

YIELD VARIATIONS IN COCONUT*

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1. INTRODUCTION

As in the case of any other tree crop, the yield of the coconut palm too varies widely due to

- (1) Genetical Factors
- (2) Soil Factors
- (3) Nutritional Factors
- (4) Pest and Diseases
- (5) Climatic and Weather Factors

In the case of the coconut palm, the yield variations due to weather factors are much more pronounced than in the case of other tree crops. This is mainly due to the fact that the reproductive cycle of coconut is very long, and consequently a bunch of coconuts during its development faces the vagaries of the weather in all its extreme manifestations.

This paper reviews the knowledge gathered to date at the Coconut Research Institute of Ceylon regarding the seasonal variations of coconut crops due to weather changes—mainly the rainfall.

2. THE DEVELOPMENT OF A BUNCH OF COCONUTS

A normally healthy coconut palm delivers one mature bunch of coconuts more or less regularly every month. Each bunch goes through a long cycle of development, from the primordial stage to maturity, lasting about 3½ years. The primordia of the inflorescence are formed about 32 months before the spathe opens; those of the spekelets about 15 months before, and those of the female flowers about 12 months before. These floral components are not visible until the spathe opens, by which time considerable development has already taken place.

Within about a month of the opening of the spathe, some female flowers get successfully pollinated to form nuts and the unpollinated flowers fall off. Some of these nuts that are formed after pollination fall at a very early age. This is termed immature nutfall. After about the fourth month, immature nutfall is negligible. In about 12 months from the opening of the spathe, the bunch is ripe and ready for harvest.

Among these harvested nuts too, one may find nuts which are either without kernel or with imperfectly developed kernels. These are termed empties or barren nuts.

3. CROP FLUCTUATIONS WITHIN THE YEAR AND THE CONTRIBUTORY FLUCTUATIONS OF THE INDIVIDUAL CROP COMPONENTS

The magnitude of a particular crop will thus depend on a series of growth factors or crop components inherent in these development cycles. These are (1) the number of bunches produced (2) number of female flowers per bunch (3) percentage setting (4) immature nutfall (5) incidence of barren nuts and (6) copra out-turn.

The relative magnitudes of the six bi-monthly crops within the year and the crop components which are primarily responsible for making each crop what it is, are shown in Table 1.

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TABLE 1—Percentage increase or decrease in crop in relation to percentage increase or decreases in their crop components

<i>Crop</i>	<i>Bunches</i>	<i>F. Flowers per bunch</i>	<i>Percentage setting</i>	<i>Immature nutfall</i>	<i>Empty nuts</i>	<i>Wt/nut C. out-turn</i>	<i>Final crop Wt. of copra</i>
1st. Crop Jan.-Feb.	.. - 8.3	- 0.9	-22.6	- 2.9	+ 0.4	+ 7.9	-26.7
2nd. Crop Mar.-Apr.	.. + 1.2	+ 3.8	+ 5.3	+ 0.2	+ 0.7	+ 5.0	+14.0
3rd. Crop May-June	.. + 4.0	+ 4.6	+25.6	+ 2.2	- 0.1	+ 2.2	+42.1
4th. Crop July-Aug.	.. - 0.1	+ 9.6	+14.7	+ 1.7	- 0.2	- 4.3	+21.2
5th. Crop Sep.-Oct.	.. + 3.3	- 7.0	- 5.1	+ 0.2	- 0.4	- 8.6	-19.5
6th. Crop Nov.-Dec.	.. - 0.0	-10.0	-17.8	- 1.3	- 0.4	- 1.4	-31.1

The first crop (harvested during January to February) is normally 27% below the average for the six picks and is the second lowest crop for the year. It has the lowest percentage setting, the lowest number of bunches, and the heaviest immature nutfall. These adverse conditions are offset to a certain extent by the fact that it has the best copra-out-turn.

The second crop (i.e. March to April) is 14% above the average for the six picks. It is conditioned by slightly above average values in all the crop components. It records the second best copra out-turn.

The third crop (i.e. May to June) has the highest crop within the year, being 42% above the average. This is brought about primarily by very heavy setting. The number of bunches harvested is also the highest. It records the lowest immature nutfall. The copra out-turn is slightly above average and third best. The incidence of barren nuts is very high.

The fourth crop (i.e. July to August) constitutes the second best crop being 21% above average. Its percentage setting and the number of bunches is appreciably lower than the best crop. The out-turn is very poor. The immature nutfall is relatively low while the incidence of barren nuts is appreciable. A compensatory feature in this crop is that it records the highest number of female flowers per bunch.

The fifth crop (i.e. September to October) is a low crop being 20% below the average. The percentage setting is slightly below normal, the number of female flowers per bunch is very low and the copra out-turn the worst. However it is very favourable from the point of view of the number of bunches.

The sixth crop (i.e. November to December) records a drop of 31% below average and is the poorest crop. All the crop components show below average values in this crop. It is the worst from the point of view of the number of female flowers per bunch.

4. MATURE NUTFALL

Mature nutfall is another factor which though not classified as a crop component, is of no less importance to the coconut grower—especially the absentee landowner. Coconuts are harvested bimonthly. Some bunches mature before the harvest and mature nutfall occurs before the pick.

These fallen mature nuts constitute a fluid fraction of the crop, in the sense that the owner can lose them due to acts of omission and commission on the part of irresponsible human elements, without the owner being aware how much he has lost.

Mature nutfall can range from as much as 1% to 38% of the total crop. There is a fairly regular seasonal pattern in mature nutfall. The mean percentage mature nutfall in each of the picks (i.e. prior to the pick) is shown in Fig. 1.

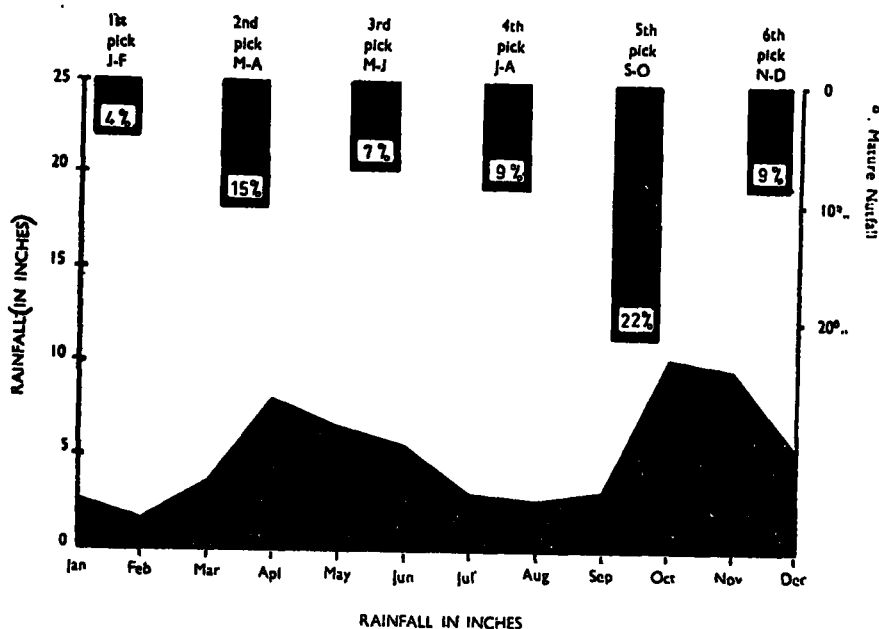


Fig. 1. Percentage Mature Nutfall

The highest mature nutfall is in the 5th pick (Sept.-Oct.), the second highest is in the second pick (March-April) and the lowest is in the first pick (January-February).

In Fig. 1 it is clear that the highest mature nutfall follows the two dry periods of the year—which are July-August and January-February. Out of these two periods too, mature nutfall is higher during the period following July-August, apparently because July-August being a dry period with longer day-lengths when compared with January-February, can be expected to bring about quicker maturity.

Detailed investigations are to be carried out with a view to ascertaining which meteorological factors contribute to quicker maturity resulting in higher mature nutfall. Work done on an interim basis shows that the mature nutfall is significantly related to the number of dry (rainless) days during the third month before the pick. Similarly if the number of bunches picked at the harvest is more, the period before such harvest should record a higher mature nutfall.

5. CROP FLUCTUATION— BETWEEN YEARS

The pattern of 'within year' crop fluctuations, explained above, is fairly consistent and therefore would be a satisfactory guide for most purposes. The fluctuations of crops between years, on the other hand, do not show any regularity whatsoever.

It is generally agreed that rainfall is the chief factor controlling these fluctuations. But the quantitative demonstration of this influence of rainfall leading to a prediction of crops on the basis of rainfall data has been elusive for a very long time.

Attempts by the Coconut Research Institute to understand crop variations as influenced by rainfall, can be considered under three periods.

Pre-1956 period

Coconut scientists and planters were aware that the previous year's rainfall controls a given year's crop. It has been explained already that the loss of nuts due to "poor setting" and/or immature nutfall takes place within about 3 to 4 months from the opening of the spathe. Thus the first 3-4 months of a developing bunch can be considered the critical period of moisture sensitivity. Therefore a bunch that is harvested in January of a given year would have its critical period of moisture sensitivity during January

to March of the previous year; the bunch that is harvested in February would have its critical period during February to April of the previous year; similarly all the bunches harvested within a given year would have their critical periods within the previous year.

Thus there is a valid basis for the belief that the rainfall in the previous year controls the crops of the current year.

In spite of this, our attempts to predict crops using previous year's rainfall did not meet with much success—the correlation coefficient (shown below) being low.

<i>Relationship</i>	<i>Correlation Coefficient</i>
Yield Vs. Total Rainfall	0.4066

It was our experience at Bandirippuwa Estate which has an average rainfall of 195.50 cms. (75 ins.) that in a certain year which had rainfall as much as 254.00 cms. (100 ins.); the crop realised was below average; in another year which had only 149.86 cms. (59 ins.) of rain, the crop was much above average.

Period 1956-1965

During this period, the concept of an effective rainfall invited our attention.

Every plant species in its bid for optimum growth lays down certain specific maxima and minima in respect of the quantity of rainfall needed. The coconut palm in its unique position as a perennial both in respect of growth and cropping is justifiably more exacting in this respect.

All the rain that falls is not available to plants. During a particular spell of rainfall, a fraction is lost as surface run-off, a fraction percolates through the soil to join the subterranean water, and a fraction is held in the soil as soil moisture. Plants get their water requirements chiefly from that fraction of rainfall held as soil moisture. Once the soil has taken in the maximum it could hold as soil moisture, any further rain will be a waste from the point of view of the plant. In fact it may even be harmful because this extra rain implies a reduction in the all important hours of sunshine. Therefore for any particular period—depending on the intensity of rainfall, the soil type and the atmospheric environment,—there is a certain maximum rainfall beyond which any further rain will be of no use to the palm.

Investigations have shown (Abeywardene 1962) that for most coconut growing areas, coconut crops do not respond to any rain over 35.56 cms (14 ins.) in a month. On this basis, an effective rainfall could be determined by deducting any rain in excess of 35.56 cms. (14 ins.) in a month.

By the incorporation of this concept of effective rainfall, our ability to predict crops showed some improvement as evidenced by the higher correlation coefficient given below:

<i>Relationships</i>	<i>Corr. Coefficient</i>
Yield Vs. Total Rainfall	0.4066
Yield Vs. Effective Rainfall	0.4869

Period 1966 onwards

Although the concept of an effective rainfall improved our understanding of crop variations, yet we were far from a satisfactory prediction.

During this period a further snag in our thinking came to light.

It was not incorrectly assumed earlier that the previous year's rainfall controls the current year's crop, because all the critical periods of moisture sensitivity in respect of the bunches harvested in a given year, fell within the year previous to the year of harvest. However, the snag lay in the fact that our thinking regarding the critical period of moisture sensitivity concentrated only on factors endogenous to the palm—namely the critical period of crop development. The fact that moisture sensitivity can be influenced by exogenous factors such as day-length, temperature and humidity escaped us until recently. Consequently our earlier assumption that the whole of the previous year was equally moisture sensitive fell far short of the true position. Different periods of the year justifiably carried different effective maxima for rainfall due to variations in the external environment.

A crop prediction function quantifying rainfall along these lines (Abeywardene 1968) yielded a correlation coefficient of 0.9345 enabling a prediction with an average error of $\pm 3\%$.

Table 2 and Fig. 2 gives the observed and predicted crops at Bandirippuwa Estate on the basis of our knowledge during the three periods mentioned above.

TABLE 2—Comparison of Observed and Predicted Crops (Bandirippuwa Estate)

Year	Observed crop per acre	Predicted crop based on total rainfall of previous year			Predicted crop based on effective rainfall			Predicted crop based on recent findings		
		Nuts per acre	Absolute error nuts/acre	% error in prediction	Nuts per acre	Absolute error nuts/acre	% error in prediction	Nuts per acre	Absolute error nuts/acre	% error in prediction
1935	3683	4412	729	17.9	4198	515	12.6	3754	71	1.7
1936	3419	3976	557	13.7	3835	416	10.2	3608	189	4.6
1937	4534	4376	158	3.9	4164	370	9.1	4521	13	0.3
1938	4052	4211	159	3.9	4247	195	4.8	4308	256	6.3
1939	3029	3567	538	13.2	3451	422	10.4	3284	255	6.3
1940	3564	3961	397	9.8	4105	541	13.3	3732	168	4.1
1941	4132	4072	60	1.5	4034	98	2.4	4077	55	1.4
1942	3920	3886	34	0.8	3878	42	1.1	3955	35	0.9
1943	4521	3913	608	14.9	3883	638	15.7	4361	160	3.9
1944	4310	3813	497	12.2	3835	475	11.7	4132	178	4.4
1945	3887	4106	219	5.4	4226	339	8.3	3856	31	0.8
1946	3767	4058	291	7.1	3734	33	0.8	3652	115	2.8
1947	4019	4293	274	6.7	4094	75	1.8	3895	124	3.0
1948	4145	3740	405	9.9	3920	225	5.5	4287	142	3.5
1949	3425	3940	515	12.7	4202	777	19.1	3418	7	0.2
1950	4475	4167	308	7.6	4037	438	10.8	4153	322	7.9
1951	4790	3899	891	21.9	4326	464	11.4	4689	101	2.5
1952	4299	4244	55	1.4	4567	268	6.6	4252	47	1.2
1953	3911	3867	44	1.1	3945	34	0.8	3845	66	1.6
1954	4182	4201	19	0.5	4270	88	2.1	4095	87	2.1
1955	4670	4214	456	11.2	4400	270	6.6	4417	253	6.2
1956	3688	4037	349	8.6	4138	450	11.0	4056	368	9.0
1957	3856	3840	16	0.4	3739	117	2.9	3647	209	5.1
1958	3547	4095	548	13.5	3936	389	9.6	3740	193	4.7
1959	4016	4058	42	1.0	3749	267	6.6	3893	123	3.0
1960	3949	3975	26	0.6	4077	128	3.1	3868	81	2.0
1961	4765	4320	445	10.9	4257	508	12.5	4829	64	1.6
1962	4475	4240	235	5.8	4311	164	4.0	4613	138	3.4
1963	4579	4194	385	9.5	4062	517	12.7	4607	28	0.7
1964	4518	4386	132	3.2	4641	123	3.0	4648	130	3.2
1965	4665	4147	518	12.7	4279	386	9.5	4749	84	2.1
1966	3481	4069	588	14.4	3738	257	6.3	3334	147	3.6

100 nuts/acre = 2471 nuts/hectare

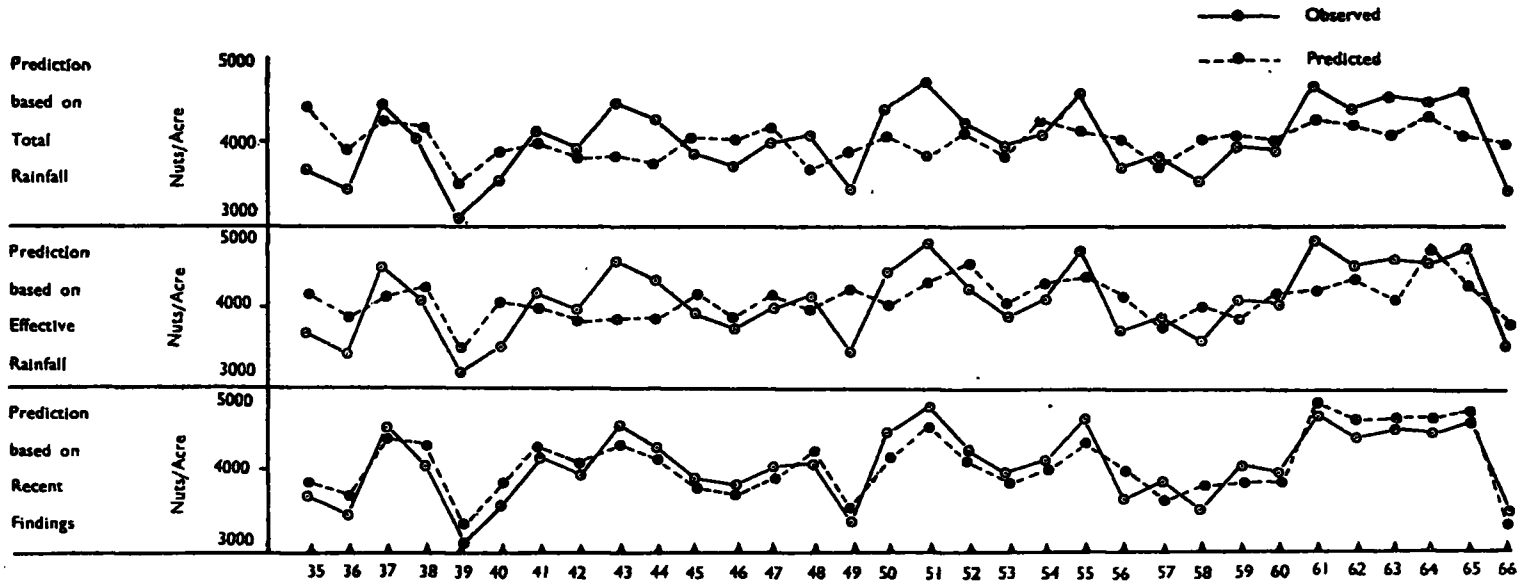


Fig. 2. Observed and Predicted Crops (Bandirippuwa Estate)

6. CROP-FORECASTING PROJECT

The Coconut Research Institute has now approved of a "Crop Forecasting Project" wherein it is intended to direct investigations towards offering crop forecasts for different regions of the Island and also for the whole Island.

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