GROWTH RATE OF OIL PALMS IN NEW BRITAIN

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ABSTRACT

The leaf area growth rate of tenera *progenies from two genetic sources at three sites in New Britain was measured in the pre-bearing stage. It appeared to be very rapid when compared with reports from other countries. Curves fitted to the growth rate data gave very high determination coefficients (>0.98) indicating that any seasonal effects were small. The small deviations in 3-monthly growth rate from the fitted curves were compared with climatic data. There was weak evidence of a positive correlation with rainfall and a negative correlation with solar radiation at one site only. A lack of prolonged dry spells and high moisture-holding capacity of pumice in the recent volcanic soil appear to be responsible for the rapid and uniform growth rate.*

The growth rate at Mosa was at least as rapid as at Keravat, in spite of the more seasonal climate at the former site. Slower growth at Siki was probably due only to poorer management and pest damage.

A clear and consistent difference in growth rate between the genetic sources was apparently due to the effect of inbreeding in the parentage of one of them.

INTRODUCTION

A previous paper (Mendham 1971a) described the establishment of and early results from a progeny x environment trial at 12 sites in Papua New Guinea. A more detailed study (Mendham 1971b) was made of the New Britain sites, as this is where initial development is taking place, and where major expansion of the industry is likely to occur. The purpose of this paper is to summarize some of the results obtained from the New Britain sites, of growth rate of the palms in the pre-bearing stage and the relationships between growth and environmental factors.

EXPERIMENTAL METHODS

The three sites are at the Lowlands Agricultural Experiment Station, Keravat, in East New Britain, and at Mosa Plantation and Siki in West New Britain. The climates and soils were described in the previous paper (Mendham 1971a). The soils are all of recent volcanic origin, and contain large amounts of pumice and ash. The soils at Siki and Keravat have a sandier texture than at Mosa. The climate at Keravat is very uniform, with 2800 mm rainfall evenly distributed over the year, and normally at least 5 hours of sunshine per day. The normal daily temperature range is about 22 to 32 degC. The climate at Mosa and Siki is more seasonal. The wet season, January to April, normally has up to 700 mm rainfall per month, and sunshine levels can be low. Dry season rainfall is still moderate, and normally no more than one month in each year has less than 100 mm rainfall. Temperatures are similar to Keravat.

The genetic material used and the site layouts were described previously. Four *tenera* progenies from each of two genetic sources were used. The sources can be described as:

Source C: Deli *dura* x (Deli x African *pisifera*)

Source H: Deli *dura* x Sumatra (originally Congo) *pisifera*

The main difference was in the *pisifera* parents. The male parents for source C were produced by using African *pisifera* pollen of varied origin on Deli *duras* already in Malaysia. These Delis were related to those used for the female parents of the final cross, hence some inbreeding resulted. The male parents for source H were descended from excellent *tenera* palms in Sumatra originally introduced from the Congo, where all the early *tenera* selection was done.

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The leaf area growth rate of these two sources was measured in the pre-bearing period, up to about 30 to 36 months from field planting. Recordings were of monthly leaf production, and 3-monthly estimates of the area of the newest fully opened leaf. The area estimates were made using the L(l x b) method described by Mendham (1971c). This involves measuring the length of the rachis (L), and multiplying by (l x b), the length x maximum breadth of a leaflet in the region of the leaf where leaflets are largest. Individual progeny calibration curves were used for both the leaflet and whole leaf area, to convert field readings of L(l x b) to area in m^2. For each 3-monthly period, a mean was taken of the area of the newest leaf at the beginning and end of the period. This was multiplied by the leaf production for the three months to give dL, the estimate of the increase in leaf area.

The Keravat seedlings were planted in August, 1967 at the optimum age of 12 months. However, there were delays in site preparation at the other two sites and seedlings had to be held back in the nursery. Planting was done in December, 1967 at Siki and early January, 1968 at Mosa. These sites were thus delayed 4 months compared to Keravat.

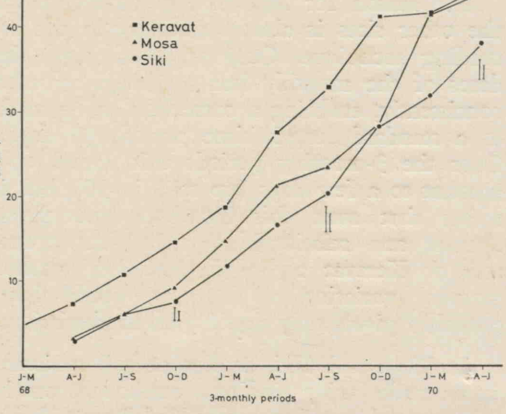

Figure 1. — Leaf area growth rate for the three sites. Vertical bars indicate least significant difference (P = 0.01 and 0.05) for three periods.

RESULTS AND DISCUSSION

Sites

The site means for each period are given in *Figure 1.* The data for three of the time periods were analysed, and the values for the least significant difference are indicated. Differences between all sites were highly significant for the first two periods, but at the last period Mosa is similar to Keravat. This was due to the high leaf production at Mosa in the last six months of recording (Mendham 1971a, Figure 4) at up to 4 leaves per month. The leaves were still smaller than at Keravat. The mean area of the newest leaves on 1st July, 1970 was 4.16 m^2 at Mosa and 4.61 m^2 at Keravat, the two being significantly different at P=0.01 (Mendham 1971a, Table 6). Allowing for the 4-month delay in planting, the growth rate at Mosa has been at least as rapid as at Keravat. The growth during the last two periods at Keravat may have indicated that the previously rapid growth rate was lessening, probably with the onset of bearing.

There was considerable variation in the differences between sites at the other periods. For the first two periods Mosa and Siki were nearly identical, but then the latter began to lag behind. Subsequently the Siki mean was only close to the Mosa mean at one period, when the Mosa curve was at a low point. The difference between Siki and Mosa is likely to be due to poorer management and pest damage at the former site. Weeding was infrequent in 1968, the legume cover-crop being allowed to grow up the palms several times. Also there was considerable damage by *Scapanes,* the New Guinea rhinoceros beetle, although no palms were killed. Thus it was not possible to isolate these effects from those due to the sandier soil.

Sources

The means of dL for the two sources are given in *Figure* 2 for the three sites separately. Various types of curves were fitted to the data. The form giving the best fit was:

$$\log Y = a + b_1X + b_2X^{\frac{1}{2}}$$

where Y = dL and X = time (3-monthly periods)

Curves of this type are plotted in *Figure 2* for each source at each site, with the appropriate equations and determination coefficients (r^2). An outstanding feature is the very high values of r^2 obtained. These are all 0.98 or higher, indicating that over 98 per cent of the variability in the data can be accounted for by the curves fitted. The fit was better at Mosa and Siki ($r^2 = 0.991 — 0.996$) than at Keravat ($r^2 = 0.979 — 0.981$). Thus any seasonal effects on the growth rate are small, and would be of little practical significance. Even so, the deviations of the observed means of the two sources from the fitted curves were consistent for each time period, both usually being either above or below their respective fitted curves.

From the curves, the difference between the sources increased with time at each site. The difference was largest at Siki and smallest at Keravat. The significance of the difference between the observed means at three time periods is also indicated in *Figure 2.* In October to December, 1968 the difference was only significant at Siki but for the other periods it was significant at all sites.

The effect of inbreeding was discussed by Hardon (1970), and it seems that almost all the difference between the sources found in the present trials is likely to be due to the effects of inbreeding in the parentage of the C source progenies. It can be expected that yields of the two sources will follow the same trends as the growth rates, with the C source being inferior.

Effects of climatic factors

The main climatic variation was in rainfall and solar radiation or sunshine hours, as temperatures were rather uniform (see previous paper for monthly data). For comparison with the growth rate curves, 3-monthly totals of rainfall and means of radiation and sunshine hours are given in *Table 1.*

The deviations in log dL from the fitted curves in *Figure 2* were compared with the data in *Table 1.* For each site the nine H means and the nine C means were pooled to give 18 points for correlation analysis (20 at Keravat), thus using the climatic data twice. The determination coefficients (r^2), correlation coefficients (r) and the significance of the latter are given in *Table 2.* In view of the limited data available, no great weight can be attached to the results, but their interpretation is discussed below.

The only significant correlations, and in fact the only ones which explained more than 5 per cent of the variation in the dL deviations ($r^2 > 0.05$) were at Mosa. The scatter diagrams for the two best correlations are given in *Figure 3.*

The effect of rainfall is quite striking, and the correlation would have been higher but for what may have been a "carry-over" effect in April to June, 1969, when there was a peak in growth (*Figure 1*), but the rainfall peak was in January to March. April rainfall was also high.

The approximate pan evaporation (U.S. Class A) at Mosa was 110 to 160 mm per month, which would indicate potential evapotranspiration of about 90 to 130 mm. The rainfall in almost every month was higher than this, hence the correlation found with growth is surprising. However, in view of the very small actual deviations from the fitted growth rate curves (*Figure 2*, where $r^2 > 0.99$) the effect is likely to be of little practical significance. Also, the determination coefficient and hence the predictive value of the correlation with rainfall was rather low.

The negative correlation found between growth deviations and solar radiation is probably not a real effect, as rainfall is itself negatively correlated with radiation. There does not appear to be any reason why increased radiation should depress growth unless the moisture supply is limiting.

The reason for lack of any correlation at the other sites is almost certainly in the recording technique. Only at Mosa were the dates of the monthly leaf markings recorded consistently, enabling a correction to be made to a standard length time period (30 days). Over the 3-monthly periods this would only amount to a few days (up to 3 in 90), but it seems that even this has been enough to obscure any relationships with climatic factors at Keravat and Siki. The less marked seasonal variation at Keravat would have probably given only small growth deviations.

At Mosa and Siki, studies of soil moisture were made using indirect methods, namely the stomatal opening method of Rees (1961), and tensiometer recordings. By either method, soil moisture stress did not occur. During the driest period recorded (2 months with less than 100 mm per month), and on the sandy

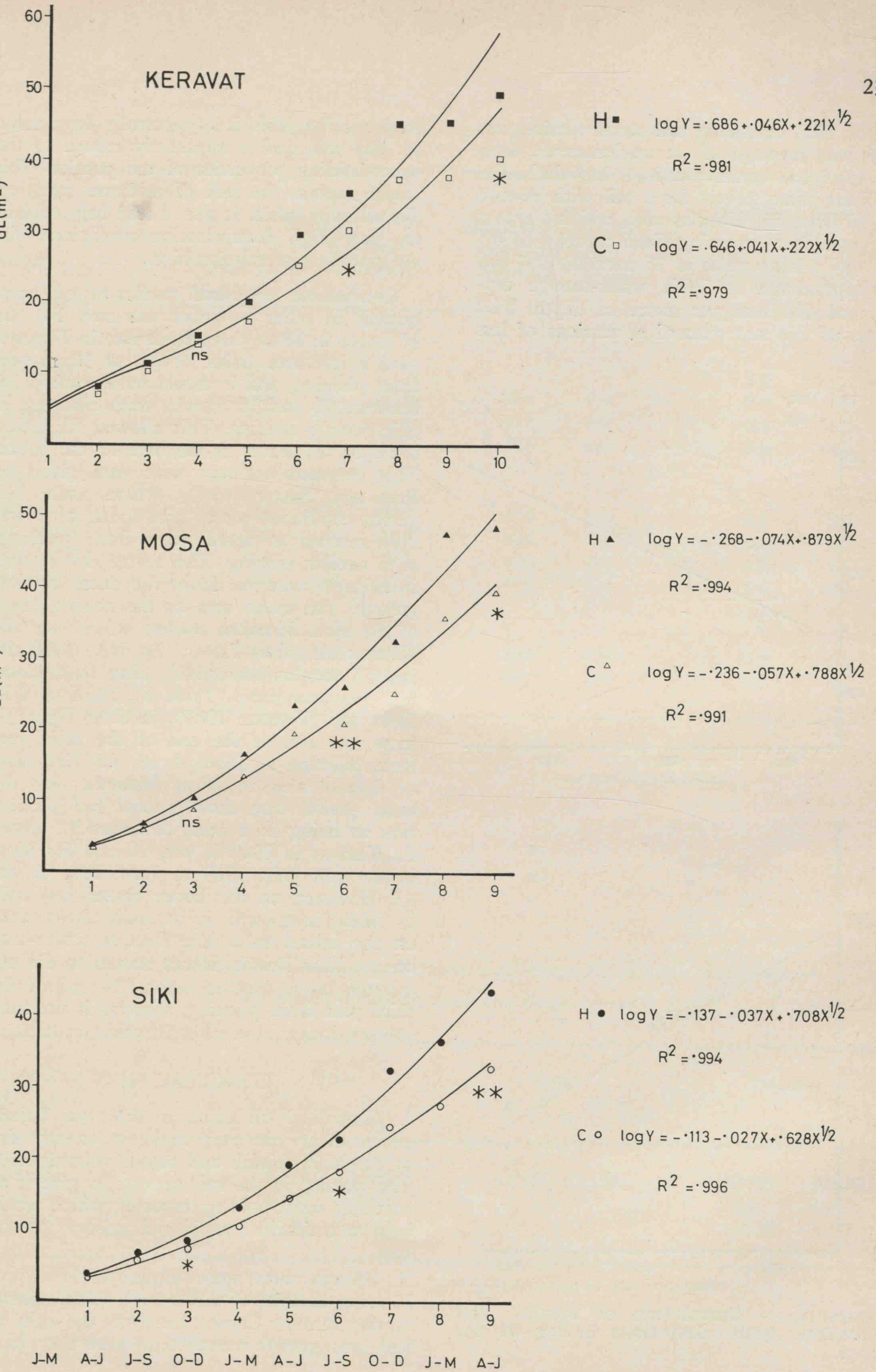

Figure 2. — Leaf area growth rate of the two sources at each site.
Y = dL and X = 3-monthly periods

* = observed means different at P = 0.05
** = observed means different at P = 0.01
ns = difference not significant

soil at Siki, maximum soil water tension was 0.36 bars (average of six tensiometers). Scotter (personal communication) has derived a moisture characteristic for a soil with pumice gravel from the Hoskins area, and his results indicated that, assuming field capacity as 0.1 bar and wilting point as 15 bars, the soil had an approximate available water-storage capacity of 440 mm per metre of depth. Two thirds of this was released at tensions of less than one bar. This is an unusually large value for any soil, and is apparently related to the water-holding properties of the pumice. This would explain the lack of moisture stress on the oil palm trials. It also would help explain the very high determination coefficients for the growth rate relationships.

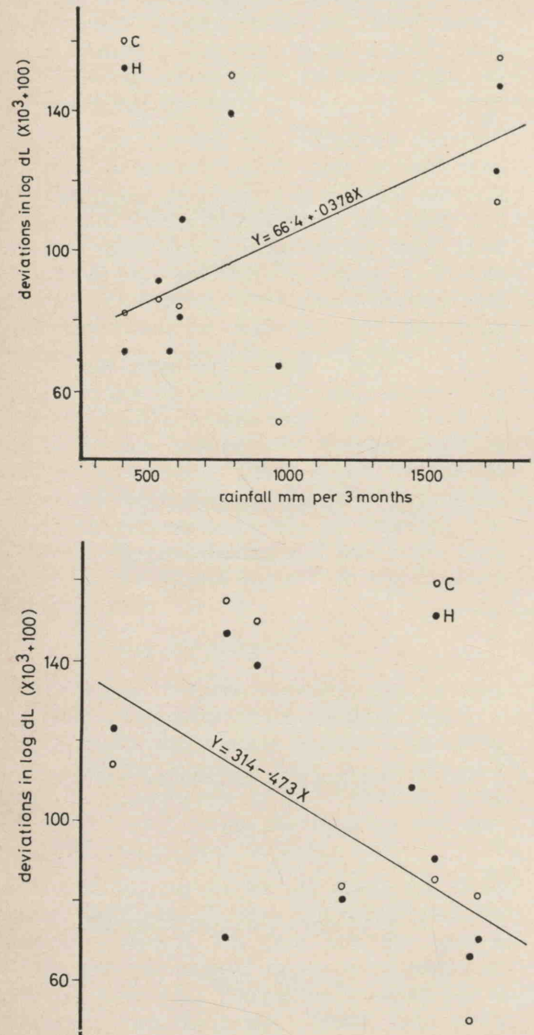

Figure 3. — Correlation of rainfall and radiation with deviations in log dL for Mosa.

Comparable published studies of oil palm growth in other countries are rare. For the H source at Mosa, the growth rate in *Figure 2* gave a leaf area index of 2.5 at 30 months from planting, and it should have reached 3.0 between 33 and 36 months from planting, at this 9-metre spacing. This allowed for senescence of old leaves at the base of the palms. This contrasts strongly with data given by Rees and Tinker (1963), where under Nigerian conditions a leaf area index of 3 was only reached at seven years from planting, at a similar spacing. The severe dry seasons in Nigeria were no doubt the cause of slow growth. The mean area of the newest leaves of the Mosa H palms reached 4.5 m^2 and the Keravat H palms 5.0 m^2 by July, 1970, 30 and 35 months respectively after field planting (previous paper, Table 6). Hardon, Williams and Watson (1969), in their Figure 2, show the area at the end of the third year from planting as about 4 m^2, for Deli *dura* on inland soils in West Malaysia. For the same period they show annual leaf production as being at a peak of about 32 leaves. At Keravat in 1969 it was 44, and for Mosa in the year July, 1969 to June, 1970 it was 43. However, on the better coastal clay soils in Malaysia growth is normally faster than on the inland soils. The *Pueraria* cover-crop on the New Britain blocks started to die out through heavy shading before the end of the third year from planting, whereas it normally persists longer than this in other countries.

CONCLUSIONS

1. Growth of oil palms in the New Britain environment was very rapid, apparently due to the high rainfall and recent volcanic soils. The pumice in the soil appears to give it an excellent water-holding capacity, which would help to maintain a rapid and uniform growth rate.

2. Growth rates were similar at Mosa and Keravat, in spite of the more seasonal climate at the former. Curves fitted to the data of leaf area growth versus time gave very high

Table 1. — Climatic data for the three sites for 3-monthly periods

Period	Rainfall (mm per 3 mths)			Radiation (mWhr cm^{-2} per day)		Sunshine Hours per Day (Campbell Stokes)	
	Keravat	Mosa	Siki	Keravat	Mosa	Keravat	Mosa
1968							
Jan.-Mar.	785						
Apr.-June	756	621	810			5.0	
July-Sept.	471	531	535	487	478	5.0	5.7
Oct.-Dec.	606	407	621	518	486	6.2	5.2
				505	499	5.6	4.0
1969							
Jan.-Mar.	845	1751	1837	468	385	4.3	2.4
Apr.-June	587	800	1010	484	429	6.2	3.4
July-Sept.	811	572	662	439	421	4.6	3.7
Oct.-Dec.	833	963	959	476	497	4.6	5.0
1970							
Jan.-Mar.	1058	1762	1968	480	420	4.4	3.7
Apr.-June	688	602	1064	457	457	5.2	5.1

Table 2. — Determination and correlation coefficients for climatic data versus deviations in log dL from the fitted curves

Deviations in log dL on:	Mosa		Siki		Keravat	
	r^2	r	r^2	r	r^2	r
Rainfall	0.352	+0.593**	0.016	+0.127	0.0005	+0.022
Solar radiation	0.337	—0.580*			0.041	—0.202
Sunshine	0.188	—0.433			0.0002	—0.014

* significant at 5 per cent level

** significant at 1 per cent level

determination coefficients (>0.98) indicating that seasonal effects were small.

3. At Mosa only, there was a significant relationship between the small deviations in growth rate and rainfall, high rainfall appearing to give the best growth rate. However, the effect is not likely to be of much practical importance. Periods of high rainfall were associated with low sunshine and solar radiation levels, and this is probably why a significant negative correlation was found between deviations in growth rate, and solar radiation.

4. A clear and consistent difference in growth rate between the two genetic sources was apparently due to the effect of inbreeding in the parentage of one of them.

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