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**A note on the yield of coconut in relation to rainfall
and leaf rot and root (wilt) diseases**

By

K. RADHA, K. N. SAHASRANAMAN & K. P. V. MENON,
Central Coconut Research Station, Kayangulam.

Environmental conditions associated with the productivity of the coconut palm have been discussed in detail by Dwyer (1938) and Menon and Pandalai (1958). The effect of climate and fundamental characters of the palm on the bearing capacity have also been reported by Patel (1938), Sayeed and Narayana (1953) and Vasudevan Pillai and Satyabalan (1960). No reports regarding yield in relation to weather and diseases have been made so far. Observations on the yield of palms as related to rainfall and the two important diseases, namely Leaf rot and Root (wilt) diseases are presented in this communication.

MATERIALS AND METHODS

One hundred palms belonging to five groups viz., healthy, leaf rot affected, and root (wilt) diseased in the early, middle and advanced stages of infection were selected from the non-experimental plots at the Central Coconut Research Station, Kayangulam. The data on the yield of nuts during the eight harvests in a year were collected from 1950 to 1960. The rainfall received during 1948 to 1960 was also recorded. Although individual tree record of yield has been maintained it is presented here as the average for 20 trees under each category. This as well as the monthly meteorological data have been summarised to represent the periods (1) January to April, (2) May to August and (3) September to December which roughly coincide with the dry months, South-west monsoon and North-east monsoon periods respectively. For the sake of comparison the yield data for the 8 harvests had to be split up so that the periods (1) and (2) consist of three harvests each and the period (3) has only two harvests.

RESULTS

Yield

Considerable fluctuation in the yield of palms in all groups during the different harvests was observed. However, the general trend indicates

seasonal variation in the yield of healthy and diseased palms. Higher yield was recorded during the first two periods *i.e.*, January to April and May to August in all the palms, the period of maximum yield remaining inconsistent for the healthy as well as diseased. Yield of nut during September to December was consistently poor in all the palms throughout the period of observation. The data in Tables 1 a & 1b indicate the average yield per tree during the different periods, and the average annual yield per tree.

Rainfall

The distribution of rainfall during the period 1948-60 is presented in Tables 2a & 2b. Annual rainfall ranges from 162.4 cm. to 357.48 cm. with an average of 249.98 cm. The period May to August records 64.02 per cent. of the total rainfall, hence variations in rainfall during this period was not considered to be important in influencing the yield. On the other hand, rainfall received during the hot weather *i. e.*, January to April and North-east monsoon, September to December accounting only to 8.3 per cent. and 27.37 per cent. of the total respectively were treated as important rains.

Yield in relation to rainfall

Annual rainfall:- A study of the average annual yield and annual rainfall for the same year indicates that a precipitation of 200 to 250 cm. is favourable for the productivity of coconut in this tract. Maximum yield of healthy and diseased palms was recorded in 1954, a year of well distributed rainfall amounting to 250.89 cm. On the other hand, the poorest yield, 48.8 nut per healthy tree was recorded in 1952 so also the lowest rainfall, 162.4 cm. (Table 1 b).

Seasonal rainfall:- Correlation between yield and seasonal rainfall during January to April and September to December was also studied. (Tables 3 & 4).

For significance at 5 per cent. level calculated value of r should be outside ± 0.6021 . Thus none of the coefficients calculated were significant, thereby indicating that the rainfall of the periods tested has no significant bearing on the yield of palms in this study.

Yield in relation to disease

Taking into consideration the average annual yield, marked reduction was observed in the diseased palms as compared to the healthy (Table 1). The palms affected by Leaf rot exhibited advanced stage of disease and their reduction in yield was to the extent of 70 per cent. In the case of palms affected by Root (wilt) disease, the initiation of the disease resulted in definite

reduction in yield, which progressively increased with the advancement of disease. Average per tree yield in the different groups for the observational period as expressed on percentage basis is:-

Healthy	100
Palms affected by Leaf rot	28.3
" " Root (wilt) disease early stage	56.7
" " " " middle stage	35.9
" " " " advanced stage	17.6

DISCUSSION

Coconut being a rainfed crop in the west coast of India the vital influence of rainfall on the yield of palms need no emphasis. However, the fact that factors other than rainfall also influence yield is indicated by the observations reported by Balasubramanian (1956) on the bearing capacity of palms at Kasaragod and Pilicode. He recorded differential behaviour of palms when the pattern of rainfall is similar and recognized the primary importance of soil and the intrinsic difference in the growth and bearing capacity of the palms in the two localities. Our observations for a period of eleven years point out the tremendous influence of disease on yield, the initiation and intensity of disease playing a dominant role in the productivity of the palm. The progressive reduction in the yield of diseased palms, after 1957 irrespective of the variations in rainfall indicate that after a certain stage the diseased condition predominates all other factors.

Considering the average annual rainfall and the annual yield it is found that a total rainfall of round about 250 cm. is favourable to the yield of both healthy and diseased palms. Thus, during the years of optimum rainfall yield is higher, the maximum yield recorded being in 1954 in both the healthy and diseased palms. Patel and Anandan (1936) have shown that at Kasaragod, the yield in any particular year is influenced by January to April rains of the two years previous to harvest together with the rains in January to April of the year of harvest. Similar correlative studies with the data gathered by us did not reveal the influence of summer rains or N. E. monsoon rains on the yield. This variation on the influence of rainfall may be attributed to the fact that the observations made by Patel and Anandan is based on the data for a much larger period and from an area free from disease, whereas the data presented by us has been collected from a heavily diseased tract, where nearly 80 per cent. of the trees are affected by Leaf rot and Root (wilt) disease. The healthy palms in this tract can at best be treated as apparently healthy with our present knowledge on the epidemiology of the Root (wilt) disease, which perhaps explains their failure to respond to the variations in rainfall as in a healthy tract like Kasaragod. Thus, from the data available at present

it appears that the bearing capacity of palms in a diseased tract is primarily subjected to the influence of the condition of the palm, the effect of minor variations in external environment like seasonal rainfall being insignificant. Perhaps the total annual rainfall is more important in this tract. However, further investigations to determine small influences, if any, adopting more refined and systematic approach will be taken up.

SUMMARY

The effect of rainfall and Leaf rot and Root (wilt) diseases on the yield of coconut at Central Coconut Research Station, Kayangulam for the period 1950 to 1960 was studied. Considerable fluctuation in yield during the different periods of the year was noticeable, January to August was found to be the heavy bearing period.

Incidence of disease results in significant reduction in yield, to the extent of 70 per cent. in palms affected by Leaf rot and 43 to 82 per cent. in palms affected by Root (wilt) disease depending on the intensity of disease.

Average annual rainfall of about 200 to 250cm. was found to be favourable for maximum yield in both healthy and diseased palms. Correlative studies of the yield and rainfall during summer and N. E. monsoon periods failed to reveal any significant correlation between the annual yield and the different combinations of rainfall tested. Perhaps in a diseased tract the minor variations in seasonal rainfall has no significant effect on the productivity of the palm.

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TABLE Ia

Yield of palms. No. of nuts per tree during the different periods in the year (1950-1960.)

		Healthy	Leaf rot	Early stage	Root (wilt) middle stage	Disease advanced stage
1950	a	27.3	8.4	11.3	9.5	6.6
	b	23.1	5.9	12.8	7.3	3.5
	c	9.3	2.1	3.9	1.2	0.5
1951	a	29.2	7.0	14.5	9.2	6.6
	b	20.1	5.3	12.9	6.1	3.7
	c	6.6	2.1	8.5	2.0	0.8
1952	a	25.6	11.2	11.8	17.5	6.5
	b	19.3	5.8	12.4	7.3	4.4
	c	3.9	0.5	2.2	1.2	0.1
1953	a	23.6	7.4	11.4	6.3	4.2
	b	29.7	8.5	18.4	10.3	6.8
	c	9.1	4.0	7.9	3.5	2.3
1954	a	36.9	13.8	18.7	15.8	10.6
	b	29.8	10.2	17.3	14.0	9.5
	c	6.2	2.1	4.9	2.7	1.5
1955	a	28.8	8.6	15.1	11.4	5.0
	b	23.3	5.7	17.4	9.4	4.6
	c	6.7	3.1	5.7	2.1	0.9
1956	a	24.9	8.1	15.8	13.6	5.1
	b	31.4	8.1	20.1	12.8	4.8
	c	7.9	1.2	7.5	3.1	1.7
1957	a	34.2	8.6	12.9	9.8	5.0
	b	27.0	9.0	18.4	14.0	6.8
	c	6.3	3.0	3.2	1.6	0.7
1958	a	32.1	9.7	13.3	6.0	3.2
	b	19.1	5.8	12.5	8.1	4.7
	c	6.8	0.4	4.3	2.0	0.8
1959	a	34.6	6.4	17.3	10.7	3.5
	b	26.4	6.3	17.6	9.8	1.8
	c	9.7	2.4	4.7	1.9	0.3
1960	a	33.1	6.9	13.1	7.5	1.6
	b	22.2	5.0	13.7	6.1	2.2
	c	4.1	0.5	3.6	1.3	0.6

a — January, February, March, April (3 harvests)

b — May, June, July, August (3 harvests)

c — September, October, November, December (2 harvests)

TABLE 1b
Annual yield of palms — 1950 — 60

	1950	51	52	53	54	55	56	57	58	59	60
Roof (wilt)											
diverse											
Healthy	59.7	55.9	48.8	62.4	73.9	58.8	64.2	67.5	58.0	70.7	59.4
Leaf rot	16.4	14.4	17.5	19.9	26.1	17.4	17.4	20.6	15.9	15.1	12.4
Early	28.0	35.9	26.4	37.7	40.9	38.2	43.4	34.5	30.1	39.6	30.4
Middle	18.0	17.3	26.0	20.1	32.5	22.9	29.5	25.4	16.1	22.4	14.9
Advanced	10.6	11.1	11.1	13.3	21.6	10.5	11.6	12.5	8.7	5.6	4.4

TABLE 2a
Rainfall during the period 1948-60 in cm.

Year & Period	January-April	May-August	September-December	Total
1948	23.06	182.14	46.53	251.73
1949	28.18	170.71	68.72	267.60
1950	33.06	159.20	69.55	261.81
1951	18.13	117.70	74.42	210.05
1952	23.01	94.41	44.78	162.40
1953	24.56	113.43	79.48	217.47
1954	28.42	159.11	63.36	250.89
1955	14.04	180.47	101.35	295.84
1956	10.67	122.48	67.30	200.45
1957	3.84	183.15	66.59	253.58
1958	16.21	178.99	34.81	230.01
1959	21.89	219.48	49.18	290.73
1960	26.11	201.77	129.60	357.48
average	20.85	160.23	68.90	249.98
Percentage of the total	8.3	64.02	27.57	

TABLE 2b

Rainfall data (month war) for the period 1948 — 60 in cm.

	January	February	March	April	May	June	July	August	September	October	November	December
1950	0.00	11.96	5.13	15.98	45.64	38.68	42.54	32.28	34.16	21.72	12.12	1.54
1951	3.86	0.08	4.55	9.58	5.64	77.62	25.93	8.20	30.84	14.86	2.11	1.73
1952	0.91	10.24	0.00	11.86	12.98	46.61	16.99	17.83	6.25	26.92	7.80	4.01
1953	5.23	0.94	3.15	15.24	3.99	19.20	78.23	12.01	17.42	45.19	16.56	0.31
1954	3.58	0.00	2.54	22.30	28.57	54.51	44.78	31.45	24.18	29.19	1.68	8.31
1955	0.00	0.25	1.14	12.65	59.13	74.17	37.47	9.70	38.51	40.49	17.96	4.39
1956	0.38	0.00	1.60	8.69	29.36	59.41	20.98	12.73	12.75	46.35	8.20	0.00
1957	0.00	0.00	1.83	2.01	28.80	75.23	56.54	22.58	5.31	33.84	19.80	7.64
1958	0.00	1.07	6.33	8.81	32.60	88.50	23.90	33.90	2.71	17.59	14.50	0.00
1959	0.00	3.10	6.63	12.16	46.05	78.57	64.18	30.68	21.82	16.22	9.34	1.80
1960	0.00	0.16	0.62	25.36	82.94	29.09	62.10	27.64	45.86	19.39	64.35	0.00
1948 mm.	33.54	17.24	41.14	138.7	300.7	780.2	420.2	320.3	94.23	153.7	217.4	53.83
1949 mm.	0.00	64.00	40.38	177.4	395.0	462.3	445.7	404.1	266.2	344.3	76.70	0.00

TABLE 3

Rainfall during January — April and annual yield

Year	Yield			X_1	X_2	X_3	X_4	X_5
	Healthy Y_1	Leaf rot Y_2	Root (wilt) advanced stage Y_3					
1950	59.7	16.4	10.6	84.29	51.23	61.23	28.17	33.06
1951	55.9	14.4	11.1	79.36	61.23	51.19	33.06	18.13
1952	48.8	17.5	11.0	74.20	51.19	41.14	18.13	23.01
1953	62.2	19.9	13.3	65.70	41.14	47.57	23.01	24.56
1954	73.9	24.1	21.6	75.99	47.57	52.98	24.56	28.42
1955	58.8	17.4	10.5	67.02	52.98	42.46	28.42	14.04
1956	64.2	17.4	11.6	53.13	42.46	24.71	14.04	10.67
1957	67.5	20.6	12.5	28.55	24.71	14.51	10.67	3.84
1958	58.0	15.9	8.7	30.72	14.51	20.05	3.84	16.21
1959	70.7	15.1	5.6	41.94	20.05	38.10	16.21	21.89
1960	59.7	12.4	4.4	64.21	38.10	48.00	21.89	26.11

x_1 — Rainfall during 2 years previous to the year of harvest + the year of harvest.

x_2 — Rainfall during 2 previous years.

x_3 — Rainfall during the previous year + the year of harvest.

x_4 — Rainfall during the previous year.

x_5 — Rainfall during the year of harvest.

TABLE 4

Rainfall during September to December and annual Yield

Year	Yield			a	b	c	d	e
	Healthy	Leaf rot	Root (wilt) disease advanced					
1950	59.7	16.4	10.6	184.80	115.25	138.27	68.72	69.55
1951	55.9	14.4	11.1	212.69	138.27	143.97	59.55	74.42
1952	48.8	17.5	11.0	188.75	143.77	119.20	74.22	44.98
1953	62.4	19.9	13.3	198.68	119.20	124.46	44.98	79.48
1954	73.9	26.1	21.6	187.82	124.46	142.84	79.48	63.36
1955	58.8	17.4	10.5	244.19	142.84	164.71	63.36	101.35
1956	64.2	17.4	11.6	232.01	164.71	168.65	101.35	67.30
1957	67.5	20.6	12.5	235.24	168.65	133.89	67.30	66.59
1958	58.0	15.9	8.7	168.70	133.89	101.40	66.59	34.81
1959	70.7	15.1	5.6	150.58	101.40	83.99	34.81	49.18
1960	59.7	12.4	4.4	213.59	83.99	178.78	49.18	129.60

TABLE 5

*Values of correlation coefficient (r) between yield and seasonal rainfall
January — April rainfall*

	X ₁	X ₂	X ₃	X ₄	X ₅
Y ₁	-0.3003	-0.3742	-0.0943	-0.1220	-0.0280
Y ₂	0.0529	0.0735	-0.0213	-0.0217	-0.0084
Y ₃	0.2997	0.3497	0.1561	0.2007	0.0697

September — December rainfall					
	X ₁	X ₂	X ₃	X ₄	X ₅
Y ₁	-0.1224	-0.0986	-0.1001	-0.1002	-0.0401

Y₁ — Yield of healthy trees
Y₂ — Yield of Leaf rot affected trees.
Y₃ — Yield of Root (wilt) affected trees.