THE RAINGAUGE AND ESTATE MANAGEMENT

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INTRODUCTION

The high magnitude of the annual fluctuations in a coconut crop resulting from the weather alone, is one of the most disconcerting features in coconut estate management. It is universally accepted that given a stable form of management and ignoring any long term trends for whatever reason it may be, the annual fluctuations in coconut crops are necessarily caused by the weather — mainly the rainfall. This is particularly so in the tall variety, the dwarf variety being supposed to be a seasonal bearer in its own right. But while this fact remains unchallenged, it is so queer and discouraging to find that very often our crops are far from what we would reasonably expect on the basis of past total rainfall. This is confirmed by the numerous queries we receive from planters, both officially and unofficially, regarding their crop fluctuations. However the need for satisfying themselves that their crops are not abnormal remains with them as insistent as ever — in fact it grows with the swiftly developing tempo of managerial control of plantations on modern lines.

The purpose of this article is to meet this need of planters to some extent. Herein we shall discuss some broad basic facts regarding the availability and effectiveness of rainfall from the point of view of a year's coconut crop. Based on these facts we shall provide the coconut planter with a more meaningful guide to his crop variations through rainfall data. Although in this institute, our approaches to such problems are more mathematical, the methods suggested in this article are simple and non-mathematical and could be handled by a clerical assistant with a fair knowledge of simple arithmetic. It has, of course, to be appreciated that this simplicity is achieved only through the inevitable sacrifice of some precision and therefore one should expect in this method only a rough guide — yet a more precise one than any hitherto known — for determining whether or not a particular year's crop is abnormal.

The effective period of rainfall in respect of a year's crop

A particular year's coconut crop is the final outcome of several crop components which are conditioned long before the actual pick. These are the number of bunches, number of female flowers in a bunch, percentage setting, immature nutfall and size of nut. The fluctuations in the final crop are merely the nett result of the fluctuations of these individual components and the fluctuations of these individual components are controlled at varying degrees by rainfalls occurring at periods varying from 3 months up to as much as 3 years prior to the mature crop. Therefore if we are to explain annual crop variations very precisely, we may have to consider a full 3-year period of rainfall prior to the crop — in fact different overlapping sections of this 3-year period as relevant to each of the above factors will have to be weighted differently depending on the relative importance of the different factors in a particular set of circumstances.

But it will be beyond the scope of this article to consider resolving these implications in such detail. We shall be well within the present purpose, if we restrict ourselves to a much shorter period such as the 12-month period preceding the crop year, because this period covers the setting of female flowers, the emergence of inflorescences and, to some extent, the immature nutfall in respect of all the bunches that mature in a particular year; and in most coconut growing areas these factors together can account for nearly 90% of the annual fluctuations of the final crop. On this basis, there is ample justification to reckon the preceding year's rainfall as the effective period of rainfall for a particular year's crop. For instance, if we are considering the crop of (say) 1960, the effective period of rainfall will be January to December 1959.

Effective quantity of rainfall

Not all the rain that falls is available to plants. When we consider 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; and these fractions invariably depend on each other and also on the soil conditions and the intensity of rainfall. The plants get their water requirements only from that fraction of rainfall held as soil moisture. In fact while the soil moisture itself forms only a fraction of the total rain, the availability to plants is further reduced by evaporation from the soil. Again once the soil has taken in the maximum it could hold as soil moisture, any further rain will be totally non-effective from the plants' view point — in fact it may even be harmful.

Therefore one can imagine that for any particular period, depending on the intensity of rain, the soil type and the atmosphoric environment, there is a certain maximum rainfall, beyond which any further rain will be of no use to the palm. From investigations carried out by us, it appears that, for Chilaw district, coconut crops do not respond to any rain over 14 inches in a month on an average. But it will be appreciated that this maximum value will vary according to the condition of the soil at commencement of the rainy spell. It will be high if the month preceding has been dry or droughty because more rain will be required to re-condition the already depleted soil moisture status of the soil; and it may be low if the preceding month has been wet.

Therefore, when we wish to determine the effective quantity of rainfall in a particular month, we have to give some weight to the preceding two months' rainfall as well.

Table I, below gives some approximate values of maximum monthly effective rainfall limits, for various ranges of the previous 2-months' rainfall. These values may be applicable to most estates in Chilaw, Kurunegala, Puttalam and Colombo districts. As we have not studied any data in Galle district, in the wet zone, we are not in a position to recommend these values to the wet zone.

TABLE I

Maximum monthly Effective Rainfall Limits

2nd month prior → / *1st month prior* ↓	*Column* (1) 0 – 2 *ins.*	*Column* (2) 2 – 5 *ins.*	*Column* (3) 5 – 10 *ins.*	*Column* (4) 10 – 15 *ins.*	*Column* (5) 15 – 20 *ins.*	*Column* (6) 20 and above *ins.*
Row (1) 0 – 2 ins.	18	16	14	12	10	8
Row (2) 2 – 5 ins.	16	14	12	10	8	8
Row (3) 5 – 10 ins.	14	12	10	8	8	8
Row (4) 10 – 15 ins.	14	12	10	8	8	8
Row (5) 15 – 20 ins.	14	12	10	8	8	8
Row (6) 20 & above ins.	14	12	10	8	8	8

The maximum effective limit for a particular month is obtained by noting the column relevant to the rainfall observed in the second month prior to the month under consideration and also the row relevant to the first month prior to the month under consideration.

Then working down the column and across the row, the corresponding maximum limit could be read.

Example 1

The effective quantity of rainfall for the month of October 1960 is required, when the observed rainfalls are as follows:—

2nd Month Prior	*1st Month Prior*	*Month Considered*
August 1960	*September* 1960	*October* 1960
4.12 ins.	18.16 ins.	24.10 ins.

The rainfall two months' prior being 4.12, the relevant range is 2 – 5 and therefore column (2) will be the appropriate column.

The rainfall in the previous month being 18.16, the relevant range is 15 – 20 and therefore row (5) will be the appropriate one.

Working downwards along column (2) and across row (5), we find that the corresponding maximum effective limit is 12 inches.

Example 2

The effective rainfall for January 1960 is required, when the observed rainfalls are as follows:—

2nd Month Prior	*1st Month Prior*	*Month Considered*
November 1959	*December* 1959	*January* 1960
18.45 ins.	6.00 ins.	7.64 ins.

Column (5) and row (3) are appropriate in this case and the effective limit is given as 8 inches.

Once we have obtained the maximum effective limit for a particular month, the effective quantity of rainfall for the month is obtained as follows. If the observed rainfall is higher than the maximum limit, the maximum limit is taken as the effective rainfall and if the observed value is lower, then the observed value itself is taken as the effective rainfall. In Example I, for instance the maximum limit was found to be 12 inches. Therefore the effective rainfall in October 1960 is only 12 inches although the observed rainfall is 24.10 inches. In Example II the maximum limit is 8 inches and observed rainfall is 7.64 ins. Therefore the effective rainfall is 7.64 ins.

In Table II on page 7, we have calculated the total effective quantity of rainfall for the year 1960 at Bandirippuwa Estate.

The effective quantity of rainfall in 1960 is the sum of the effective rainfalls for the 12 months i.e. 75.54 inches and this incidentally will be the rainfall that controls the crops of 1961.

A Distribution Index for the Effective Rainfall

From the point of view of higher availability and greater effectiveness of rainfall, and also the elimination of pronounced dry spells, a more uniform distribution of rainfall over the year is very important. Most planters appreciate this fact and are quite accustomed to speak in terms of rainfall distribution. But it is doubtful whether anyone has been fortunate enough to measure rainfall distribution by means of a numerical index. Some probably base their judgment on distribution of rainfall by mere observation which is vague and some use the number of rainy days as the distribution index which, we have found, does not indicate any thing more than what is indicated by the total rainfall.

We shall give below a method of determining a simple yet effective index of rainfall distribution.

The data required are the effective monthly totals of rainfall obtained by the method suggested earlier.

TABLE II

EFFECTIVE RAINFALL IN 1960 AT BANDIRIPPUWA

	Nov. 59	Dec. 59	Jan. 60	Feb. 60	Mar. 60	Apr. 60	May 60	June 60	July 60	Aug. 60	Sep. 60	Oct. 60	Nov. 60	Dec. 60
Observed rainfall	11.49	1.13	0.57	3.30	2.02	17.59	14.10	3.50	15.58	0.91	2.15	14.07	12.64	1.02
Maximum Limit	—	—	12.00	18.00	16.00	14.00	12.00	8.00	10.00	12.00	10.00	16.00	12.00	8.00
Effective rainfall	—	—	0.57	3.30	2.02	14.00	12.00	3.50	10.00	0.91	2.15	14.07	12.00	1.02

The following computational procedure will lead to the distribution index.

1. Obtain the 2-monthly moving averages (11 in all) for the 12 effective monthly totals of rainfall for the year under consideration. The first average being the average of January and February, the second average that of February and March, the third that of March and April — so on and so forth.

2. For these averages, calculate the average deviation from their mean. This is obtained by (i) totalling these averages and dividing by 11 to get their mean; (ii) calculating the differences of each moving average from their mean calculated in (i) — there being 11 differences in all; and (iii) calculating the average of these 11 differences.
The latter average is termed the 'mean deviation'.

3. The index of distribution is given by $\frac{\text{Mean of moving averages (i).}}{\text{Mean Deviation (iii)}}$

The higher this index, better the spread of rainfall over the year and *vice versa.*

It will be interesting to calculate the index of distribution by the above method and see for oneself how vague and misleading an assessment by observation or any other methods can be.

Table III, below shows the various steps in the computation of the index of distribution for the monthly effective rainfall of, Bandirippuwa Estate for the year 1960 calculated earlier.

TABLE III
INDEX OF DISTRIBUTION — 1960

1960	*Effective Rainfall (Ref. Table II)*	*2 monthly Moving Averages*	*Deviation from mean*
Jan.	0.57	$\frac{1}{2}$(0.57 + 3.30) = 1.94	6.80 − 1.94 = 4.86
Feb.	3.30	$\frac{1}{2}$(3.30 + 2.02) = 2.66	6.80 − 2.66 = 4.14
Mar.	2.02	$\frac{1}{2}$(2.02 + 14.00) = 8.01	8.01 − 6.80 = 1.21
April	14.00	$\frac{1}{2}$(14.00 + 12.00) = 13.00	13.00 − 6.80 = 6.20
May	12.00	$\frac{1}{2}$(12.00 + 3.50) = 7.75	7.75 − 6.80 = 0.95
June	3.50	$\frac{1}{2}$(3.50 + 10.00) = 6.75	6.80 − 6.75 = 0.05
July	10.00	$\frac{1}{2}$(10.00 + 0.91) = 5.46	6.80 − 5.46 = 1.34
August	0.91	$\frac{1}{2}$(0.91 + 2.15) = 1.53	6.80 − 1.53 = 5.27
Sept.	2.15	$\frac{1}{2}$(2.15 + 14.07) = 8.11	8.11 − 6.80 = 1.31
Oct.	14.07	$\frac{1}{2}$(14.07 + 12.00) = 13.05	13.04 − 6.80 = 6.24
Nov.	12.00	$\frac{1}{2}$(12.00 + 1.02) = 6.51	6.80 − 6.51 = 0.29
Dec.	1.02		
Mean		6.80	2.90

$$\text{Index of distribution} = \frac{6.80}{2.90} = 2.34$$

Coconut crop vis a vis effective rainfall and distribution indices

Now we are armed with two criteria for judging (or predicting) our annual coconut crop — namely the total effective rainfall and the index of the rainfall distribution in the previous year.

It is to be expected that given the same distribution of rainfall, the crop will increase as the total effective rainfall increases, with the reservation that as we get up to higher rainfall, the increase in yield per unit increase in rainfall becomes less and less. In technical jargon, we say that the relationship of crop with rainfall follows the law of diminishing returns. Given the same total effective rainfall, the crop increases as the Index of distribution increases. For a higher effective rainfall and low distribution index and *vice versa* or medium rainfall and medium distribution, the crop should be average. For a high effective rainfall and high index of distribution the crop should be extremely good. For a low effective rainfall and low distribution index, the crop should be very poor. Crop prospects for intermediate situations will obviously be intermediate.

Crop Variations and Rainfall at Bandirippuwa Estate

Let us apply the above procedures on Bandiruppuwa Estate data and ascertain to what extent we can justify the crop variations in different years.

Table IV gives for the period 1935-1957 the crop per palm in each year, the corresponding total rainfall, the effective rainfall and the distribution index, for the year previous to the crop year. The years 1944, 1945 and 1946 have been avoided because the yields have been mixed up. The data are arranged in descending order of yield (i.e. crop per palm). The effective rainfall, the distribution index and the yields have been further broadly classified arbitrarily as very high, high, medium, low and very low etc. For a particular estate one may prepare his own arbitrary scales in respect of the two indices, alloting for the medium a range near the mean value over a number of years, for the very high a range near the highest observed value, for the very low a range near the lowest observed value and similarly for intermediate situations.

The scales of classifications used now are as follows:—

Effective Rainfall

CLASS	*Range of Effective Rainfall (inches)*
Very High ..	75 & above
High ..	68 – 74
Medium ..	60 – 67
Low ..	50 – 59
Very Low ..	below 50

Distribution Index

CLASS	*Range of Index*
Excellent ..	3.00
Very High ..	2.50 – 3.00
High ..	2.25 – 2.50
Medium ..	2.00 – 2.25
Low ..	1.80 – 2.00
Very Low ..	1.80

Table IV given below contains these classifications too.

TABLE IV

Crop Year	Crop Nuts/ Palms	Previous year's rainfall			Crop Classification	Rainfall Classification	
		Total Rainfalls	Effective Rainfall	Distri. Index		Effective Rainfall	Distribution Index
1951	72.6	67.66	65.86	3.13	Very High	Medium	Excellent
1955	70.8	93.70	81.98	2.75		Very High	Very High
1937	68.7	93.26	75.25	2.77		Very High	Very High
1943	*68.5*	*69.37*	*65.33*	*2.00*		*Medium*	*Medium*
1950	*67.8*	*86.37*	*72.04*	*1.87*		*High*	*Low*
1952	*65.1*	*94.09*	*79.19*	*3.42*		*Very High*	*Excellent*
1954	63.4	88.30	73.53	2.08	High	High	Medium
1948	62.8	59.93	59.93	3.49		Low	Excellent
1941	*62.6*	*81.92*	*67.21*	*1.83*		*Medium*	*Low*
1938	61.4	87.41	75.53	1.97		Very High	Low
1947	*60.9*	*97.89*	*72.11*	*1.95*		*High*	*Low*
1942	59.4	71.97	61.62	2.11	Medium	Medium	Medium
1953	59.3	62.40	62.40	2.14		Medium	Medium
1957	*58.4*	*53.27*	*53.27*	*2.06*		*Low*	*Medium*
1956	55.9	83.41	71.34	1.78	Low	High	Very Low
1935	55.8	100.08	73.14	1.79		High	Very Low
1940	*54.0*	*70.07*	*70.07*	*2.54*		*High*	*Very High*
1949	*51.9*	*73.35*	*66.64*	*2.94*	Very Low	*Medium*	*Very High*
1936	51.8	66.94	62.62	1.92		Medium	Low
1939	45.9	47.81	47.81	2.04		Very Low	Medium

Let us study the crops from the point of view of these two indices viz. the effective rainfall and distribution index. The data in italics may be avoided for the present because they do not fall into the general pattern. These will be explained later.

(*a*) General Pattern

From table IV, we observe that the total rainfall which is generally used to explain crop variations is very inadequate to explain the crop. In fact the very low crop of 55.8 nuts per palm in 1935 is associated with the highest total rainfall of 100.08 inches in 1934; and very high yields of 72.6 nuts per palm in 1951 and 62.8 in 1948 are associated with very low rainfalls of 67.66 and 59.93 inches.

When we take the effective rainfall alone, the position is slightly improved but not sufficient to explain the crops to any appreciable degree.

When we take the distribution index alone, we seem to be in still better a position than taking the effective rainfall alone. Yet there are far too many deviations in the crops from what we would expect on the basis of this index alone.

But when we take both factors into consideration, we are in a better position to explain the crops. The following general trends are very clear:—

(1) Very high yields are associated with either very high effective rainfall and very high distribution index or medium rainfall and excellent distribution index.

(2) High yields are associated with either high effective rainfall and medium distribution or very high effective rainfall and low distribution or low effective rainfall and excellent distribution.

(3) Medium yields are associated with medium effective rainfall and medium distribution.

(4) Low yields are associated with high effective raiafall and very low distribution.

(5) Very low yields are associated with either medium effective rainfall and low distribution or very low effective rainfall and medium distribution.

(*b*) Deviations from the general pattern

The above patterns are reasonable with what we have set out earlier and our judgment based on the two indices has given us a close justification of our crops in most years. But as seen in the data given in italics, there are a few years that have belied our expectations.

In order to understand these deviations, we may have to extend beyond our present concept of effective period of rainfall. For the purposes of this article we decided earlier to restrict ourselves only to the preceding 12-months' rainfall, which we have now found to be satisfactory more often than not. But it will be useful to remember that while the preceding 12-months' rainfall is very important, extreme departures from the normal either on the favourable or unfavourable side in the second half of the second year previous to the crop year and the first half of the crop year itself also can bring in appreciable differences on the crop though not to such a degree as the preceding 12-months' period.

Let us see what has happened in these abnormal years.

The year 1943 has given a very high yield although the effective rainfall has been medium and the distribution too is medium, a set of circumstances under which we would not have expected anything above medium yield. We find that the second half of 1941 has had favourable rainfall and the first two months of 1943 have had a rainfall above normal — hence the very high yield observed.

The year 1950 with only a high effective rainfall and low distribution too should not have given anything above medium crop. But the high yield observed is again explained by the unusually good rainfall in the last quarter of 1948 and first quarter of 1950.

The year 1952 with a yield of 65.1 nuts per palm although very high, should on the basis of the very high effective rainfall and excellent distribution, have registered a much higher yield. But we find that the *total* rainfall during the period December 1951 to April 1952 has been only 14.58 inches — very much below the normal for this period.

The year 1941 with only a medium effective rainfall and low distribution, could have given only a low yield. But it has given a high yield of 62.6 nuts per palm. We are not in a position to explain this high yield by any of the above methods.

The high yield of 60.9 nuts per palm recorded in the year 1947 with a high effective rainfall and low distribution is too high. We would have expected only a medium yield. The reason is due to the fact that the first quarter of 1947 recorded very favourable weather.

The year 1957, with low rainfall and medium distribution, has given a medium yield of 58.4 nuts per palm. It should have been slightly less. It is observed that the rainfall in the last quarter of 1955 is much above normal — hence the showing up.

The year 1940 with a high effective rainfall and very high distribution should have given at least a high yield (say within a range of 60 – 65 nuts). But the crop of 54.0 nuts per palm observed is low. This is because of the extremely droughty conditions that prevailed in 1938 — the rainfall for the period May to December 1938 being only 20.52 inches when the average for the corresponding period is nearly 60 inches.

The year 1949 with a medium effective rainfall and very high distribution, should have recorded a high yield or anything above medium. But the observed crop is very low (51.9 nuts per palm.) This is due to the complete failure of the inter-monsoonal rain in the second half of 1947 and also the extremely droughty conditions in the first quarter of 1949.

A Crop — Control Chart for your Estate

Arising from the above, the following procedures will lead to the preparation of a very handy crop — control chart for one's estate.

(1) At least 15 years' monthly rainfall totals are required. If rainfall data are not available for the estate, data from the nearest rainguage in the locality may be used tentatively. The latter may be obtained from the Colombo Observatory or from the Coconut Research Institute.

(2) Calculate the total effective rainfall and the distribution index for each year.

(3) Classify the effective rainfall and the distribution index as High, Medium and Low — a range near the mean value over a number of years may be classified as medium, values above the medium may be classified as high and values below the medium as low.

(4) Then for any year, its rainfall will be indicated by any one combination of the classifications for effective rainfall and distribution.

(5) Refer up Chart I (below), and obtain the expected crop in the following year.

(6) When the observed crop is far above or below the expected crop shown by the chart, look up the rainfall in the last quarter or so of the 2nd. year, prior to the crop year and or the first quarter of the crop year itself, to see whether such rainfalls are much above or below the normal for the periods in question.

(7) Any crop — control chart prepared on the above lines without the help of the past crops has to be considered as tentative, although it may in most instances be quite adequate.

After checking up with a few years' crops, the chart may be adjusted to be more precise.

In fact, what we have given in the Chart as Very High, High etc., can conveniently be put down as so many nuts per acre or nuts per palm.

For further guidance, the Coconut Research Institute may be consulted.

CHART I

RAINFALL vs. CROP