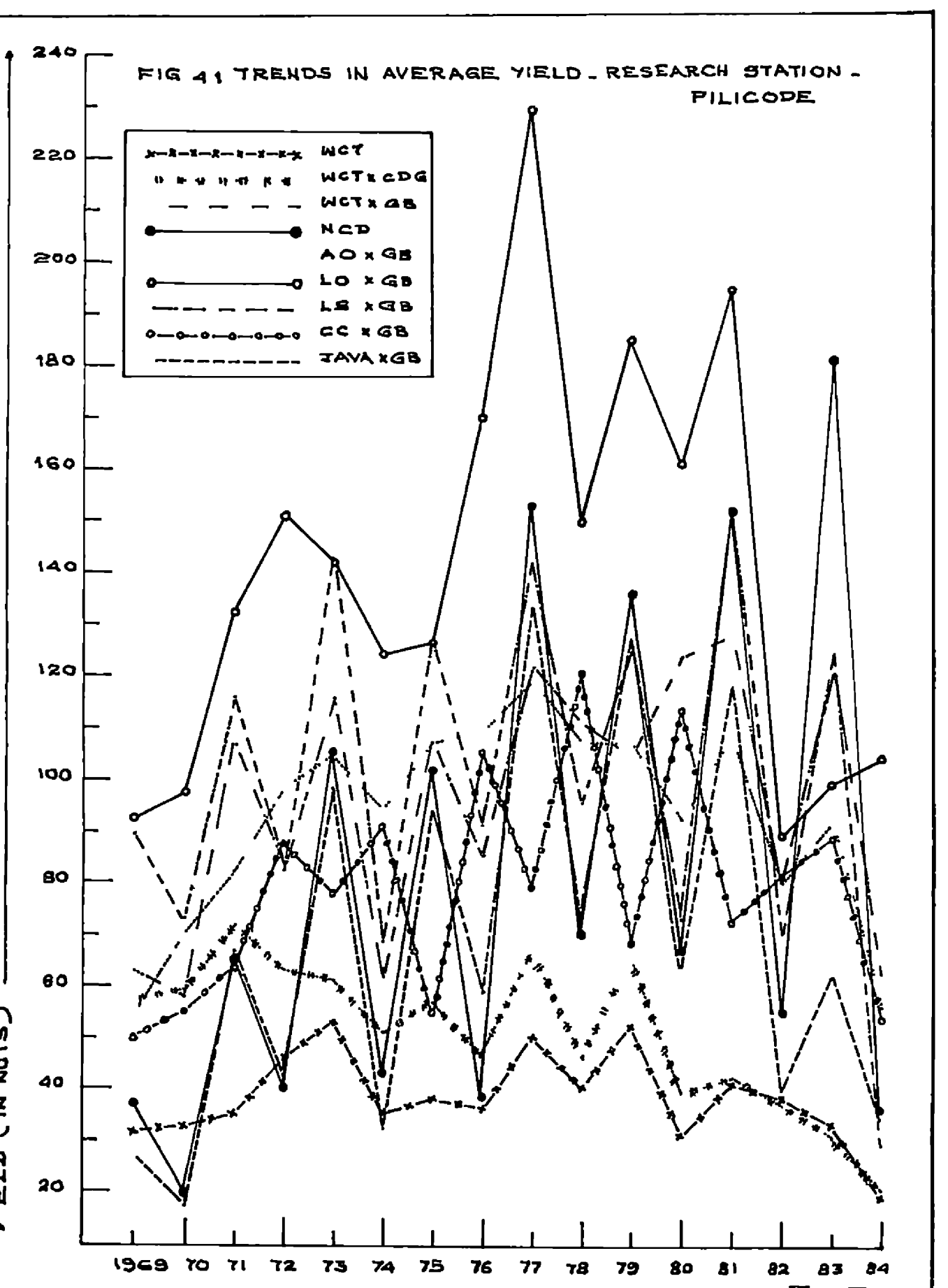
FIG 41 TRENDS IN AVERAGE YIELD - RESEARCH STATION - PILICODE
WCT
WCT x CDG
WCT x GB
NCD
AO x GB
LO x GB
LS x GB
CC x GB
JAVA x GB
240
220
200
180
160
140
120
100
80
60
40
20
1969
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84

Table 4.1.1. Annual rainfall and average yield per palm during the period 1969-1984

Research Station - Pilicode

Year	Annual rainfall (in mm)	Average yield per palm (in nuts)								
		WCT	WCT x CDG	WCT x GB	NCD	AO x GB	LO x GB	LS x GB	CC x GB	Java x GB
1969	2594.8	32	58	64	38	55	93	90	51	28
1970	4065.0	33	60	59	20	71	98	73	56	18
1971	3677.2	36	73	109	66	83	133	117	65	68
1972	3070.8	47	64	85	41	99	152	84	88	44
1973	2893.4	54	62	117	106	105	143	144	79	100
1974	3804.0	36	52	63	44	95	125	70	92	33
1975	4636.4	39	58	109	103	108	127	128	56	96
1976	2920.2	37	48	86	39	110	171	92	106	60
1977	4096.1	51	68	123	154	120	230	144	80	136
1978	4995.4	41	47	112	71	108	151	96	121	73
1979	3838.6	53	67	106	137	108	186	127	69	129
1980	3156.3	32	40	125	68	93	162	74	114	64
1981	3686.6	42	43	129	153	110	196	151	73	120
1982	3563.9	30	38	81	56	81	90	70	82	41
1983	3535.8	34	32	122	182	93	100	126	90	64
1984	3552.8	20	21	63	37	57	105	30	55	35

during the period 1969 to 1973 showed an increasing trend while alternate peaks and troughs in yield was observed from 1973 to 1981. A steady decrease in yield was seen from 1981 onwards. The increase and decrease in yield over alternate years during 1974 to 1982 was observed for WCT x CDG palms and from 1981 onwards a steady decrease in yield was seen. The trend in yield of WCT x GB showed alternate peaks and troughs during the period under study except for 1978 to 1981. The yield of NCD palms showed alternate bearing tendency throughout the period 1969 to 1984. The yield of AO x GB palms showed an increasing trend during the period 1969 to 1973 and during 1974 to 1977. Alternate peaks and troughs were observed during 1979 to 1984. During 1969 to 1972 and 1974 to 1977 the yield of LO x CB variety exhibited an increasing trend. These palms showed alternate increase and decrease in yield during 1976 to 1983. The LS x GB and Java x GB hybrid palms exhibited peaks and troughs in alternate years throughout 1969 to 1984. An increased trend in yield of CC x GB palms was seen during 1969 to 1972, and 1981 to 1983 and alternate peaks and troughs were seen from 1971 to 1982.

The above results do not give a quantitative estimate of biennial tendency. The 'B' factor described in Chapter III was applied to the data to estimate the

magnitude of bienniality. The results are presented in Table 4.1.2 to 4.1.6 . The 'B' factor is based on 8 pairs of successive signs. The probability distribution function $Pr(x) = {}^{8}C_{x} (\frac{1}{2})^{x} (\frac{1}{2})^{8-x}$ gives the probability of getting 0, 1, 2, ..., 8 consecutive like signs in 8 pairs of consecutive years. The observed proportion of palms showing bienniality is tested against the expected proportion of palms using χ^2-test of significance. Hence based on these proportions one can observe that a WCT palm showing a 'B' factor equal to or higher than 2/8 is significantly biennial in bearing ($\chi^2 = 6.14$). As such all the 169 WCT palms exhibited biennial tendency. In the case of WCT x CDG, a palm showing a 'B' factor $\geq 3/8$ is significantly biennial in bearing ($\chi^2 = 9.73$). As such 97.59 per cent of the palms showed biennial tendency. 94.12 per cent of WCT x GB palms with a B $\geq 5/8$ was found to have significant biennial tendency ($\chi^2 = 9.7$). With the same value for 'B' factor all the NCD palms showed biennial tendency ($\chi^2 = 5.71$). The biennial tendency of some hybrid varieties of palms are given in Table 4.1.6 .

Shrikande (1958) and Pankajakshan (1960) reported alternate bearing tendency in most of the coconut palms, though their magnitude was not given.

Table 4.1.2. Biennial Tendency (Factor 'B')

Variety - WCT Research Station - Pilicode

Factor 'B' (Proportion of palms showing biennniality)	No. of palms	Percentage of palms	Cumulative percentage
0/8	0	0.00	100.00
1/8	0	0.00	100.00
2/8	13	7.69	100.00
3/8	9	5.33	92.31
4/8	25	14.79	86.98
5/8	26	15.38	72.19
6/8	27	15.98	56.81
7/8	38	22.49	40.83
8/8	31	18.34	18.34
Total	169	100.00	

Table 4.1.3. Biennial Tendency (Factor 'B')

Variety - WCT x CDG Research Station - Pillicode

Factor 'B' (Proportion of palms showing bienniality	No. of palms	Percentage of palms	Cumulative percentage
0/8	0	0.00	100.00
1/8	0	0.00	100.00
2/8	2	2.41	100.00
3/8	3	3.61	97.59
4/8	5	6.02	93.98
5/8	9	10.84	87.96
6/8	18	21.69	77.12
7/8	26	31.33	55.43
8/8	20	24.10	24.10
Total	83	100.00	

Table 4.1.4. Biennial tendency (Factor 'B')

Variety - WCT x GB Research Station - Pilicode

Factor 'B'	No. of palms	Percentage of palms	Cumulative percentage
0/8	0	0.00	100.00
1/8	0	0.00	100.00
2/8	0	0.00	100.00
3/8	0	0.00	100.00
4/8	1	5.83	100.00
5/8	2	11.76	94.12
6/8	2	11.76	82.36
7/8	5	29.42	70.60
8/8	7	41.18	41.18
Total	17	100.00	

Table 4.1.5. Biennial tendency (Factor 'B')

Variety - NCD Research Station - Pilicode

Factor 'B'	No. of palms	Percentage of palms	Cumulative percentage
0/8	0	0	100
1/8	0	0	100
2/8	0	0	100
3/8	0	0	100
4/8	0	0	100
5/8	1	10	100
6/8	0	0	90
7/8	2	20	90
8/8	7	70	70
Total	10	100	

Table 4.1.6 . Biennial Tendency (Factor 'B')

Sl. No.	Hybrid variety	Sample size	χ^2	'B' factor	Percentage of palms showing biennniality
1.	AO x GB	2	4.12	5/8	80.00
2.	LO x GB	5	8.76	5/8	100.00
3.	IS x GB	5	4.12	5/8	80.00
4.	CC x GB	5	8.76	5/8	100.00
5.	Java x GB	6	5.73	5/8	83.33

Abeywardena (1962) reported that 38.5 per cent of the palms are significantly biennial in bearing from a study on 300 palms maintained under a uniform system of management for nineteen years from 1956 to 1934. Saraswathi (1983) reported 41 per cent biennniality in coconut palms with a population of 132 WCT palms for a period of twelve years.

Intensity of the degree of crop fluctuations was measured by the 'I' factor described in Chapter III. The results are presented in Tables from 4.1.7 to 4.1.15. The values of I can vary from 0 to 100 per cent. 83.43 per cent of the WCT palms showed an intensity of crop fluctuation less than 50 per cent of which in 79.29 per cent the intensity ranged from 20 to 50 per cent. None of the

Table 4.1.7. Intensity of crop fluctuations (Factor 'I')

Variety - WCT Research Station - Pilicode

Factor 'I'	No. of palms	Percentage of palms	Cumulative percentage
less than 10%	1	0.59	0.59
10 to less than 20%	6	3.55	4.14
20 to less than 30%	48	28.40	32.54
30 to less than 40%	44	26.04	58.58
40 to less than 50%	42	24.85	83.43
50 to less than 60%	13	7.69	91.12
60 to less than 70%	10	5.92	97.04
70 to less than 80%	4	2.37	99.41
80 to less than 90%	1	0.59	100.00
90 to less than 100%	0	0.00	100.00
Total	169	100.00	

Table 4.1.8. Intensity of crop fluctuations (Factor 'I')

Variety - WCT x CDG Research Station - Pilicode

Factor 'I'	No. of palms	Percentage of palms	Cumulative percentage
less than 10%	0	0.00	0.00
10 to less than 20%	9	10.84	10.84
20 to less than 30%	28	33.74	44.58
30 to less than 40%	17	20.48	65.06
40 to less than 50%	16	19.28	84.34
50 to less than 60%	5	6.02	90.36
60 to less than 70%	2	2.41	92.77
70 to less than 80%	4	4.82	97.59
80 to less than 90%	2	2.41	100.00
90 to less than 100%	0	0.00	100.00
Total	83	100.00	

Table 4.1.9i. Intensity of crop fluctuations (Factor 'I')

Variety - UCT x GB Research Station - Pilicode

Factor 'I'	No. of palms	Percentage of palms	Cumulative percentage
less than 10%	1	5.88	5.88
10 to less than 20%	2	11.70	17.65
20 to less than 30%	5	29.41	47.06
30 to less than 40%	1	5.88	52.94
40 to less than 50%	5	29.41	82.35
50 to less than 60%	1	5.88	88.23
60 to less than 70%	0	0.00	88.23
70 to less than 80%	2	11.70	100.00
80 to less than 90%	0	0.00	100.00
90 to less than 100%	0	0.00	100.00
Total	17	100.00	

Table 4.1.10. Intensity of crop fluctuations (Factor 'I')

Variety - NCD Research Station - Pilicode

Factor 'I'	No. of palms	Percentage of palms	Cumulative percentage
less than 10%	0	0	0
10 to less than 20%	0	0	0
20 to less than 30%	2	20	20
30 to less than 40%	1	10	30
40 to less than 50%	2	20	50
50 to less than 60%	0	0	50
60 to less than 70%	2	20	70
70 to less than 80%	2	20	90
80 to less than 90%	1	10	100
90 to less than 100%	0	0	100
Total	10	100	

Table 4.1.11. Intensity of crop fluctuations (Factor 'I')

Variety - AO x GB Research Station - Pilicode

Factor 'I'	No. of palms	Percentage of palms	Cumulative percentage
less than 10%	0	0	0
10 to less than 20%	1	20	20
20 to less than 30%	1	20	40
30 to less than 40%	0	0	40
40 to less than 50%	2	40	80
50 to less than 60%	1	20	100
Greater than 60%	0	0	100
Total	5	100	

Table 4.1.12. Intensity of crop fluctuations (Factor 'I')

Variety - LO x GB Research Station - Pilicode

Factor 'I'	No. of palms	Percentage of palms	Cumulative percentage
less than 10%	0	0	0
10 to less than 20%	1	20	20
20 to less than 30%	0	0	20
30 to less than 40%	2	40	60
40 to less than 50%	1	20	80
50 to less than 60%	0	0	80
60 to less than 70%	1	20	100
Greater than 70%	0	0	100
Total	5	100	

Table 4.1.13. Intensity of crop fluctuations (Factor 'I')

Variety - LS^{c} x GB Research Station - Pilicode

Factor 'I'	No. of palms	Percentage of palms	Cumulative percentage
less than 10%	1	20	20
10 to less than 20%	1	20	40
20 to less than 30%	1	20	60
30 to less than 40%	0	0	60
40 to less than 50%	1	20	80
50 to less than 60%	0	0	80
60 to less than 70%	0	0	80
70 to less than 80%	1	20	100
80 to less than 90%	0	0	100
90 to less than 100%	0	0	100
Total	5	100	

Table 4.1.14. Intensity of crop fluctuations (Factor 'I')

Variety - CC x GB Research Station - Pilicode

Factor 'I'	No. of palms	Percentage of palms	Cumulative percentage
less than 10%	0	0	0
10 to less than 20%	1	20	20
20 to less than 30%	1	20	40
30 to less than 40%	0	0	40
40 to less than 50%	0	0	40
50 to less than 60%	1	20	60
60 to less than 70%	0	0	60
70 to less than 80%	1	20	80
80 to less than 90%	1	20	100
90 to less than 100%	0	0	100
Total	5	100	

Table 4.1.16. Intensity of crop fluctuations (Factor 'I')

Variety - Java x GB Research Station - Pilicode

Factor 'I'	No. of palms	Percentage of palms	Cumulative percentage
less than 10%	0	0.00	0.00
10 to less than 20%	2	33.33	33.33
20 to less than 30%	1	16.67	50.00
30 to less than 40%	1	16.67	66.67
40 to less than 50%	0	0.00	66.67
50 to less than 60%	1	16.67	83.34
60 to less than 70%	1	16.67	100.00
Greater than 70%	0	0.00	100.00
Total	6	100.00	

palms showed an intensity greater than 90 per cent. Among WCT x CDG 84.34 per cent of palms showed an 'I' factor less than 30 per cent of which 73.5 per cent of the palms showed an intensity in crop fluctuation ranging from 20 to 30 per cent. 82.35 per cent of the WCT x GB palms gave an 'I' factor less than 30 per cent. But for 64.7 per cent of these palms, the crop fluctuations ranged from 20 to 30 per cent. However, only 5.88 per cent of these palms gave an 'I' factor within the range 30 to 40 per cent. 30 per cent of the NCD palms showed an I factor less than 30 per cent while for the remaining 30 per cent I ranged from 70 to 90 per cent. The I factor was found to be between 10 and 30 per cent for 40 per cent of AO x GB palms and for 60 per cent of the palms intensity ranged from 40 to 60 per cent. 20 per cent of the LO x GB palms showed an 'I' factor ranging from 10 to 20 per cent while 60 per cent of the palms were found in the range 30 to 50 per cent. For the remaining 20 per cent of these palms the 'I' factor was found to lie between 60 and 70 per cent. The 'I' factor was found to be between 0 to 30 per cent for 60 per cent of the LS x GB palms. For 20 per cent of these palms the I factor ranged from 40 to 50 per cent and for the remaining 20 per cent the 'I' factor ranged from 70 to 80 per cent. The 'I' factor was found within the range 10 to 30 per cent for 40 per cent of the CC x GB

palms. 'I' ranged from 50 to 60 per cent for 20 per cent of these palms. For the remaining 40 per cent the value of 'I' was found between 70 and 90 per cent. For 33.33 per cent of the Java x GB palms the intensity ranged from 10 to 20 per cent, for 33.34 per cent it ranged from 20 to 40 per cent and for the remaining 33.34 per cent the range was 50 to 70 per cent.

Abeywardena (1962) observed an 'I' factor ranging from 5 to 15 per cent for 85.4 per cent of palms of which 44.7 per cent was found between 10 and 15 per cent.

Saraswathi (1983) reported that 85.5 per cent of the palms showed an 'I' factor ranging from 0 to 30 per cent and for the remaining 14.5 per cent of palms the 'I' factor ranged from 30 to 90 per cent.

When biennial tendency is observed among a large number of palms one can expect 50 per cent of the palms in the 'on' phase and the remaining 50 per cent in the 'off' phase. However this equiprobability may not be observed in each year. One can observe this from Tables 4.1.16 to 4.1.24. Of the 169 WCT palms this equiprobability was observed in years 1971, 1976, 1978 and 1982. This agreement of expectation and observation was tested by χ^2-test of significance. In 1972, 74, 80 and 84

Table 4.1.16. No. of palms showing 'on' and 'off' phase during 1969-1984

Variety - WCT Research Station - Pilicode

Year	equal yield	'on' phase	'off' phase	χ^2	Percentage 'on' phase
1969	7	94	68	4.17*	55.62
1970	7	68	94	4.17*	40.24
1971	7	70	92	2.99	41.42
1972	3	51	115	24.67*	30.18
1973	4	100	65	7.42*	59.17
1974	2	47	120	31.91*	27.81
1975	2	86	81	0.15	50.89
1976	5	78	86	0.39	46.15
1977	8	109	52	20.18*	64.50
1978	1	74	94	2.38	43.79
1979	5	106	58	14.05*	42.72
1980	3	44	122	36.65*	26.04
1981	2	105	62	11.07*	62.13
1982	7	74	88	1.21	45.79
1983	4	65	100	7.42*	38.46
1984	9	41	119	38.03*	24.26
Total	76	1212	1416		44.82

* Significant at 5 per cent level

Table 4.1.17. No. of palms showing 'on' and 'off' phase during 1969-1984

Variety - WCT x CDG Research Station - Pilicode

Year	equal yield	'on' phase	'off' phase	χ^2	Percentage 'on' phase
1969	2	43	38	0.31	51.81
1970	2	38	43	0.31	45.78
1971	0	56	27	10.13*	67.47
1972	1	35	47	1.76	42.17
1973	1	33	49	3.12	39.76
1974	0	33	50	3.48	39.76
1975	0	50	33	3.48	60.24
1976	1	31	51	4.88*	37.35
1977	1	54	28	8.24*	65.05
1978	0	25	58	13.12*	30.12
1979	0	60	23	16.49*	72.29
1980	0	22	61	18.33*	26.51
1981	3	38	42	0.20	45.78
1982	3	28	52	7.20*	33.73
1983	0	32	51	4.35*	38.55
1984	3	29	51	6.05*	34.94
Total	17	607	704		45.71

* Significant at 5 per cent level

Table 4.1.18. No. of palms showing 'on' and 'off' phase during the period 1969-1984

Variety - WCT x GB Research Station - Pilicode

Year	equal yield	'on' phase	'off' phase	χ^2	Percentage 'on' phase
1969	0	9	8	0.06	52.94
1970	0	8	9	0.06	47.06
1971	0	11	6	1.47	64.71
1972	0	6	11	1.47	35.29
1973	0	13	4	4.76*	76.47
1974	1	3	13	6.25*	17.65
1975	0	11	6	1.47	64.71
1976	0	5	12	2.83	29.41
1977	0	14	3	7.12*	82.35
1978	0	6	11	1.47	35.29
1979	0	9	8	0.06	52.94
1980	0	6	11	1.47	35.29
1981	1	12	4	4.00*	70.59
1982	0	3	14	7.12*	17.65
1983	0	11	6	1.47	64.71
1984	0	2	15	9.94*	11.76
Total	2	129	141		47.43

* Significant at 5 per cent level

Table 4.1.19. No. of palms showing 'on' and 'off' phase during the period 1969-1984

Variety - NCD Research Station - Pilicodo

Year	equal yield	'on' phase	'off' phase	χ^2	Percentage 'on' phase
1969	1	6	5	1.0	60
1970	1	3	6	1.0	30
1971	0	8	2	3.6	80
1972	0	2	8	3.6	20
1973	0	8	2	3.6	80
1974	0	2	8	3.6	20
1975	0	8	2	3.6	80
1976	0	1	9	6.4*	10
1977	0	10	0	10.0*	100
1978	0	2	8	3.6	20
1979	0	8	2	3.6	80
1980	0	2	8	3.6	20
1981	0	7	3	1.6	70
1982	0	2	8	3.6	20
1983	0	9	1	6.4*	90
1984	0	1	9	6.4*	100
Total	2	79	79		49.38

* Significant at 5 per cent level

Table 4.1.20. No. of palms showing 'on' and 'off' phase during the period 1969-1984

Variety - AO x GB Research Station - Pilicode

Year	equal yield	'on' phase	'off' phase	χ^2	Percentage 'on' phase
1969	0	2	3	0.2	40
1970	0	3	2	0.2	60
1971	0	3	2	0.2	60
1972	0	2	3	0.2	40
1973	0	2	3	0.2	40
1974	0	3	2	0.2	60
1975	0	3	2	0.2	60
1976	0	2	3	0.2	40
1977	0	3	2	0.2	60
1978	0	2	3	0.2	40
1979	0	3	2	0.2	60
1980	0	2	3	0.2	40
1981	0	2	3	0.2	40
1982	0	3	2	0.2	60
1983	0	2	3	0.2	40
1984	0	1	4	1.8	20
Total	0	38	42		47.5

Table 4.1.21. No. of palms showing 'on' and 'off' phase during the period 1969-1984

Variety - LO x GB Research Station - Pillicode

Year	equal yield	'on' phase	'off' phase	χ^2	Percentage 'on' phase
1969	0	3	2	0.2	60
1970	0	2	3	0.2	40
1971	0	3	2	0.2	60
1972	0	3	2	0.2	60
1973	0	3	2	0.2	60
1974	0	2	3	0.2	40
1975	0	3	2	0.2	60
1976	0	3	2	0.2	60
1977	0	4	1	1.8	80
1978	0	1	4	1.8	20
1979	0	4	1	1.8	80
1980	0	2	3	0.2	40
1981	0	4	1	1.8	80
1982	0	1	4	1.8	20
1983	1	2	2	0.0	40
1984	0	2	3	0.2	40
Total	1	42	37		52.5

Table 4.1.22. No. of palms showing 'on' and 'off' phase during the period 1969-1984

Variety - LS x GB Research Station - Pilicode

Year	equal yield	'on' phase	'off' phase	χ^2	Percentage 'on' phase
1969	0	2	3	0.2	40
1970	0	3	2	0.2	60
1971	0	5	0	5.0*	100
1972	0	1	4	1.8	20
1973	0	4	1	1.8	80
1974	0	0	5	5.0*	0
1975	0	5	0	5.0*	100
1976	0	1	4	1.8	20
1977	0	4	1	1.8	80
1978	0	2	3	0.2	40
1979	1	3	1	1.0	60
1980	0	3	2	0.2	60
1981	0	5	0	5.0*	100
1982	0	0	5	5.0*	0
1983	0	3	2	0.2	60
1984	1	0	4	3.2	0
Total	2	41	37		51.25

* Significant at 5 per cent level

Table 4.1.23. No. of palms showing 'on' and 'off' phase during the period 1969-1984

Variety - CC x GB Research Station - Pilicode

Year	equal yield	'on' phase	'off' phase	χ^2	Percentage 'on' phase
1969	0	3	2	0.2	60
1970	0	2	3	0.2	40
1971	0	3	2	0.2	60
1972	0	2	3	0.2	40
1973	0	3	2	0.2	60
1974	0	2	3	0.2	40
1975	0	2	3	0.2	40
1976	0	3	2	0.2	60
1977	0	1	4	1.8	20
1978	0	3	2	0.2	60
1979	0	2	3	0.2	40
1980	0	2	3	0.2	40
1981	0	2	3	0.2	40
1982	0	2	3	0.2	40
1983	0	3	2	0.2	60
1984	0	2	3	0.2	40
Total	0	37	43		46.25

Table 4.1.24. No. of palms showing 'on' and 'off' phase during the period 1969-1984

Variety - Java x GB Research Station - Pilicode

Year	equal yield	'on' phase	'off' phase	χ^2	Percentage 'on' phase
1969	1	2	3	0.20	33.33
1970	1	3	2	0.20	50.00
1971	0	6	0	6.00*	100.00
1972	0	2	4	0.67	33.33
1973	0	5	1	2.67	83.33
1974	0	0	6	6.00*	0.00
1975	0	5	1	2.67	83.33
1976	0	1	5	2.67	16.67
1977	0	6	0	6.00*	100.00
1978	0	2	4	0.67	33.33
1979	0	4	4	0.67	66.67
1980	1	0	5	5.00*	0.00
1981	0	4	2	0.67	66.67
1982	0	0	6	6.00*	0.00
1983	1	4	1	1.80	66.67
1984	1	1	4	1.80	16.67
Total	5	45	46		46.88

* Significant at 5 per cent level

percentage of palms in the 'on' phase was significantly low, in the remaining periods the percentage of palms in the 'on' phase was significantly high. For the WCT x CDG palms, the equiprobability of 'on' and 'off' phase was observed in 1969, 1970, 1972, 1973, 1974 and 1975. The percentage of palms in the 'on' phase was found to be significantly high in 1971, 1977 and 1979 and in the remaining years' it was found to be significantly low. For the WCT x GB variety except for 1973, 1974, 1977, 1981, 1982 and 1984, the equiprobability of 'on' and 'off' phase was observed in all other years. In 1973, 1977 and 1981 the number of palms in the 'on' phase was found to be significantly high and in 1974, 1982 and 1984 it was found to be significantly low. For the NCD palms the equiprobability of 'on' and 'off' phase was not observed in 1976, 1977, 1983 and 1984. In 1977 and 1983, the percentage of palms in the 'on' phase was found to be significantly high. For the Java x GB variety the equiprobability of 'on' and 'off' phase was observed in 1969, 1970, 1972, 1973, 1975, 1976, 1978, 1979, 1981, 1983 and 1984. During 1971 and 1977 the proportion of palms in the 'on' phase was found to be significantly high and in the remaining years it was found to be significantly low. The CC x GB palms, LO x GB palms and AO x GB palms showed the equiprobability of 'on' and 'off' phase throughout the

period 1969 to 1984. The equiprobability of 'on' and 'off' phase for the LS x GB palms was observed in 1969, 1970, 1972, 1973, 1976, 1977, 1978, 1979, 1980, 1983 and 1984. During 1971, 1975 and 1981 the proportion of palms in the 'on' phase was significantly high and in the remaining years it was significantly low. The variations in the number of palms in the 'on' and 'off' phase are attributed to climatic factors especially rainfall. A coconut palm requires an even distribution of rainfall throughout the year than the total amount of rainfall received by the palm.

Significance of biennial tendency and time-trend were tested using the criterion given in Chapter III and the results are presented in Table 4.1.25. The biennial tendency of the palms was first tested by F_1 criterion on the hypothesis of the absence of time-trend. As such WCT palms and the hybrid varieties exhibited biennial tendency. Then the effect of time-trend was tested by using F_2 criterion. WCT palms were found to be not influenced by time-trend during the study period. So the F_1 ratio itself gives an evidence of biennial tendency. In the case of WCT x CDG F_2 was significant indicating the presence of time-trend. So the proper test criterion for testing the significance of biennial tendency is F_4.

Table 4.1.25. Biennial tendency and time-trend (Test of significance)

Research Station - Pilicode

Variety	No. of palms	M.S. due to contrasts					F ratio			
		X_1	X_2	X_3	X_4	X_5	F_1	F_2	F_3	F_4
WCT	169	3435.12	88892.16	30090.83	2640.69	23016.76	25.88*	1.21		
WCT x CDG	83	2734.16	77486.95	29505.73	2336.34	22084.53	28.34*	1.38*		8.38*
WCT x GB	17	7699.85	487524.51	106626.36	6200.65	119337.10	63.32*	0.84		
NCD	10	2584.99	440475.21	85279.21	4880.28	102881.61	170.40*	0.76		
AO x GB	5	1028.20	454916.00	89692.20	1985.20	139027.00	442.44*	0.78		
LO x GB	5	20958.80	1441706.70	176117.30	7716.70	301001.70	68.79*	0.47		
LS x GB	5	4268.70	930459.70	266188.50	3066.30	254865.70	217.97*	1.13		
CC x GB	5	1143.30	569713.70	106150.50	587.30	148553.70	498.31*	0.74		
Java x GB	6	13135.77	606868.30	184422.70	3891.50	226126.97	46.20*	1.14		

* Significant at 5 per cent level

A significant F_4 value revealed the existence of biennial tendency in WCT x CDG in the presence of time-trend. In the case of other hyorid varieties from Pilicode, the absence of time-trend was established by the F_2 ratio.

4.2. Yield data from RARS, Kumarakom

The data used for the study refers to 243 palms of WCT, 9 palms of T x SS and 7 palms each of T x G, T x AD and T x LD. A rough idea of biennial tendency can be observed from Fig. 4.2. The figure consists of the trends of annual yields over years. The annual rainfall (in mm) and the average yield per palm (in nuts) from 1976 to 1987 are given in Table 4.2.1. From the figure one can see that biennial tendency exists among these palms. During the period 1976 to 1986 the trend line for the WCT palms exhibited alternate increase and decrease in yield. However this was not observed in the period 1986 to 1987. The T x AD palms exhibited alternate peaks and troughs throughout the period 1976 to 1987. The trend of the T x G palms exhibited marked peaks and troughs during the period 1977 to 1981 and 1983 to 1985. But this was not observed during 1976 to 1977, 1981 to 1983 and 1985 to 1987. The average yields were found to be equal in 1976 and 1977. During 1976 to 1978 and 1982 to 1985 the trend of the T x LD palms exhibited alternate

FIG 4.2 TRENDS IN AVERAGE YIELD - RESEARCH STATION - KUMARAKOM

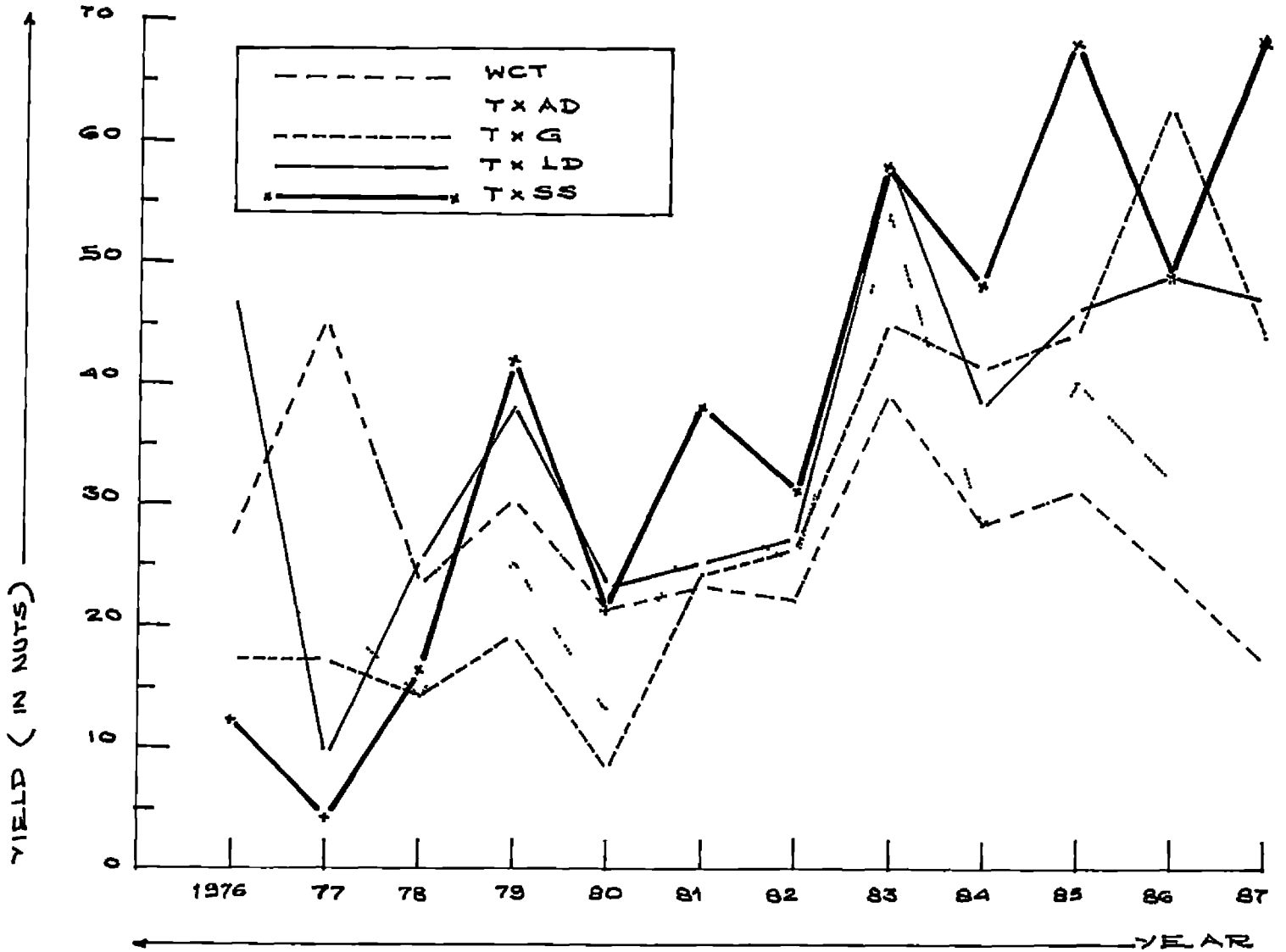

Table 4.2.1. Annual rainfall and average yield per palm during the period 1976-1987

Research Station - Kumarakom

Year	Annual rainfall (in mm)	Average yield per palm (in nuts)				
		WCT	T x C	T x SS	T x LD	T x AD
1976	NA	27	17	12	47	20
1977	NA	45	17	4	9	21
1978	2206.5	23	14	16	25	14
1979	1580.6	30	19	42	38	25
1980	1936.1	21	8	21	23	13
1981	2001.1	23	24	38	25	29
1982	2037.1	22	26	31	27	25
1983	2305.1	39	45	58	58	54
1984	2317.9	28	41	48	38	28
1985	2997.2	31	44	44	46	40
1986	2238.8	24	63	49	49	32
1987	2114.8	17	44	68	47	35

NA - Not available

increase and decrease in yield while this characteristic was not observed during the periods 1978 to 1982 and 1983 to 1987. During 1976 to 1987 the trend of the T x SS palms showed marked peaks and troughs in yield except during 1978 to 1980.

The Tables 4.2.2 to 4.2.6 gives the results of the quantitative estimate of biennial tendency. The data covered a period of twelve years from 1976 to 1987. A test of significance of bienniality can be obtained by calculating the probabilities.

$$Pr(x) = 6\,C_x\,(\tfrac{1}{2})^x\,(\tfrac{1}{2})^{6-x},\quad x = 0, 1, \ldots\ldots, 6.$$

Based on the observed and expected probabilities one can observe that a CT palm showing a 'B' factor equal to or higher than 4/6 is significantly biennial in bearing ($\chi^2 = 34.48$). Thus 52.26 per cent of the WCP palms are significantly biennial in bearing. The 'B' factor $\geq 4/6$ was found to be significantly biennial in bearing for both the T x G ($\chi^2 = 4.26$) and T x SS ($\chi^2 = 4.16$) palms. Thus 71.42 per cent of the T x G and 66.67 per cent of the T x SS palms are significantly biennial in bearing. For the T x LD and T x AD hybrids palms a 'B' factor $\geq 6/6$ was found to show significant bienniality ($\chi^2 = 7.39$). As such 14.29 per cent each of the T x LD and T x AD palms are significantly biennial in bearing.

Table 4.2.2. Biennial Tendency (Factor 'B')

Variety - WCT , Research Station - Kumarakom

Factor 'B' (Proportion of palms showing bienniality)	No. of palms	Percentage of palms	Cumulative percentage
0/6	0	0.00	100.00
1/6	26	10.70	100.00
2/6	65	26.75	89.30
3/6	25	10.29	62.55
4/6	58	23.87	52.26
5/6	42	17.28	28.39
6/6	27	11.11	11.11
Total	243	100.00	

Table 4.2.3. Biennial Tendency (Factor 'B')

Variety - T x G Research Station - Kumarakom

Factor 'B' (Proportion of palms showing bienniality)	No. of palms	Percentage of palms	Cumulative percentage
0/6	0	0.00	100.00
1/6	0	0.00	100.00
2/6	1	14.29	100.00
3/6	1	14.29	85.71
4/6	2	28.57	71.42
5/6	3	42.85	42.85
6/6	0	0.00	0.00
Total	7	100.00	

Table 4.2.4. Biennial Tendency (Factor 'B')

Variety - T x SS Research Station - Kumarakom

Factor 'B' (Proportion of palms showing bienniality)	No. of palms	Percentage of palms	Cumulative percentage
0/6	0	0.00	100.00
1/6	0	0.00	100.00
2/6	1	11.11	100.00
3/6	2	22.22	88.89
4/6	2	22.22	66.67
5/6	3	33.33	44.45
6/6	1	11.11	11.11
Total	9	100.00	

Table 4.2.5. Biennial Tendency (Factor 'B')

Variety - T x LD Research Station - Kumarakom

Factor 'B' (Proportion of palms showing bienniality)	No. of palms	Percentage of palms	Cumulative percentage
0/6	0	0.00	100.00
1/6	0	0.00	100.00
2/6	1	14.29	100.00
3/6	3	42.86	85.71
4/6	1	14.29	42.85
5/6	1	14.29	28.56
6/6	1	14.29	14.29
Total	7	100.00	

Table 4.2.6. Biennial Tendency (Factor 'B')

Variety - T x AD Research Station - Kumarakom

Factor 'B' (Proportion of palms showing bienniality)	No. of palms	Percentage of palms	Cumulative percentage
0/6	0	0.00	100.00
1/6	0	0.00	100.00
2/6	0	0.00	100.00
3/6	3	42.86	100.00
4/6	2	28.57	57.14
5/6	1	14.29	28.57
6/6	1	14.29	14.29
Total	7	100.00	

The 'I' factor which measures the intensity of the degree of crop fluctuations are presented in Tables from 4.2.7 to 4.2.11. The 'I' factor was found to be less than 50 per cent for 82.3 per cent of the WCT palms of which for 73.25 per cent of the palms the intensity ranged from 20 to 50 per cent. For the remaining 17.7 per cent of palms the degree of crop fluctuations ranged from 50 to 80 per cent. The 'I' factor ranged from 30 to 60 per cent for all the T x G palms of which for the 85.72 per cent of palms the 'I' factor ranged from 30 to 50 per cent. For 88.88 per cent of the T x SS palms the magnitude of crop fluctuations was 10 to 50 per cent of which in 66.66 per cent the 'I' factor ranged from 30 to 50 per cent. For the remaining 11.11 per cent of the palms the 'I' was between 60 and 70 per cent. The intensity ranged from 10 to 60 per cent for all the T x LD palms of which for 57.14 per cent of palms, it ranged from 20 to 40 per cent. For all the T x AD palms, the intensity was found to be between 20 and 60 per cent of which for 57.1 per cent of palms, the magnitude of 'I' was 30 to 40 per cent.

The equiprobability of 'on' and 'off' phase can be observed from Tables 4.2.12 to 4.2.16. For the 243 WCT palms, the equiprobability of 'on' and 'off' phase can be observed in 1981, 1982 and 1985. The number of palms in

61

Table 4.2.7. Intensity of crop fluctuations (Factor 'I')

Variety - WCT Research Station - Kumarakom

Factor 'I'	No. of palms	Percentage of palms	Cumulative percentage
less than 10%	0	0.00	0.00
10 to less than 20%	22	9.05	9.05
20 to less than 30%	54	22.22	31.27
30 to less than 40%	69	28.40	59.67
40 to less than 50%	55	22.63	82.30
50 to less than 60%	20	8.23	90.53
60 to less than 70%	18	7.41	97.94
70 to less than 80%	5	2.06	100.00
80 to less than 90%	0	0.00	100.00
90 to less than 100%	0	0.00	100.00
Total	243	100.00	

Table 4.2.8. Intensity of crop fluctuations (Factor 'I')

Variety - T x G Research Station - Kumarakom

Factor 'I'	No. of palms	Percentage of palms	Cumulative percentage
less than 10%	0	0.00	0.00
10 to less than 20%	0	0.00	0.00
20 to less than 30%	0	0.00	0.00
30 to less than 40%	3	42.86	42.86
40 to less than 50%	3	42.86	85.72
50 to less than 60%	1	14.28	100.00
Greater than 60%	0	0.00	100.00
Total	7	100.00	

Table 4.2.9. Intensity of crop fluctuations (Factor 'I')

Variety - T x SS Research Station - Kumarakom

Factor 'I'	No. of palms	Percentage of palms	Cumulative percentage
less than 10%	0	0.00	0.00
10 to less than 20%	1	11.11	11.11
20 to less than 30%	1	11.11	22.22
30 to less than 40%	3	33.33	55.55
40 to less than 50%	3	33.33	88.88
50 to less than 60%	0	0.00	88.88
60 to less than 70%	1	11.11	100.00
Greater than 70%	0	0.00	100.00
Total	9	100.00	

Table 4.2.10. Intensity of crop fluctuations (Factor 'I')

Variety - T x LD Research Station - Kumarakom

Factor 'I'	No. of palms	Percentage of palms	Cumulative percentage
less than 10%	0	0.00	0.00
10 to less than 20%	1	14.29	14.29
20 to less than 30%	2	28.57	42.86
30 to less than 40%	2	28.57	71.43
40 to less than 50%	1	14.29	85.72
50 to less than 60%	1	14.29	100.00
Greater than 60%	0	0.00	100.00
Total	7	100.00	

Table 4.2.11. Intensity of crop fluctuations (Factor 'I')

Variety - T x AD Research Station - Kumarakom

Factor 'I'	No. of palms	Percentage of palms	Cumulative percentage
less than 10%	0	0.0	0.0
10 to less than 20%	0	0.0	0.0
20 to less than 30%	1	14.3	14.3
30 to less than 40%	4	57.1	71.4
40 to less than 50%	1	14.3	85.7
50 to less than 60%	1	14.3	100.00
Greater than 60%	0	0.00	100.00
Total	7	100.00	

Table 4.2.12. No. of palms showing 'on' and 'off' phase during 1976-1987

Variety - WCT Research Station - Kumarakom

Year	equal yield	'on' phase	'off' phase	χ^2	Percentage 'on' phase
1976	2	65	176	51.12*	26.75
1977	2	176	65	51.12*	72.43
1978	6	20	217	163.75*	8.23
1979	16	146	81	18.61*	60.08
1980	7	65	171	47.61*	26.75
1981	16	117	110	0.22	48.15
1982	15	115	113	0.02	47.33
1983	8	207	28	136.34*	85.19
1984	8	48	187	82.22*	19.75
1985	12	120	111	0.35	49.38
1986	12	76	155	27.02*	31.28
1987	23	66	154	35.20*	27.16
Total	127	1221	1568		41.87

* Significant at 5 per cent level

Table 4.2.13. No. of palms showing 'on' and 'off' phase during 1976-1987

Variety - T x G Research Station - Kumarakom

Year	equal yield	'on' phase	'off' phase	χ^2	Percentage 'on' phase
1976	0	4	3	0.14	57.14
1977	0	3	4	0.14	42.86
1978	3	1	3	1.00	14.29
1979	1	5	1	2.67	71.43
1980	1	1	5	2.67	14.29
1981	0	7	0	7.00*	100.00
1982	0	3	4	0.14	42.86
1983	0	5	2	1.29	71.43
1984	0	4	3	0.14	57.14
1985	0	4	3	0.14	57.14
1986	1	5	1	2.67	71.43
1987	0	3	4	0.14	42.86
Total	6	45	33		53.57

* Significant at 5 per cent level

Table 4.2.14. No. of palms showing 'on' and 'off' phase during 1976-1987

Variety - T x SS Research Station - Kumarakom

Year	equal yield	'on' phase	'off' phase	χ^2	Percentage 'on' phase
1976	3	3	3	0.00	33.33
1977	3	3	3	0.00	33.33
1978	1	8	0	8.00*	88.99
1979	0	8	1	5.44*	88.89
1980	0	1	8	5.44*	11.11
1981	0	6	3	1.00	66.67
1982	0	3	6	1.00	33.33
1983	0	9	0	9.00*	100.00
1984	0	4	5	0.11	44.44
1985	0	7	2	2.78	77.78
1986	0	3	6	1.00	33.33
1987	1	6	2	2.00	66.67
Total	5	61	39		58.10

* Significant at 5 per cent level

Table 4.2.15. No. of palms showing 'on' and 'off' phase during 1976-1987

Variety - T x LD Research Station - Kumarakom

Year	equal yield	'on' phase	'off' phase	χ^2	Percentage 'on' phase
1976	1	5	1	2.67	71.43
1977	1	1	5	2.67	14.29
1978	0	7	0	7.00*	100.00
1979	0	4	3	0.14	57.14
1980	0	3	4	0.14	42.86
1981	1	4	2	0.67	57.14
1982	0	3	4	0.14	42.86
1983	0	7	0	7.00*	100.00
1984	0	0	7	7.00*	0.00
1985	0	5	2	1.29	71.43
1986	1	4	2	0.67	57.14
1987	0	3	4	0.14	42.86
Total	4	46	34		54.76

* Significant at 5 per cent level

Table 4.2.16. No. of palms showing 'on' and 'off' phase during 1976-1987

Variety - T x AD Research Station - Kumarakom

Year	equal yield	'on' phase	'off' phase	χ^2	Percentage 'on' phase
1976	2	3	2	0.20	42.86
1977	2	2	3	0.20	28.57
1978	0	4	3	0.14	57.14
1979	0	6	1	3.57	85.71
1980	1	1	5	2.67	14.29
1981	0	7	0	7.00*	100.00
1982	0	2	5	1.29	28.57
1983	0	6	1	3.57	85.71
1984	0	0	7	7.00*	0.00
1985	0	5	2	1.29	71.43
1986	0	3	4	0.14	42.86
1987	0	3	4	0.14	42.86
Total	5	42	37		50.00

* Significant at 5 per cent level

the 'on' phase during 1977, 1979 and 1985 was found to be significantly high and during 1976, 1978, 1980, 1984, 1986 and 1987 it was found to be significantly low. For the T x G palms the equiprobability of 'on' and 'off' phase was observed throughout the period from 1976 to 1987 except in the year 1981. 100 per cent of these was observed in the 'on' phase in 1981. The T x SS palms showed the equiprobability of 'on' and 'off' phase in 1976, 1977, 1981, 1982, 1984, 1985, 1986 and 1987. The percentage of palms in the 'on' phase was significantly high during 1978, 1979 and 1983 and in the remaining periods it was significantly low. For the T x LD palms the equiprobability of 'on' and 'off' phase was not observed during 1978, 1983 and 1984. During 1978 and 1983 the proportion of palms in the 'on' phase was 100 per cent. For the T x AD palms the equiprobability of 'on' and 'off' phase was not observed during 1981 and 1984; 100 per cent of palms was observed in the 'on' phase during 1981.

The results on the significance of biennial tendency and time-trend are presented in Table 4.2.17 . The WCT, T x G and T x SS palms showed significant biennial tendency. In the case of T x LD and T x AD palms the Γ_1 ratio revealed the absence of biennial tendency. In order to test the significance of time-trend, the Γ_2 criterion

Table 4.2.17. Biennial tendency and time-trend (Tests of significance)

Research Station - Kumarakom

Variety	No. of palms	M.S. due to contrasts					F - ratio			
		X_1	X_2	X_3	X_4	X_5	F_1	F_2	F_3	F_4
WCT	243	1870.06	9770.54	11675.19	2137.84	2219.33	5.22*	3.04*		1.52*
T x G	7	1610.33	6868.24	5234.81	5234.81	1570.33	4.24*	1.79		
T x SS	9	3008.94	11842.28	6592.94	2114.50	2953.78	3.94*	1.26		
T x LD	7	1045.24	2457.62	22385.81	2765.62	1621.14	2.35		2.65	
T x AD	7	516.57	1044.29	12455.62	1445.62	1359.81	2.02		2.80	

* Significant at 5 per cent level

was considered. The significance of Γ_2 ratio revealed the existence of time-trend in the case of WCT palms. Then Γ_4 criterion was used to test the significance of biennial tendency in the presence of time-trend. Significant biennial tendency was observed in presence of time-trend for WCT palms. Time-trend did not influence the T x G and T x SS palms during the study period. Since biennial tendency was found to be absent in the case of T x LD and T x AD palms, the F_3 criterion was used to test the significance of time-trend in the absence of biennial tendency. These tests revealed the absence of time-trend in the absence of biennial tendency.

4.3. Yield data from CRS, Balaramapuram

The data consists of 198 WCT palms, 23 T x D palms and 18 T x GB palms. A rough idea of the biennial tendency can be observed from Fig. 4.3. The annual rainfall (in mm) and average yield per palm (in nuts) from 1976 to 1987 are given in Table 4.3.1. The trend of WCT palms exhibited alternate increase and decrease in yield during the periods 1976 to 1980 and 1983 to 1987. From 1980 to 1983 marked peaks and troughs in yield were not observed. The trend in yield of T x D palms showed alternate peaks and troughs during 1976 to 1980, 1980 to 1983 and 1983 to 1987. But a single trend was not observed. The continuity

FIG 4.3 TRENDS IN AVERAGE YIELD - RESEARCH STATION BALARAMAPURAM

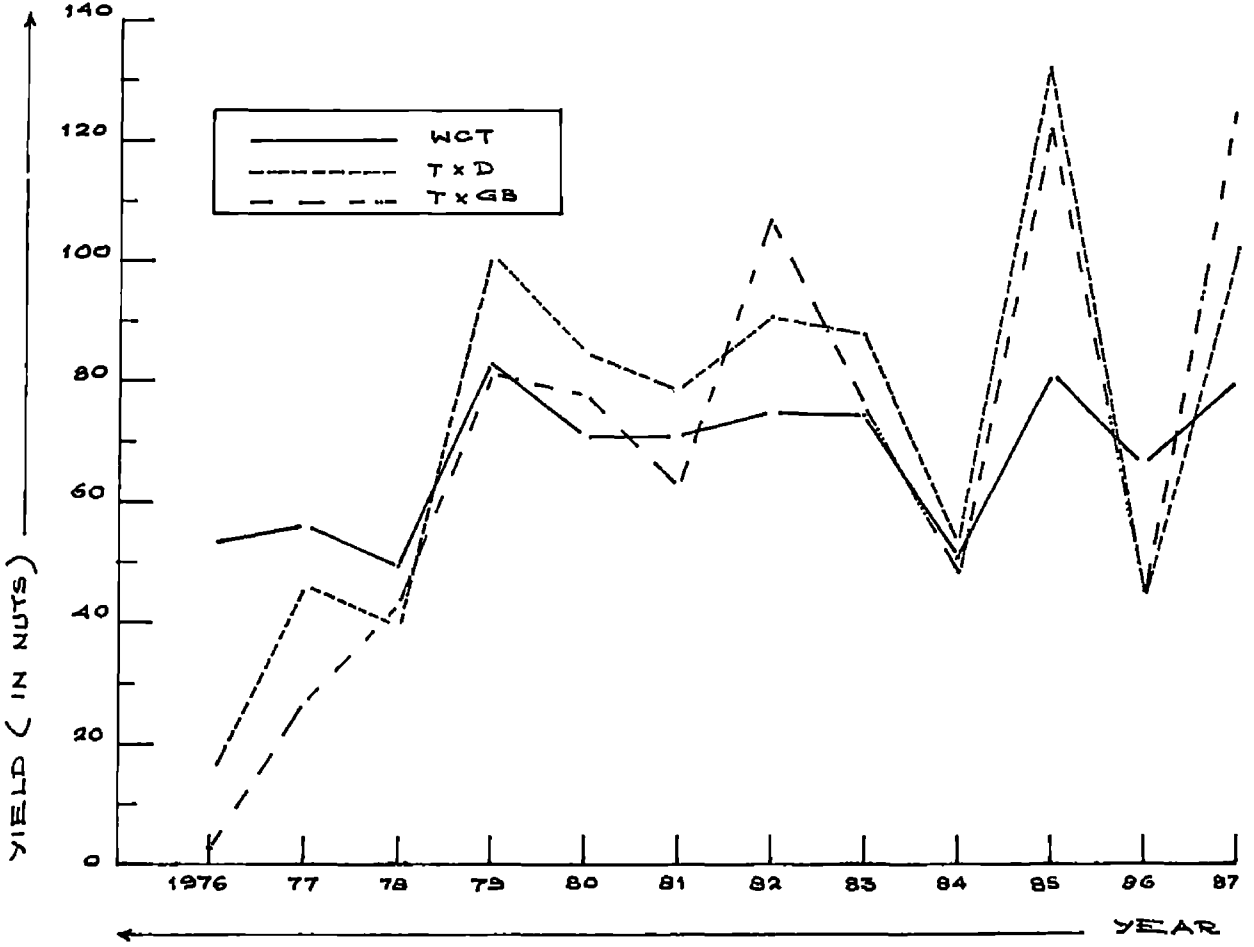

Table 4.3.1. Annual rainfall and average yield per palm during the period 1976-1987

Research Station - Balaramapuram

Year	Annual rainfall (in mm)	Average yield per palm (in nuts)			
		WCT	T x D	T x G	WCT (Exp.palms)
1976	NA	53	16	3	20
1977	2389.1	56	46	27	31
1978	1872.5	49	39	43	31
1979	1589.8	83	101	82	39
1980	1351.6	71	85	78	40
1981	2057.6	71	79	63	43
1982	1296.3	75	91	107	57
1983	1142.4	75	88	76	44
1984	1499.5	51	53	49	33
1985	1466.3	81	132	122	78
1986	1181.6	66	44	45	38
1987	410.2+	80	102	125	68

NA - Not available

\+ - The rainfall is recorded upto 15/6/1987

was lost in 1981 and 1984. The T x GB palms exhibited an increasing trend during 1976 to 1979 and a decreasing trend during 1979 to 1981. During 1981 to 1987 alternate peaks and troughs in yield were observed except for the year 1984.

The proportion of palms showing varying degrees of biennniality as per the 'B' factor is presented in Tables from 4.3.2 to 4.3.4. This set of data covered a period of twelve years from 1976 to 1987 and as such the 'B' factor is based on 6 pairs of successive signs. On the basis of the hypothesis that the probability of like signs in successive pairs is $\frac{1}{2}$, a test of significance of biennniality can be obtained by calculating the probabilities given by

$$Pr(x) = 6C_x \left(\frac{1}{2}\right)^x \left(\frac{1}{2}\right)^{6-x}, \quad x = 0, 1, \ldots\ldots, 6$$

where x is the number of like signs in 6 pairs of consecutive years. Based on the probabilities one can observe that a WCT palm showing a 'B' factor $\geq 2/6$ is significantly biennial in bearing ($\chi^2 = 20.04$). Thus 98.99 per cent of WCT palms showed significantly biennniality. A palm showing a 'B' factor $\geq 3/6$ was found to be having significant biennniality in the case of T x D ($\chi^2 = 9.19$) and T x GB ($\chi^2 = 4.32$) palms. As such 95.65 per cent of the T x D palms and 89.89 per cent of the T x GB palms are

Table 4.3.2. Biennial Tendency (Factor 'B')

Variety - WCT Research Station - Balaramapuram

Factor 'B' (Proportion of palms showing bienniality)	No. of palms	Percentage of palms	Cumulative percentage
0/6	0	0.00	100.00
1/6	2	1.01	100.00
2/6	29	14.65	98.99
3/6	24	12.12	84.34
4/6	59	29.80	72.22
5/6	56	28.28	42.42
6/6	28	14.14	14.14
Total	198	100.00	

Table 4.3.3. Biennial Tendency (Factor 'B')

Variety - T x D Research Station - Balaramapuram

Factor 'B' (Proportion of palms showing bienniality)	No. of palms	Percentage of palms	Cumulative percentage
0/6	0	0.00	100.00
1/6	0	0.00	100.00
2/6	1	4.35	100.00
3/6	0	0.00	95.65
4/6	3	13.04	95.65
5/6	11	47.83	82.61
6/6	8	34.78	34.78
Total	23	100.00	

Table 4.3.4. Biennial Tendency (Factor 'B')

Variety - T x GB Research Station - Balaramapuram

Factor 'B' (Proportion of palms showing bienniality)	No. of palms	Percentage of palms	Cumulative percentage
0/6	0	0.00	100.00
1/6	0	0.00	100.00
2/6	2	11.11	100.00
3/6	0	0.00	83.89
4/6	5	27.78	88.89
5/6	3	16.67	61.11
6/6	8	44.44	44.44
Total	18	100.00	

significantly biennial in bearing.

The intensity of crop fluctuations are presented in Tables from 4.3.5 to 4.3.7. For all the WCT palms the 'I' factor was found to be less than 60 per cent. In that for 84.85 per cent of palms the 'I' factor ranged from 10 to 40 per cent. The 'I' factor ranged from 10 to 50 per cent for 69.57 per cent of the T x D palms. For the remaining 30.43 per cent of palms the 'I' factor ranged from 50 to 70 per cent. For all the eighteen T x GB palms the 'I' factor ranged from 20 to 60 per cent of which for the 50 per cent the 'I' factor was between 30 and 40 per cent.

The equiprobability of 'on' and 'off' phase can be examined from Tables 4.3.8 to 4.3.10. For the 198 WCT palms, the equiprobability of 'on' and 'off' phase was observed in 1981, 1982 and 1983. One can observe that in 1976, 1978, 1980 and 1984 the percentage of palms in the 'on' phase was significantly low while in the remaining periods the percentage of palms in the 'on' phase was significantly high. The equiprobability of 'on' and 'off' phase for the T x D palms was found in 1978, 1980, 1981 and 1983. The number of palms in the 'on' phase was found to be significantly high in 1977, 1979, 1982, 1985 and 1987 and significantly low in 1976, 1984 and 1986. For the T x GB palms the equiprobability of 'on' and 'off'

Table 4.3.5. Intensity of crop fluctuations (Factor 'I')

Variety - WCT Research Station - Balaramapuram

Factor 'I'	No. of palms	Percentage of palms	Cumulative percentage
less than 10%	21	10.00	10.60
10 to less than 20%	91	45.96	56.56
20 to less than 30%	57	28.79	85.35
30 to less than 40%	20	10.10	95.45
40 to less than 50%	6	3.03	98.48
50 to less than 60%	3	1.52	100.00
Greater than 60%	0	0.00	100.00
Total	198	100.00	

Table 4.3.6. Intensity of crop fluctuations (Factor 'I')

Variety - T x D Research Station - Balaramapuram

Factor 'I'	No. of palms	Percentage of palms	Cumulative percentage
less than 10%	0	0.00	0.00
10 to less than 20%	2	8.70	8.70
20 to less than 30%	2	8.70	17.40
30 to less than 40%	8	34.78	52.18
40 to less than 50%	4	17.39	69.57
50 to less than 60%	5	21.73	91.31
60 to less than 70%	2	8.70	100.00
Greater than 70%	0	0.00	100.00
Total	23	100.00	

Table 4.3.7. Intensity of crop fluctuations (Factor 'I')

Variety - T x GB Research Station - Balaramapuram

Factor 'I'	No. of palms	Percentage of palms	Cumulative percentage
less than 10%	0	0.00	0.00
10 to less than 20%	0	0.00	0.00
20 to less than 30%	3	16.67	16.67
30 to less than 40%	9	50.00	66.67
40 to less than 50%	5	27.78	94.45
50 to less than 60%	1	5.55	100.00
Greater than 60%	0	0.00	100.00
Total	18	100.00	

Table 4.3.8. No. of palms showing 'on' and 'off' phase during 1976-1987

Variety - WCT Research Station - Balaramapuram

Year	equal yield	'on' phase	'off' phase	χ^2	Percentage 'on' phase
1976	19	70	109	8.50*	39.39
1977	19	109	70	8.50*	55.05
1978	11	65	122	17.37*	32.83
1979	4	181	13	145.48*	91.41
1980	7	45	146	53.41*	22.73
1981	4	96	98	0.02	48.48
1982	1	110	87	2.69	55.56
1983	2	97	99	0.02	48.99
1984	2	25	171	108.76*	12.63
1985	2	178	18	130.61*	89.90
1986	4	138	56	34.66*	69.70
1987	7	129	62	23.50*	65.15
Total	82	1243	1051		52.31

* Significant at 5 per cent level

Table 4.3.9. No. of palms showing 'on' and 'off' phase during 1976-1987

Variety - T x D Research Station - Balaramapuram

Year	equal yield	'on' phase	'off' phase	χ^2	Percentage 'on' phase
1976	2	1	20	17.19*	4.35
1977	2	20	1	17.19*	86.96
1978	0	11	12	0.04	47.83
1979	0	23	0	23.00*	100.00
1980	1	7	15	2.91	30.43
1981	0	9	14	1.09	39.13
1982	1	18	4	8.91*	78.26
1983	0	9	14	1.09	39.13
1984	0	5	18	7.35*	21.74
1985	0	20	3	12.57*	86.96
1986	0	0	23	23.00*	0.00
1987	0	21	2	15.70*	91.30
Total	6	144	126		52.17

* Significant at 5 per cent level

Table 4.3.10. No. of palms showing 'on' and 'off' phase during 1976-1987

Variety - T x GB Research Station - Balaramapuram

Year	equal yield	'on' phase	'off' phase	χ^2	Percentage 'on' phase
1976	7	0	11	11.00*	0.00
1977	7	11	0	11.00*	61.11
1978	0	15	3	8.00*	83.33
1979	0	17	1	14.22*	94.44
1980	1	7	10	0.53	38.89
1981	1	2	15	9.94*	11.11
1982	0	18	0	18.00*	100.00
1983	1	1	16	13.24*	5.56
1984	0	2	16	10.89*	11.11
1985	0	17	1	14.22*	94.44
1986	0	1	17	14.22*	5.56
1987	0	17	1	14.22*	94.44
Total	17	108	91		50.00

* Significant at 5 per cent level

Table 4.3.11. Biennial tendency and time-trend (Tests of significance)

Research Station - Balaramapuram

Variety	No. of palms	M.S. due to contrasts					F ratio			
		X_1	X_2	X_3	X_4	X_5	F_1	F_2	F_3	F_4
WCT	198	2056.40	12897.96	19242.36	3241.26	3146.32	6.27*	4.04*		1.33*
T x D	23	3278.15	48470.02	10509.17	3027.88	10860.69	14.79*	0.72		
T x GB	18	8966.84	30310.61	20841.79	3767.95	6058.59	3.38*	1.46		

* Significant at 5 per cent level

phase was observed only in the year 1980. During 1977, 1978, 1979, 1982, 1985 and 1987 the number of palms in the 'on' phase was found to be significantly high and in the remaining years it was significantly low.

Tests of biennial tendency and time-trend were carried out with this data and the results are presented in Table 4.3.11. The significant F_1 ratio revealed the existence of biennial tendency in the case of WCT, T x D and T x GB palms. Effect of time-trend was tested by using F_2 criterion. Time-trend significantly influenced the WCT palms while T x D and T x GB palms were not influenced by this. The WCT palms were hence tested by F_4 criterion and this revealed the existence of biennial tendency among these palms in the presence of time-trend.

4.4. Yield data from Instructional Farm, Vellayani

The yield data of 40 Komadan palms for a period of four years from 1981 to 1984 were utilised for the study. A palm showing a 'B' factor 2/2 can be said to be significantly biennial in bearing. Thus from the Table 4.4.1 one can observe that 25 per cent of the Komadan palms are significantly biennial in bearing.

The Table 4.4.2 shows the intensity of crop fluctuations. For 90 per cent of the palms the intensity

FIG 4.4 TREND IN AVERAGE YIELD INSTRUCTIONAL FARM VELLAYANI

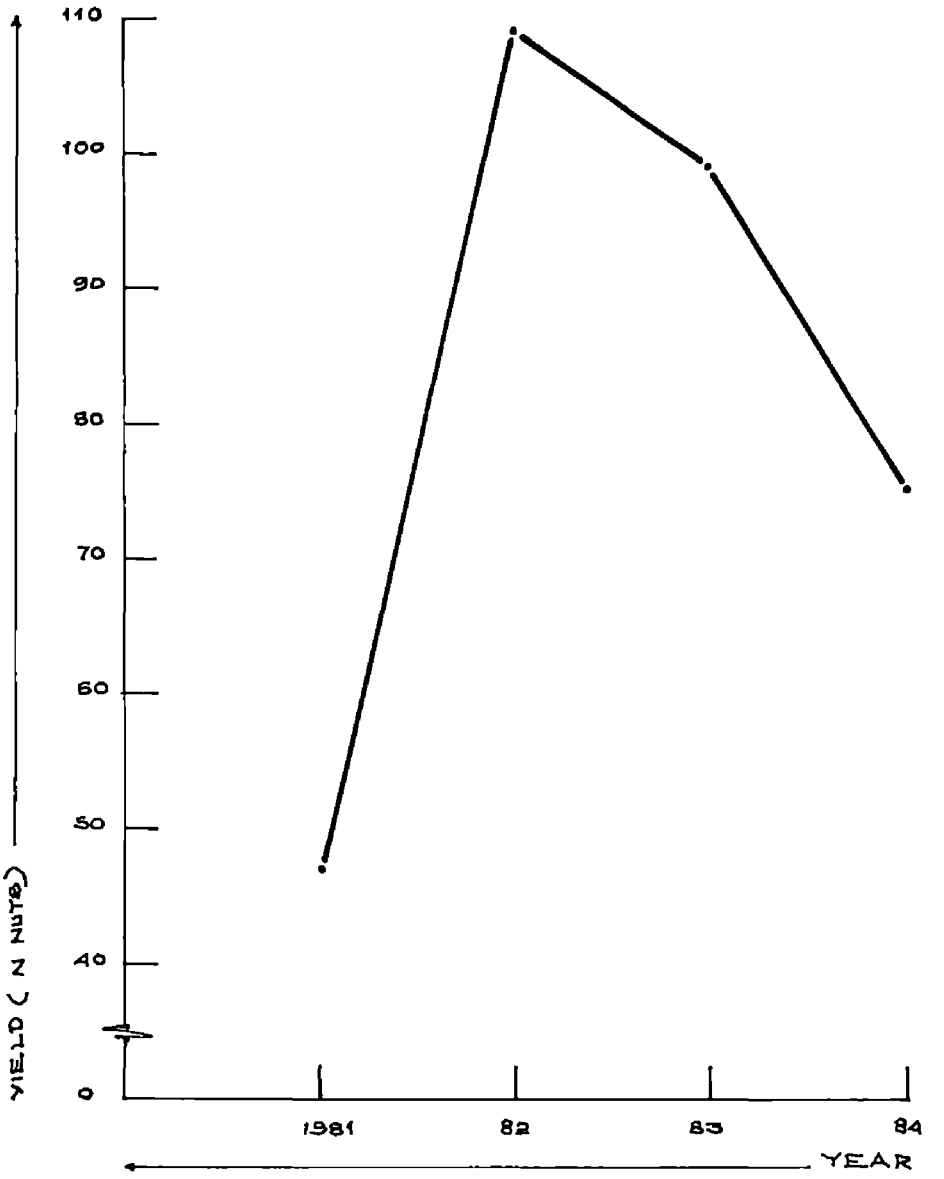

Table 4.4.1. Biennial Tendency (Factor 'B')

Variety - Komadan Research Station - Instructional Farm, Vellayani

Factor 'B' (Proportion of palms showing bienniality)	No. of palms	Percentage of palms	Cumulative percentage
0/2	0	0	100
1/2	30	75	100
2/2	10	25	25
Total	40	100	

Table 4.4.2. Intensity of crop fluctuations (Factor 'I')

Variety - Komadan Research Station - Instructional Farm, Vellayani

Factor 'I'	No. of palms	Percentage of palms	Cumulative percentage
less than 10%	1	2.5	2.5
10 to less than 20%	9	22.5	25.0
20 to less than 30%	11	27.5	52.5
30 to less than 40%	10	25.0	77.5
40 to less than 50%	5	12.5	90.0
50 to less than 60%	3	7.5	97.5
60 to less than 70%	0	0.0	97.5
70 to less than 80%	1	2.5	100.0
80 to less than 90%	0	0.0	100.0
90 to less than 100%	0	0.0	100.00
Total	40	100.0	

Table 4.4.3. No. of palms showing 'on' and 'off' phase during 1981-1984

Variety - Komadan Research Station - Instructional Farm, Vellayani

Year	equal yield	'on' phase	'off' phase	χ^2	Percentage 'on' phase
1981	0	38	2	32.40*	95.0
1982	0	2	38	32.40*	5.3
1983	1	15	24	2.09	37.5
1984	0	11	29	8.10*	27.5
Total	1	66	93		41.25

* Significant at 5 per cent level

Table 4.4 4. Biennial tendency and time-trend (Test of significance)

Variety - Komadan Research Station - Instructional Farm, Vellayani

Contrast	Mean squares
X_1	3766.55
X_2	9840.55
X_3	4178.77
X_4	1050.76
X_5	1505.94

$F_1 = 2.61^*$

$F_2 = 0.79$

* Significant at 5 per cent level

ranged from 0 to 50 per cent. Among these for 75 per cent of the palms the intensity ranged from 10 to 40 per cent. The 'I' factor ranged from 50 to 60 per cent for 7.5 per cent of palms. For the remaining 2.5 per cent of palms the 'I' ranged from 70 to 80 per cent.

The equiprobability of 'on' and 'off' phase can be observed from Table 4.4.3. This equiprobability was observed only in 1983. During 1981 the number of palms in the 'on' phase was found to be significantly high and during 1982 and 1984 it was found to be significantly low.

The tests of significance of biennial tendency and time-trend are given in Table 4.4.4. The significant F_1 ratio revealed the existence of biennial tendency while the non-significant F_2 ratio revealed the absence of time-trend.

4.5. Effect of treatments on the magnitude of biennial tendency

The data utilised for this study was taken from RARS, Balaramapuram. The data consists of 109 WCT palms which are subjected to NPK manuring during the period under study. A visual expression of biennial tendency among these palms can be seen from Fig. 4.5. The trend of these palms exhibited alternate increase and decrease

in yield during the period from 1976 to 1987 except for the period 1977 to 1981.

The Table 4.5.1 gives the quantitative estimate of biennial tendency. The data covered a period of twelve years from 1976 to 1987 and as such the 'B' factor is based on 6 pairs of successive signs. A test of significance of bienniality can be obtained by calculating the probabilities

$$Pr\ (x) = 6C_x\ (\tfrac{1}{2})^x\ (\tfrac{1}{2})^{6-x},\ x = 0, 1, \ldots\ldots, 6.$$

Based on these probabilities a 'B' factor $\geq 2/6$ exhibited biennial tendency among these experimental palms ($\chi^2 = 13.35$). As such all the 109 WCT experimental palms showed significant bienniality.

The intensity of crop fluctuations are presented in Table 4.5.2. The intensity was found to be less than 50 per cent for 93.58 per cent of these palms. For the remaining 6.42 per cent of palms the 'I' factor ranged from 50 to 60 per cent.

The Table 4.5.3 gives the equiprobability of 'on' and 'off' phase. For these palms the equiprobability of 'on' and 'off' phase was observed only in 1978. The number of palms in the 'on' phase was found to be significantly high during 1977, 1979, 1980, 1981, 1982, 1985 and 1987

FIG 4.5 TREND IN AVERAGE YIELD - RESEARCH STATION - BALARAMAPURAM

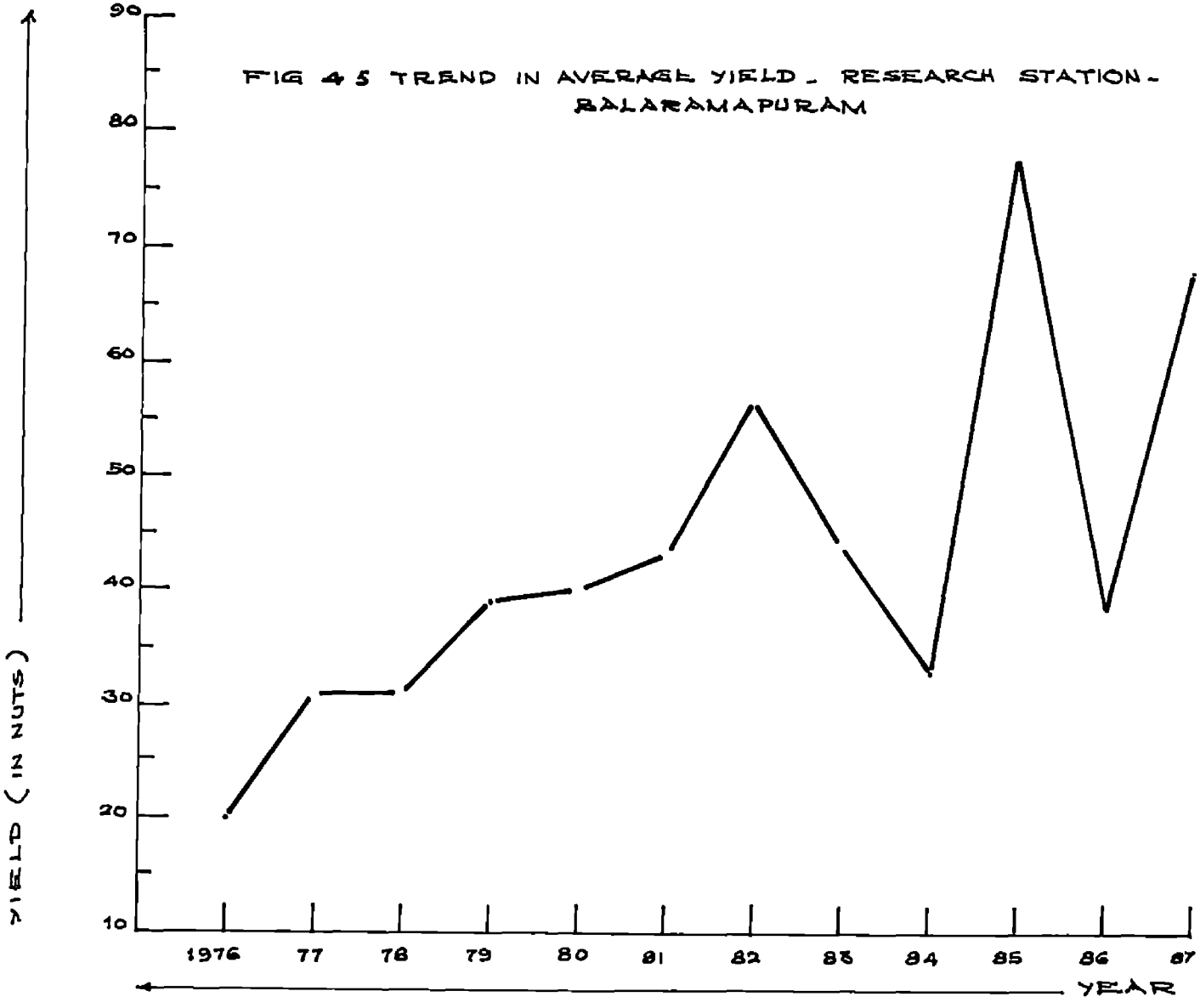

Table 4.5.1. Biennial tendency (Factor 'B')

Variety - WCT (Exp. palms) Research Station - Balaramapuram

Factor 'B'	No. of palms	Percentage of palms	Cumulative percentage
0/6	0	0.00	100.00
1/6	0	0.00	100.00
2/6	22	20.18	100.00
3/6	3	2.75	79.82
4/6	24	22.02	77.07
5/6	36	33.03	55.05
6/6	24	22.02	22.02
Total	109	100.00	

Table 4.5.2. Intensity of crop fluctuations (Factor 'I')

Variety - WCT (Exp. palms) Research Station - Balarampuram

Factor 'I'	No. of palms	Percentage of palms	Cumulative percentage
less than 10%	1	0.92	0.92
10 to less than 20%	20	18.35	19.27
20 to less than 30%	31	28.44	47.71
30 to less than 40%	31	28.44	76.15
40 to less than 50%	19	17.43	93.58
50 to less than 60%	7	6.42	100.00
Greater than 60%	0	0.00	100.00
Total	109	100.00	

Table 4.5.3. No. of palms showing 'on' and 'off' phase during the period 1976-1987

Variety - WCT (Exp. palms) Research Station - Balaramapuram

Year	equal yield	'on' phase	'off' phase	χ^2	Percentage 'on' phase
1976	3	21	85	38.64*	19.27
1977	3	85	21	38.64*	77.98
1978	6	57	46	1.17	52.29
1979	3	69	37	9.66*	63.30
1980	1	62	46	2.37	56.60
1981	6	69	34	11.89*	63.30
1982	0	79	30	22.03*	72.48
1983	2	29	78	22.44*	26.61
1984	3	27	79	25.51*	24.77
1985	0	103	6	86.32*	94.50
1986	4	11	94	65.61*	10.09
1987	1	95	13	62.26*	87.16
Total	32	707	569		54.03

* Significant at 5 per cent level

and in the remaining years it was found to be significantly low.

Tests of biennial tendency and time-trend were carried out with this data and the results are presented in Tables from 4.5.4 to 4.5.7. For all the varying levels of N, P and K the test of significance of biennial tendency and time-trend were carried out. For the zero, first and second levels of N, P and K the significant F_1 ratio revealed the existence of biennial tendency. F_2 ratio was not found to be significant in any of these cases pointing out the absence of time-trend. Significant biennial tendency was observed among all these palms treated with N and P. Except for the n_1 and p_1 level of N and P, time-trend did not influence these palms at all the other levels of NP combination. The F_4 ratio was used to test the significance of biennial tendency in the presence of time-trend for the palms treated with n_1p_1. The significant F_4 ratio revealed the existence of biennial tendency in the presence of time-trend among the palms. Biennial tendency was observed among palms treated with N and K but was not influenced by time-trend. Since the yield of palms was very low in the absence of K at these combinations, these palms were excluded from the tests of significance. For all the other palms treated with P and K the existence of biennial tendency and the absence

Table 4.5.4. Biennial tendency and time-trend (Tests of significance)

Variety - ICT (Exp. palms) Research Station - Balaramapuram

Treatment	No. of palms	M.S. due to contrasts					F ratio			
		X_1	X_2	X_3	X_4	X_5	F_1	F_2	F_3	F_4
n_0	26	1494.82	22073.98	3850.66	1089.08	3261.77	14.77*	0.58		
n_1	39	1095.78	14412.47	7529.44	1521.72	3288.64	13.15*	1.70		
n_2	45	1693.48	41940.08	11431.36	2671.06	7615.07	24.77*	0.97		
p_0	32	992.82	30720.22	10595.42	1727.32	6244.96	30.94*	1.26		
p_1	41	1844.19	29864.98	12748.39	2384.40	6320.71	16.19*	1.44		
p_2	36	1353.17	29274.71	5579.96	2232.75	4471.22	21.63*	0.67		
k_0	6	520.67	4024.97	1985.77	612.27	466.57	7.73*	1.42		
k_1	49	1512.87	16019.20	6244.36	1571.04	2834.69	10.59*	1.22		
k_2	54	1352.14	41206.48	12131.17	2615.66	7158.32	30.48*	1.07		

* Significant at 5 per cent level

Table 4.5.5. Biennial tendency and time-trend (Tests of significance)

Variety - WCT (Exp. palms) Research Station - Balaramapuram

Treatment	No. of palms	M.S. due to contrasts					F ratio			
		X_1	X_2	X_3	X_4	X_5	F_1	F_2	F_3	F_4
n_0p_0	10	624.71	32851.38	5162.84	1428.23	4988.84	52.59*	0.59		
n_0p_1	7	2135.48	14090.67	3996.62	1070.62	1992.62	6.60*	0.78		
n_0p_2	8	1532.79	12474.00	3069.71	891.71	1813.36	8.14*	0.72		
n_1p_0	8	1160.20	14938.00	3318.86	1053.64	3805.64	12.87*	0.72		
n_1p_1	17	1336.36	17562.00	11905.65	2427.07	4134.93	13.14*	2.21*		2.57*
n_1p_2	14	921.98	8361.30	2821.26	754.23	1370.40	9.07*	1.01		
n_2p_0	14	952.25	40741.45	14700.75	2237.91	8190.59	42.78*	1.35		
n_2p_1	17	2431.51	51679.38	15495.26	2829.57	10804.76	21.25*	1.05		
n_2p_2	14	1649.57	23785.81	4892.25	2232.99	3196.25	14.42*	0.68		

* Significant at 5 per cent level

Table 4.5.6. Biennial tendency and time-trend (Tests of significance)

Variety - *CT (Exp. palms) Research Station - Balaramapuram

Treatment	No. of palms	M.S. due to contrasts					F ratio			
		X_1	X_2	X_3	X_4	X_5	F_1	F_2	F_3	F_4
n_0k_0										
n_0k_1	9	2083.53	12286.86	2667.00	538.50	1688.00	5.88*	0.58		
n_0k_2	13	1220.07	32978.08	5265.36	1642.74	4772.03	27.03*	0.57		
n_1k_0										
n_1k_1	19	908.69	13592.92	7017.04	1234.99	3006.93	14.96*	1.72		
n_1k_2	19	1143.18	14888.05	7222.93	1739.09	3499.34	13.02*	1.58		
n_2k_0										
n_2k_1	22	1814.69	21396.41	5349.47	1706.16	3357.57	11.79*	0.80		
n_2k_2	21	1689.25	56521.53	13007.49	3168.09	10131.66	33.46*	0.84		

* Significant at 5 per cent level

Table 4.5.7. Biennial tendency and time-trend (Tests of significance)

Variety - WCT (Exp. palms) Research Station - Balaramapuram

Treatment	No. of palms	M.S. due to contrasts					F ratio			
		X_1	X_2	X_3	X_4	X_5	F_1	F_2	F_3	F_4
p_0k_0										
p_0k_1	15	984.21	16995.50	9224.24	1270.35	3839.74	17.27*	1.85		
p_0k_2	13	1195.03	43517.76	12238.58	2546.60	7743.73	36.42*	1.04		
p_1k_0										
p_1k_1	21	2117.93	12374.85	5757.43	1098.46	2130.69	5.84*	1.23		
p_1k_2	18	1517.23	46641.55	14397.23	2664.60	10050.25	30.74*	1.12		
p_2k_0										
p_2k_1	14	1262.40	19897.21	4111.52	1740.07	3571.23	15.76*	0.69		
p_2k_2	22	1362.18	32455.69	6752.36	2473.83	3918.54	25.83*	0.74		

* Significant at 5 per cent level

of time-trend were revealed by the F-test.

The presence of biennial tendency was reported by Saraswathi (1983) during the pre-experimental and experimental periods and its accence during the post-experimental period. Her studies revealed the predominance of biennial tendency at various levels of N and K and at higher levels of P. At 0.25 kg (per palm per year) level of P, presence of bienniality has been established.

A knowledge of the magnitude of bienniality in various hybrid varieties of coconut will be helpful to design experiments on them by utilising calibration techniques and also in the analysis of several years' yield data. If the yield data of 'on' and 'off' years are combined the biennial effect will be nullified and this combined data can be used for design and analysis. Bienniality is found to be independent of fertilizer application. So the production in the 'off' year may not be improved by fertilizer applications. Since bienniality is established in all the varieties of coconut studied the selection of adult palms for experiments need be selected on the basis of an even years' of yield data.

SUMMARY

CHAPTER V

SUMMARY

Coconut is a perennial crop which is also not free from the special characteristic of perennials, namely biennial tendency. The present study is conducted with the objective of estimating the magnitude of biennial tendency among hybrid varieties of coconut and to test for the significance of this tendency in comparison with WCT variety of coconut. Non-parametric and parametric approaches were used to estimate the magnitude of biennial tendency and time-trend and to test for their significance. The intensity of crop fluctuations was also estimated.

The trend line fitted to yield data for WCT and hybrid varieties of coconut for a period ranging from 12 to 16 years exhibited peaks and troughs in alternate years giving a rough idea of their biennial bearing tendency. An increasing or decreasing trend exhibited for shorter periods in the time interval may be attributed to climatic factors, especially rainfall.

A quantitative estimate of biennial tendency was obtained by the non-parametric approach using 'B' factor. The WCT palms taken from RARS, Pilicode; RARS, Kumarakom and CRS, Balaramapuram showed biennial tendency to a magnitude of 100 per cent, 52.26 per cent and 84.34 per cent respectively. The WCT palms which were subjected to NPK

manuring at CRS, Balaramapuram showed 100 per cent bienniality. Among hybrids NCD, LO x GB, and CC x GB palms exhibited 100 per cent bienniality. 97.59 per cent of WCT x CDG palms showed the biennial bearing tendency. Biennial tendency was less for T x AD and T x LD palms. 14.29 per cent of these palms showed significant bienniality. For the other hybrid varieties, viz. WCT x GB, AO x GB, Java x GB, LS x GB, T x G, T x SS, T x D, T x GB and Komadan, the magnitude of biennial tendency was respectively 94.12, 80, 83.33, 80, 71.42, 66.67, 95.69, 88.89 and 25 per cent.

The value of 'I' which is a measure of the intensity of crop fluctuations was found to be less than 50 per cent for almost all these varieties. For more than 60 per cent of the palms of all varieties the value of 'I' ranged from 20 to 50 per cent. The number of palms showing an 'I' value higher than 70 per cent was very few. For 82 to 98 per cent of the WCT palms the intensity of crop fluctuations was less than 50 per cent. 100 per cent of the AO x GB, T x G, T x AD, T x LD and T x GB hybrid varieties exhibited an intensity less than 60 per cent. Intensity of crop fluctuations was less than 50 per cent for 80 to 90 per cent of WCT x CDG, WCT x GB, LO x GB, LS x GB, T x SS and Komadan varieties, 60 to 70 per cent of CC x GB, Java x GB and T x D and 50 per cent of NCD palms. 50 per cent of the NCD palms showed high intensity of crop fluctuations, ranging from 70 to 90 per cent.

Distribution of palms in the 'on' and 'off' phase with respect to all varieties also gave an evidence of biennial tendency among these palms.

The test of significance of biennial tendency revealed the existence of biennial tendency among all the WCT and hybrid varieties except for T x AD and T x LD hybrid palms. Almost all the palms were found to be not influenced by time-trend. But the WCT experimental palms and WCT x CDG palms were influenced by both the time-trend and biennial tendency.

REFERENCE

REFERENCES

Abeywardena, V. (1962). Studies on biennial bearing tendency in coconut. Cey. Coco. Quart., 13: 112-25.

Abeywardena, V. (1966). Crop fluctuations in coconut. Cey. Coco. Plt. Rev., 47-53.

Abeywardena, V. (1968). Forecasting coconut crops using rainfall data (A preliminary study). Cey. Coco. Quart., 19: 161-76.

Abeywardena, V. (1979). Influence of watering on the yield of coconut. Cey. Coco. Quart., 30: 91-100.

Anonymous (1988). Agrometeorology of plantation crops. Directorate of Extension, Kerala Agricultural University, Mannuthy, Trichur, pp. 171.

Das, G.C. and Sahoo, S. (1981). Effect of gibberellic acid (GA_3) and Urea on the 'off' year shoots in Lanrga mango (Mangifera indica, L.). Orissa Journal of Horticulture, 9(2): 40-43.

Haldane, J.B.S. (1958). Suggestions for research on Coconut. Indian Coco. J., 12: 1-9.

Hoblyn, T.N. and Grubb, N.H., Painter, A.C. and Wates, B.L. (1936). Studies in biennial bearing. J. Pomol., 14: 39-76.

Marchetti, S. and Ughini, V. (1984). Possible use of a modified succession test in the evaluation of the degree of varietal susceptibility to alternate bearing in apple (Malus domestica). Annalidella Facolta Agraria Universita Catlolica del Sacro Cuore. 24(1): 15-24.

Northwood, P.J. (1967). The variation in Cashew yields in Southern Tanzania. E. Afr. agric. For. J., 32: 237-9.

Pal, R.N., Chadh, K.L. and Rao, M.R.K. (1984). Effect of different plant growth regulators and other chemicals on flowering behaviour of mango. Indian Journal of Horticulture, 41 (½): 8-15.

Pankajakshan, A.S. (1960). A note on the relative contribution of genetic and environmental factors on the yield of uniformly treated coconut trees. Ind. Coco. J., 14: 37-43.

Pearce, S.C. (1953). Field experimentation with fruit trees and other perennial plants. Common Wealth Bur. Hort. Plantation crops. Tech. Comm., 23.

Pearce, S.C. and Urbane, S.D. (1967). The measurement of irregularity in growth and cropping. J. Hort. Sci., 42(3): 295-305.

Saraswathi, P. (1983). Methodological studies in designing experiments on coconut. Unpublished Ph.D. Thesis, IARI, New Delhi, pp. 122.

Satyabalan, K., Sankar, N. and Chani, P. (1968). Studies on the bearing tendency of the coconut palm, 1 - Preliminary investigations. The character of irregular bearing and its incidence in different yield groups. Trop. Agri. Trin., 45: 67-71.

Shrikande, V.J. (1957). Some considerations in designing experiments on coconut trees. J. Ind. Soc. Agri. Stat., 9(1): 82-99.

Shrikande, V.J. (1958). Some considerations in designing experiments on Coconut trees. Indian Coco. J., 11(4): 140-157.

Singh, L.B. (1948). Studies in biennial bearing II. A review of literature. J. Hort. Sci., 24: 45-65.

Singh, L.B. (1961a). Biennial bearing in mango as affected by cultural operations, weather conditions and tree vigour. Hort. adv., 5: 17-23.

Singh, L.B. (1961b). Biennial bearing studies in mango - effect of Gibberellic acid and Maleic Hydrazide. Hort. adv., 5: 97-103.

Thampan, P.K. (1982). Handbook on Coconut palm. Oxford & IBH Publishing Co., New Delhi, pp. 311.

Webster, C.C. (1939). A note on a uniformity trial with oil palms. Trop. Agri. Trin., 16: 15-19.

BIENNIAL TENDENCY AMONG COCONUT HYBRIDS- A STATISTICAL STUDY

By
LATHY K S

ABSTRACT OF A THESIS
submitted in partial fulfilment of the requirements
for the degree
MASTER OF SCIENCE IN AGRICULTURAL STATISTICS
Faculty of Agriculture
Kerala Agricultural University

Department of Statistics
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
Mannuthy Trichur

1989

ABSTRACT

The present study deals with the objective of estimating the magnitude of biennial tendency among coconut hybrids and WCT and to test for their significance. Non parametric and parametric approaches were tried for the study. The intensity of crop fluctuations was also estimated.

The magnitude of biennial tendency was 100 per cent, 52.26 per cent and 84.34 per cent respectively for the WCT palms taken from RARS, Pilicode; RARS, Kumarakom and CRS, Balaramapuram. 100 per cent biennniality was observed for the WCT palms which were subjected to NPK manuring and for the hybrid varieties NCD, LO x GB and CC x GB palms. 97.59, 94.12, 80, 03.33, 80, 71.42, 66.67, 95.69, 88.80 and 25 per cent of the palms of WCT x CDG, WCT x GB, AO x GB, Java x GB, LS x GB, T x G, T x SS, T x D, T x GB and Komadan exhibited biennial tendency. T x AD and T x LD palms showed only 14.29 per cent biennniality. Intensity of crop fluctuations was less than 50 per cent for almost all these varieties. The distribution of palms in the 'on' and 'off' phase also established the existence of biennial tendency. The test of significance of biennial tendency established the existence of biennial tendency among all the WCT and hybrid palms except for T x AD and T x LD. The time-trend

was not found to be a significant characteristic for almost all the varieties. WCT palms which were subjected to fertiliser management during the period of the study and WCT x CDG palms were found to be influenced by both the time-trend and biennial tendency.