Journal of Plantation Crops 24 (2): 126-129, December 1996

Short Scientific Report

A STUDY OF YIELD VARIABILITY IN COCOA*

(Manuscript Received: Aug. '95, Revised: Dec. '95, Accepted: Mar. '96)

Trend and seasonal variation in yield is a common feature in most of the perennial crops. These variations are generally attributed to genetical, environmental and physiological factors. There have been many investigations to study the yield variability in perennial crops (Abeywardana, 1962, Satyabalan *et al.* 1968, Jacob Mathew *et al.* 1993). In the case of cocoa, Alvim (1977) reported that seasonal variations in yield is more pronounced in regions where there is marked seasonal variations in climatic factors like rainfall, temperature and sunshine hours. In perennial crop like cocoa, which gives yield throughout the year, the seasonal observations in yield cannot be considered as independent observations and hence the usual regression technique may not be suitable for the yield variability studies. In the present study, a time series model based approach has been tried to explain yield variations in cocoa in addition to trend and seasonal variations.

Monthly yield data (wt. of beans/tree) from 1973 to 1990 of 17 cocoa trees planted at a spacing of 2.7m x 5.4m at Central Plantation Crops Research Institute, Regional Station, Vittal during the year 1970 were considered for the present study. The yield data were compiled on quarterly basis as (1) December - February (2) March - May (3) June - August (4) September - November and obtained the series y_t with 72 observations (Fig. 1). Seasonal variation has been removed from the series y_t by taking deviations from the mean quarterly yield and then taking first order difference of the series, the trend factor has been removed (Chatfield, 1975). The resultant series Z_t (Fig. 2) is a stationary series. Auto-correlation function (ACF) and Partial auto correlation function (PACF) were worked out for the series Z_t Fig (3). Moving average process of order 2 (MA(2) has been fitted to the series Z_t using Melard's algorithm provided in the SPSS/PC 5.0.1 statistical software package. The estimated parameters and their standard errors of the fitted MA(2) process are shown in Table 1. Yield data of another set of 15 cocoa trees for 12 years planted at a spacing of 5.4m x 5.4m were used to verify the results.

Quarterly yield data of cocoa for 18 years (Fig 1) indicates that there is both trend and seasonal variations in production of cocoa. On an average 40% of fruits are harvested during June - August, 30% between March - May, 16% between September - November and the remaining 14% between December - February. Seasonal variation and trend has been removed from the series Y_t by taking deviation from the mean quarterly yield and then taking first order difference of the series. The resultant series Z_t (Fig. 2) is stationary and can be utilized for the time series analysis to find out any other estimable variations other than trend and seasonal variations which exists in the series Y_t. Auto correlation function and partial auto correlation function of the series Z_t (Fig. 3) indicates that the series is not random but it follows a moving average process of order two (MA(2)). Estimated parameters of the MA (2) process fitted to the series Z_t with their standard errors are shown in Table 1. Auto correlation function for the residual series a_t (Fig. 3) are not

* *CPCRI Contribution No. 915*

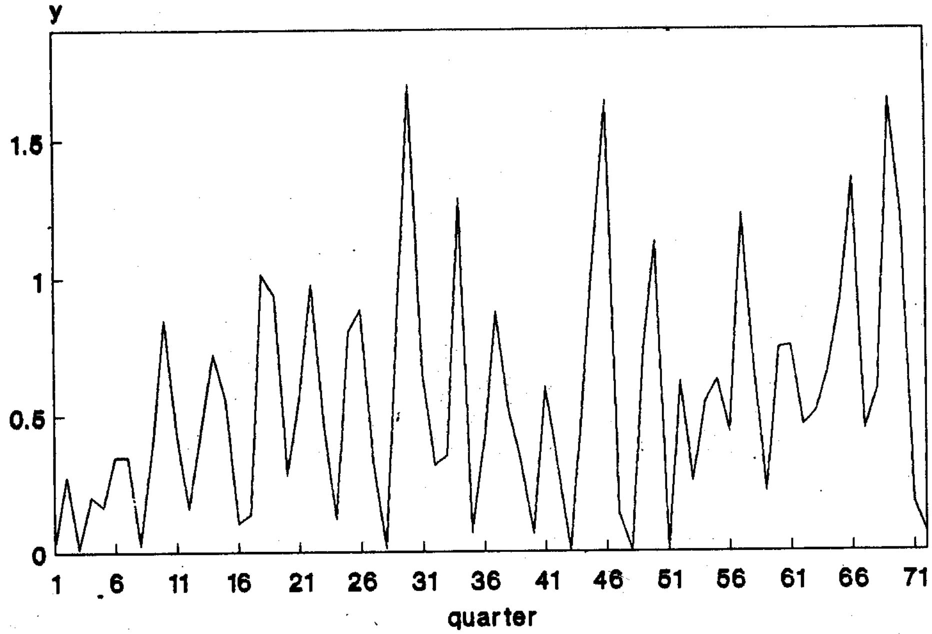

Fig. 1. Quarterly yield data of cocoa (dry bean weight/tree in kg.)

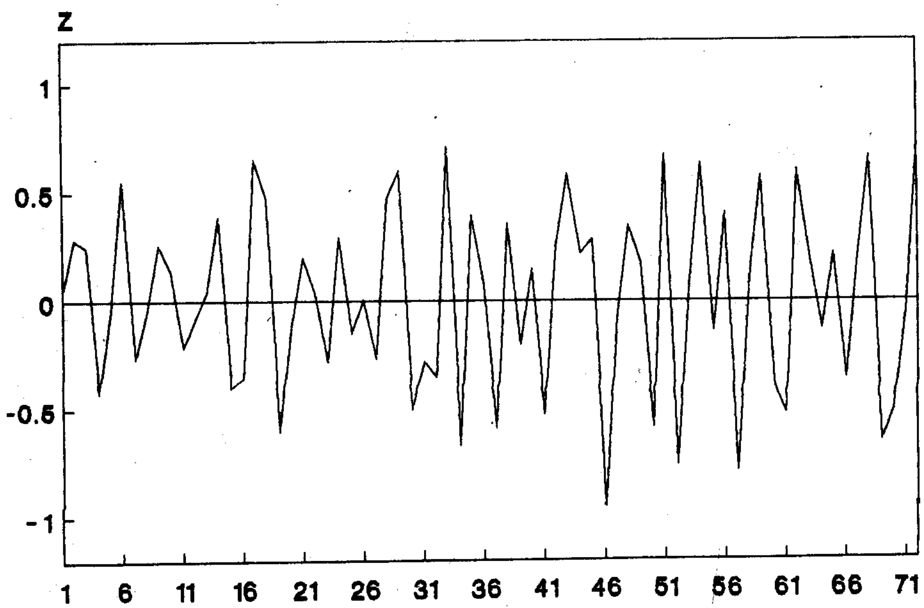

Fig. 2. Stationary series Z obtained by removing trend and seasonality from Y.

gnificant and thus it can be considered as random or white noise sequence.

The fitted model $Z_t = a_t - 0.575\ a_t\text{-}1$ 0.405 $a_t\text{-}2$ indicates that the random eviations in yield for the previous two seasons (quarters) inversely affects the current seasons (quarter) yield. Since 5-6 months is required from flowering to harvest in cocoa, this may be due to the large requirement of resources for maintaining the existing crop which ultimately affects

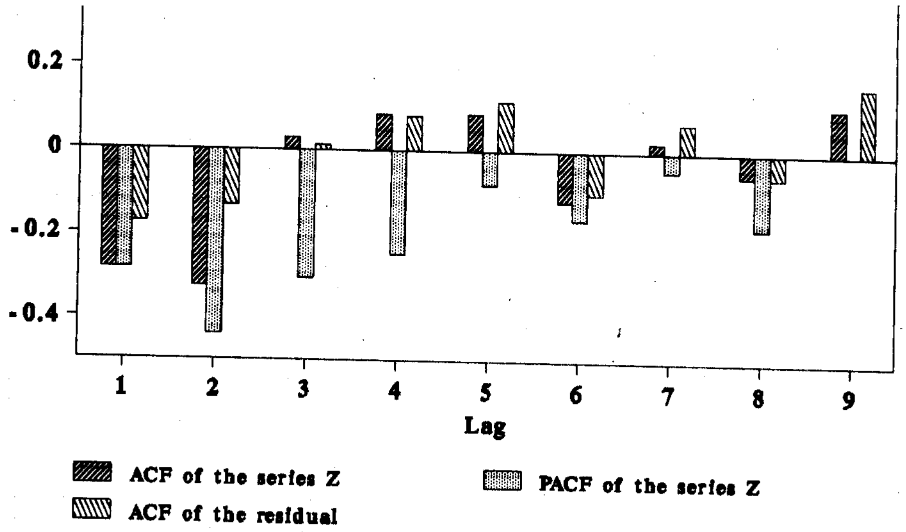

Fig. 3. Auto-correlation function and partial auto correlation function of the Zt.

flowering/fruit setting. Alvim (1984) reported that the flowering intensity showed marked increase by manual removal of the fruits in the tree. Hutcheon *et al.* (1972) observed that in regions where there is pronounced seasonal variations in flowering, the period of low flowering invariably occurs when the plants have the highest fruit load. The present study shows that yield deviation of a particular quarter will have inverse relationship with yield deviations in the previous two quarters which is the flowering season of the current crop. In other words, previous two quarters yield will have inverse effect on the current quarters yield. These are clear indications of a competitive relationship or a inverse effect of fruits on flowering. To verify the results, the above analysis were repeated for another set of 12 years data of 15 cocoa trees. The results are similar and the esti- mated parameters of the model (MA(2) process) with their standard errors are shown in Table 1.

The results thus indicate that in addition to the seasonal variation and trend the random

Table 1. ***Estimated parameters of the MA(2) process***

Set	Parameter	Value	SE	t-value
I	1	0.575	0.184	3.12
(17 trees)	2	0.405	0.141	2.87
II	1	0.477	0.175	2.73
(15 trees)	2	0.449	0.161	2.78

deviation in production for the previous two quarters also influence the cocoa yield of the present quarter. The MA(2) model fitted for the series Z_t gives the competitive relationship between yield deviations at different lag periods and this can be utilised for forecasting of cocoa yield by adding trend and seasonal factor in the model. It is important to consider this competitive factor for forecasting, crop-weather modelling and yield variability studies in cocoa.

ACKNOWLEGMENT

Author is grateful to Dr. M. K. Nair, Director CPCRI for the help and encouragement.

REFERENCES

BEYWARDANA, V. 1962 Studies on the biennial tendency in coconut 1. The measurement of bienniality in coconut. *Cey. Coc. Quart.* 13:112-125.

LVIM, P. de T. 1977 Cacao. In: *Ecophysiology of Tropical Crops*. (Eds.) Alvim, P. de. T. and Kozlowski, T. T. Academic Press, New York, 279-313.

LVIM, P. de T. 1984. Flowering of cocoa. *Cocoa Growers Bulletin* 35:23-31

HATFIELD, C. 1975 Analysis of Time Séries : Theory and Practice, Chapman and Hall, London.

ACOB MATHEW, NAMPOOTHIRI, K. U. K., PILLAI, R. S. N. and KESAVAN NAMPOOTHIRI C. 1993. Trend in oil palm yield during the early years of bearing under rainfed condition. *J. Plantn. Crops.*: 21(Supplement) 399-402.

HUTCHEON, W. V., SMITH, R. W. and ASOMANING E. J. A. 1972. Effect of irrigation on the yield and physiological behaviour of mature Amelonado cocoa in Ghana. *Trop. Agric.* (Trinidad) 50(4): 261-272.

SATYABALAN K., SANKAR N. and CHAMI, P. 1968. Studies on the bearing tendency of the coconut palm *(Cocos nucifera L.)* 1. Preliminary investigations : The character of irregular bearing and its incidence in different yield groups. *Trop. Agric.*, Trinidad. 45: 67-71.

Central Plantation Crops Research Institute,
Regional Station, Vittal - 574 243, Karnataka

C. T. JOSE