

PRELIMINARY OBSERVATIONS ON THE GROWTH AND PRODUCTION OF BANANAS IN THE NORTHERN DISTRICT OF PAPUA NEW GUINEA

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ABSTRACT

Growth and production measurements were taken from three varieties: Dwarf Cavendish, Giant Cavendish and Tui grown on a volcanic ash sandy loam soil over a 16-month period at Lejo experimental station in the Northern District.

*The dry season was exceptionally severe. However the main factor limiting yields appeared to be Sigatoka leaf spot (*Cercospora musa*). The level of this disease was markedly reduced by the dry season, but despite a constant spraying programme using a mancozeb-oil mixture with shoulder-mounted misting machines, it increased in severity as the wet season advanced. There was a close correlation between bunch weight and the degree of Sigatoka as measured by number of functional leaves at harvest.*

Giant Cavendish maintained the heaviest bunch weight throughout most of the trial, but this cannot be regarded as a true varietal test due to the variation in level of Sigatoka infection between the three varieties. Failure to properly control Sigatoka was partly put down to failure to give adequate protection to newly emerging leaves.

Growth rates of all the three varieties was markedly reduced during the dry season and a close correlation between rainfall and growth rate existed during the first nine months of the trial. There was some evidence of parental dominance on young suckers of Tui and Dwarf Cavendish but not Giant Cavendish. Tui and Dwarf Cavendish showed significantly greater growth rates during the early life of a sucker and although not significant this could also be the case with Giant Cavendish. Level of Sigatoka infection appeared to have no effect on growth rates of any of the three varieties.

Time taken to throw a bunch varied significantly between varieties with Dwarf Cavendish taking the least time and Tui the longest.

INTRODUCTION

Bananas have been grown on a subsistence basis in the Northern District for a long time and form an important part of the human diet. With some interest being shown in the commercial production of this crop for export it was considered necessary to study yield and growth variations in some detail.

The literature indicates that environmental factors such as temperature and rainfall can largely influence the growth and yield potential of bananas (Turner 1971, Simmonds 1959, Wardlaw 1961). Simmonds (1959) suggests that a mean monthly temperature of

less than 21 degrees C would result in some check in growth as it would probably imply that the mean minimum temperatures would be in the region of 15.5 degrees C. Temperatures are uniformly higher (greater than 21 degrees C) in the Northern District with only slight seasonal variation (Slatyer 1964). Temperature cannot therefore be regarded as a major limitation to growth or production at any time in the Northern District. On the other hand, rainfall is seasonal and a definite dry period does exist.

The aim of the trial was therefore to gain some knowledge of the main factors influencing growth and yields of these commercial banana types under Northern District conditions.

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MATERIAL AND METHODS

The varieties tested included Dwarf Cavendish, Giant Cavendish and a tall robust growing type locally called Tui, but bearing a strong resemblance to the Gros Michel described by Simmonds (1959).

The total area sampled was approximately 2/3 hectare. The three varieties were randomly planted throughout this block on a 3.6 by 3.6 metre spacing, giving a total of 510

stools. Due to the relatively wide spacing and severity of leaf spot it was considered that the taller varieties did not gain special advantage from shading of the smaller ones.

The suckers were initially planted in November, 1969 in a volcanish ash sandy loam soil which had been growing cocoa and *Leucaena leucocephala* for over ten years. Results of soil analysis performed on samples obtained in October, 1971 are as outlined in Table 1.

Table 1.—Results of chemical analysis of Lejo soil

Depth	pH	Nitrogen %	Carbon %	Olsen P ppm	Exchangeable rations				Total Exchange Capacity	Base Satn. %
					Ca m.e. %	Mg m.e. %	K m.e. %	Na m.e. %		
0-15 cms	6.7	0.18	1.8	16.0	11	1.9	0.3	0.4	13.6	100
15-30 "	6.0	0.13	1.3	7.0	8	1.4	0.4	0.7	10.5	98

There was no attempt at pruning until October, 1970, by which stage there were several well developed suckers clustered around the mother plant on every stool. During the pruning some retarded mother plants were knocked out where a well developed sucker was prominent. Another smaller sucker was also left so that there would have been two suckers per stool. When the mother plant bunched, another sucker was allowed to develop. There were therefore two to three plants per stool depending on the age of the mother plant. This system was maintained throughout the trial.

Harvesting commenced in December, 1971. Due to a very severe attack of Sigatoka leaf spot disease (*Cercospora musa*) bunches were initially often harvested when no leaves remained on the stem and fingers were only half full. When incidence of leaf spot decreased permitting fruit to fill out before ripening, bunches were harvested at the full stage.

Attempts to control Sigatoka were commenced in February, 1972. The mixture used was 2.25 kg mancozeb, 2.8 litres superior white oil per hectare. This was applied with shoulder mounted misting machines. Initially spraying intervals were irregular (3 to 5 weeks) until July, 1972 when it was changed to a regular 3-weekly spray and then to every fortnight in early November, 1972.

An estimate was made on the severity of leaf spot disease by estimating the number of functional leaves or part thereof in the field at harvest. For example if there were three leaves remaining at harvest with an average of 50 per cent infection then the number of functional leaves would be 1.5. The estimate of Sigatoka is therefore a negative index and in fact is an estimate of freedom from Sigatoka.

No weeding was carried out during the trial but a creeping vine (*Momordica charantia*) established itself naturally and was very successful in controlling growth of other weeds. Later it was discovered that the roots of this vine were infected with the root knot nematode *Meloidogyne incognita*. This nematode was not considered to be pathogenic on the banana roots. However two other species, *Radophylus similis* (Cobb.) and *Helicotylenchus* spp., were extracted from banana roots following observations that some stems carrying immature bunches toppled over in August, 1972. A small number of stools continued to topple over during the remainder of the trial. However no nematicide was added at any stage.

During November, 1971 a 0.1 per cent solution of Heptachlor was sprayed around the base of each stool to combat an infestation of banana weevil borer (*Cosmopolites sordidus* Germ.). A further build-up was

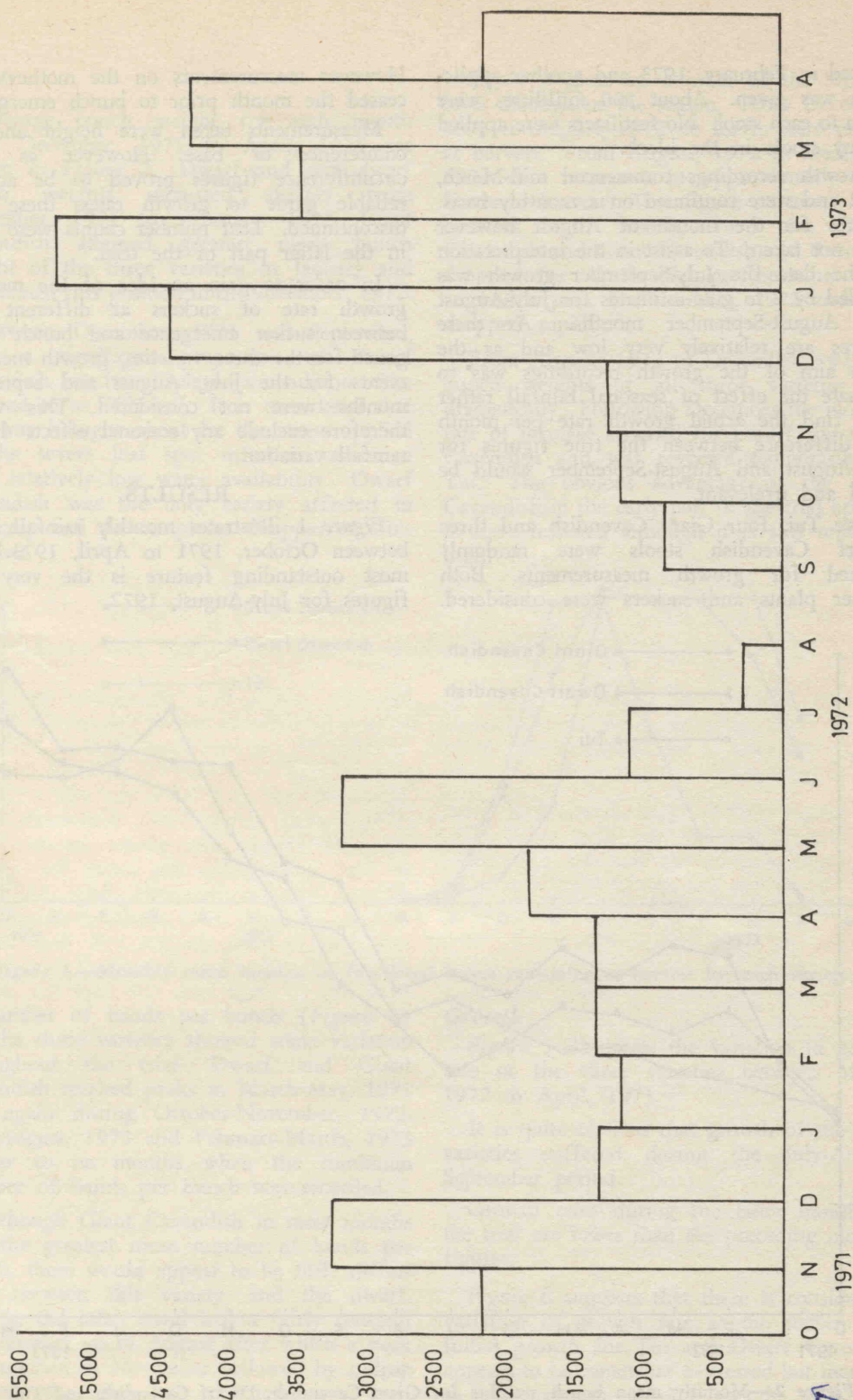


Figure 1.—Monthly Rainfall variations.
Rainfall in (mm)

50 to 500 mm (?)

noticed in February, 1973 and another application was given. About 500 millilitres were given to each stool. No fertilizers were applied to any stools in the block.

Growth recordings commenced mid-March, 1972 and were continued on a monthly basis. Figures for the month of August however were not taken. To assist in the interpretation of the data the July-September growth was divided by 2 to give estimates for July-August and August-September months. As these figures are relatively very low and as the main aim of the growth recordings was to evaluate the effect of seasonal rainfall rather than find the actual growth rate per month any difference between the true figures for July-August and August-September would be small and irrelevant.

Five Tui, four Giant Cavendish and three Dwarf Cavendish stools were randomly selected for growth measurements. Both mother plants and suckers were considered.

However measurements on the mother plant ceased the month prior to bunch emergence.

Measurements taken were height and circumference of base. However as basal circumference figures proved to be an unreliable guide to growth rates, these were discontinued. Leaf number counts were taken in the latter part of the trial.

In order to gain an idea of the monthly growth rate of suckers at different ages between sucker emergence and bunch emergence for the three varieties, growth measurements for the July, August and September months were not considered. This would therefore exclude any seasonal effects due to rainfall variation.

RESULTS

Figure 1 illustrates monthly rainfall totals between October, 1971 to April, 1973. The most outstanding feature is the very low figures for July-August, 1972

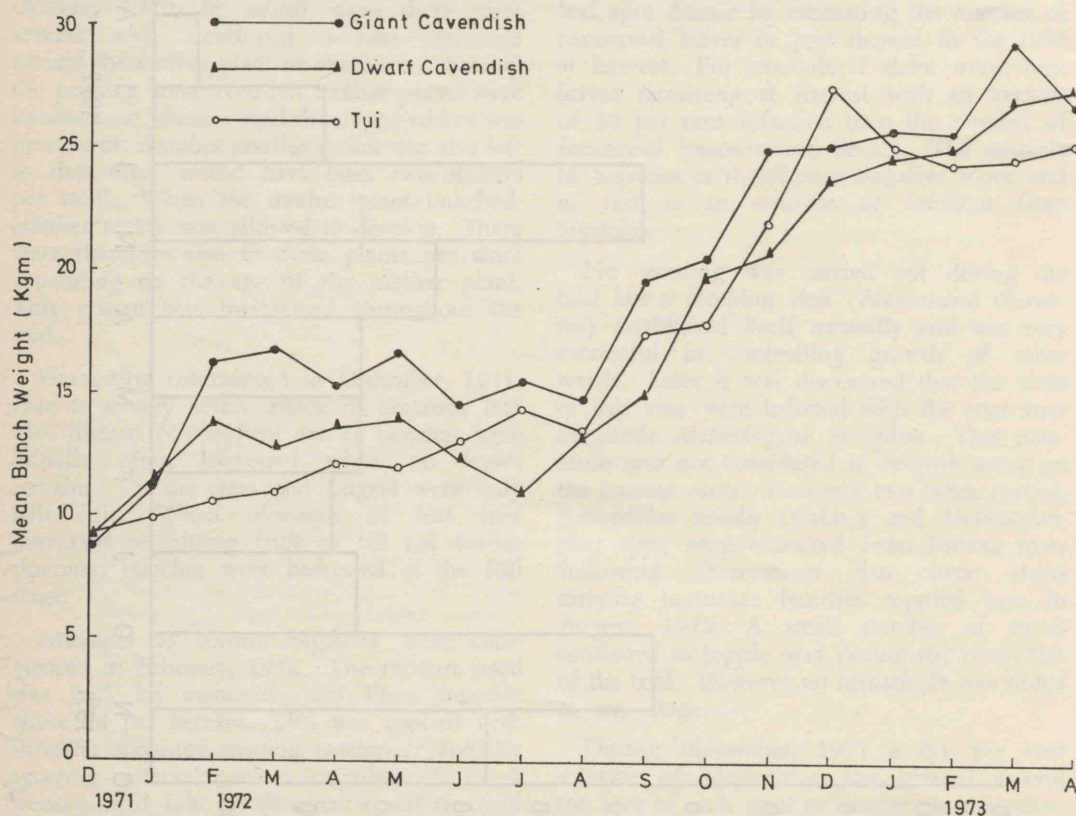


Figure 2.—Monthly mean bunch weights for Giant Cavendish, Dwarf Cavendish, and Tui.

Yields

Average bunch weight for each month from December, 1971 to April, 1973 are shown in Figure 2. Dwarf and semi-dwarf bunch weights increased sharply from December, 1971 to February, 1972. Giant Cavendish attained greatest mean bunch weight of the three varieties in January and maintained this position until November, 1972.

Between December, 1971 and September, 1972 a significant proportion of Dwarf Cavendish bunches displayed a condition often referred to as "Choke". It is considered that this was brought about by the stress applied by the severe leaf spot infection combined with relatively low water availability. Dwarf Cavendish was the only variety affected in this crop and the symptoms disappeared after October.

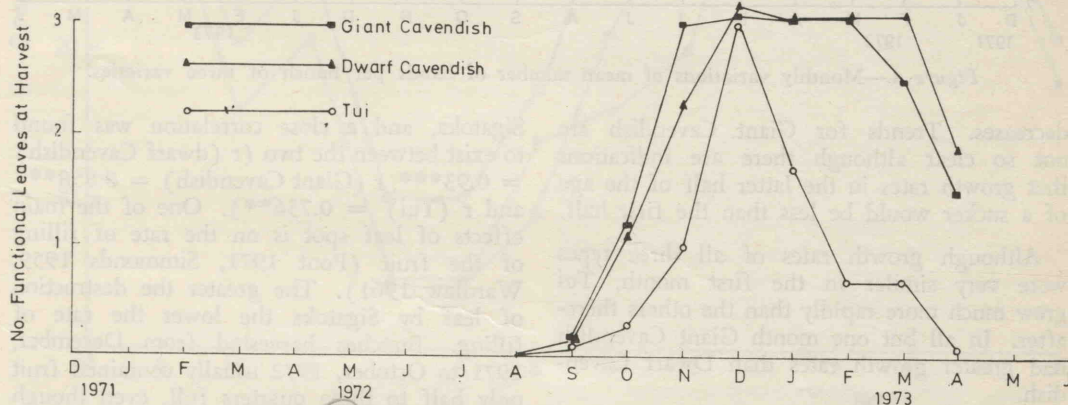


Figure 3.—Monthly mean number of functional leaves remaining at harvest for each variety.

Number of hands per bunch (Figure 4) for the three varieties showed some variation throughout the trial. Dwarf and Giant Cavendish reached peaks in March-May, 1972 and again during October-November, 1972. July-August, 1972 and February-March, 1973 appear to be months when the minimum number of hands per bunch was recorded.

Although Giant Cavendish in most months had the greatest mean number of hands per bunch, there would appear to be little difference between this variety, and the dwarf. Tui on the other hand had a fairly constant low number up to August after which a peak was reached in November followed by a drop as with the other two varieties.

Figure 3 gives an estimate of the Sigatoka level throughout the season. From December, 1971 to August, 1972 no leaves were present at harvest. From August, 1972 to December, 1972 this increased to approximately three leaves at harvest. This figure remained fairly constant until March, 1973 for Dwarf Cavendish and Giant Cavendish and then both dropped for April. Tui on the other hand reached a peak in December, 1972 and then dropped rapidly.

From August, 1972 to December, 1972 the bunch weights of all three varieties rose dramatically. Following December the monthly rate of increase lessened for Dwarf and Giant Cavendish and was reversed temporarily for Tui. The obvious advantage of the Giant Cavendish in the early part of the trial appears to have lessened although it is still relatively high.

Growth

Figure 5 illustrates the variation in growth rate of the three varieties between March, 1972 to April, 1973.

It is quite obvious that growth of the three varieties suffered during the July-August-September period.

Growth rates during the latter months of the trial are lower than the preceding month's figures.

Figure 6 suggests that there is considerable variation in growth rate as the suckers age. Initial growth for Tui and Dwarf Cavendish appears to be somewhat depressed but increases to a maximum at 3-4 months and then

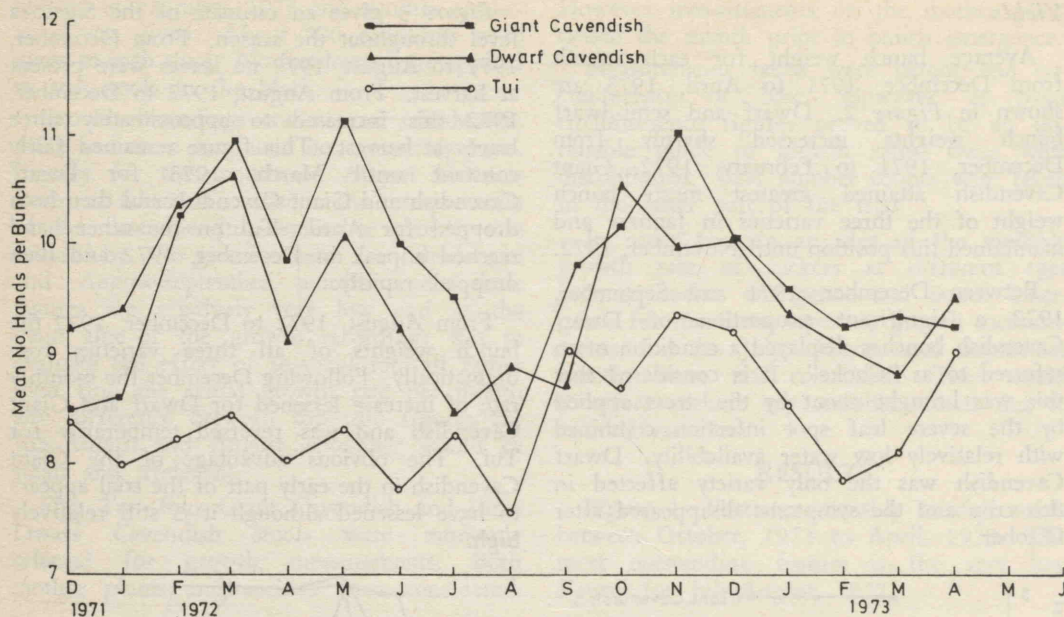


Figure 4.—Monthly variations of mean number of hands per bunch of three varieties.

decreases. Trends for Giant Cavendish are not so clear although there are indications that growth rates in the latter half of the age of a sucker would be less than the first half.

Although growth rates of all three types were very similar in the first month, Tui grew much more rapidly than the others thereafter. In all but one month Giant Cavendish had greater growth rates than Dwarf Cavendish.

Table 2 gives an indication of time taken from sucker emergence to bunch emergence for the three varieties. All these figures considered included any effects of the dry spell.

DISCUSSION

Yields

Mean monthly bunch weights after February, 1972 are closely related to the number of functional leaves not killed by

Sigatoka, and a close correlation was found to exist between the two (r (dwarf Cavendish) = 0.93***, r (Giant Cavendish) = 0.858*** and r (Tui) = 0.736**). One of the main effects of leaf spot is on the rate of filling of the fruit (Pont 1971, Simmonds 1959, Wardlaw 1961). The greater the destruction of leaf by Sigatoka the lower the rate of filling. Bunches harvested from December, 1971 to October, 1972 usually contained fruit only half to three quarters full, even though they were not harvested until all leaves were dead and in some cases the fruit had started to ripen. During the months of November, 1972 and December, 1972 fruit were harvested at the hard green full stage and if left on the plant the fruit would split. This situation is much more desirable than that of the previous months and indicates the importance of maintaining at least three leaves at harvest as has been found by other workers (Turner 1970 and Firman 1970).

Table 2.—Mean length of time (months) from sucker emergence to bunch emergence for three varieties

Tui	difference	Giant Cavendish	difference	Dwarf Cavendish
13.2	P = .05	11.4	P = .001	9.5

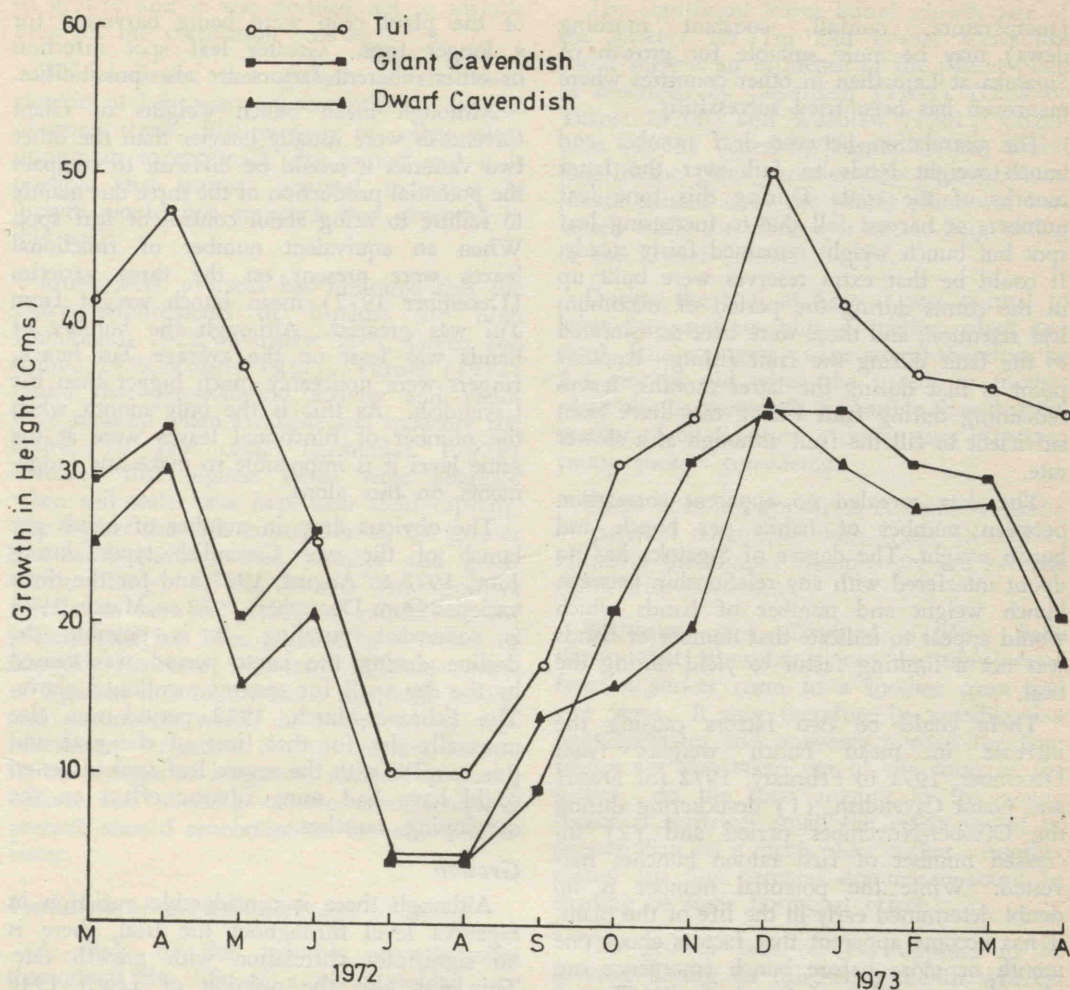


Figure 5.—Mean growth in height per month of three varieties between March 1972 to April 1973.

While seasonal variation of Sigatoka with rainfall (or morning dews) is well recognised (Stover 1968, Wardlaw 1961, Simmonds 1959), actual statistical analysis of results was complicated by the method used to estimate Sigatoka level and also effects of the spraying programme. However it is reasonably obvious that the dry period did decrease the level of the disease and the following wet months increased its spread.

Although the mancozeb-white oil water mixture applied with low volume misters has been used successfully overseas (Pont 1971, Broderick and Kuhne 1971), it appears that proper control was not achieved at Lejo using

this method. From observations only it would appear that failure to protect the recently emerged leaves could be an important factor especially with the tall variety (Tui). This factor has also been put forward by Allen and Benson (1970) and Long (1973) as a problem with shoulder mounted misting machines in bananas. Spraying at closer intervals may have produced better control during the wet season. The interval between production of new young leaves was then approximately a week (unpublished data) so that during the week when spraying did not occur at least one leaf per plant would have been subject to infection until the next application of spray. Another factor is that conditions

(temperature, rainfall, constant morning dews) may be more suitable for growth of Sigatoka at Lejo than in other countries where mancozeb has been tried successfully.

The correlation between leaf number and bunch weight tends to fail over the latter months of the trial. During this time leaf numbers at harvest fell due to increasing leaf spot but bunch weight remained fairly steady. It could be that extra reserves were built up in the corms during the period of maximum leaf retention, and these were later translocated to the fruit during the fruit filling. Another point is that during the latter months, leaves remaining during fruit filling may have been sufficient to fill the fruit although at a slower rate.

The data revealed no apparent correlation between number of hands per bunch and bunch weight. The degree of Sigatoka has no doubt interfered with any relationship between bunch weight and number of hands which would appear to indicate that number of hands was not a limiting factor to yield during the trial.

There could be two factors causing the increase in mean bunch weights from December, 1971 to February, 1972 for Dwarf and Giant Cavendish, (1) desuckering during the October-November period and (2) increased number of first ratoon bunches harvested. While the potential number is no doubt determined early in the life of the plant, it has become apparent that factors about one month or more before bunch emergence can alter the proportion of female fruits (Turner 1970b, Summerville 1944, Simmonds 1959). It is therefore possible that the removal of the numerous suckers eased the competitive strain on the mother plant and allowed a greater proportion of female flowers to develop. *Figure 2* does show that the hand number did increase from December to reach a maximum in March and this could have caused some increase in bunch weight. The other reason is due to the many observations that the first ratoon crop usually produces bigger and heavier bunches than the plant crop at wide spacing (author's own observations, Simmonds 1959, Turner 1970b). Tui on the other hand has shown a slower response to the above factors. This could be related to its having a longer growth cycle than either of the Cavendish varieties so that bunches

of the plant crop were being harvested for a longer time. Greater leaf spot infection or other inherent factors are also possibilities.

Although mean bunch weights of Giant Cavendish were usually heavier than the other two varieties it would be difficult to compare the potential production of the three due mainly to failure to bring about control of leaf spot. When an equivalent number of functional leaves were present on the three varieties (December 1972) mean bunch weight from Tui was greatest. Although the number of hands was least on the average Tui bunch, fingers were noticeably much bigger than the Cavendish. As this is the only month when the number of functional leaves were at the same level it is impossible to make any judgements on this alone.

The obvious drop in number of hands per bunch of the two Cavendish types during June, 1972 to August, 1972 and for the three varieties from December, 1972 to March, 1973 is somewhat puzzling. It is possible the decline during the latter period was caused by the dry spell for reasons mentioned above. The February-March, 1972 period was also unusually dry for that time of the year and this coupled with the severe leaf spot infection could have had some adverse effect on the developing bunches.

Growth

Although there is considerable variation in Sigatoka level throughout the trial, there is no significant correlation with growth rate. This was also the opinion of Leach 1946 (cited by Simmonds 1959).

The lower growth rates in the latter months of the trial are difficult to interpret. Possible reasons are (1) build up of nematode numbers following the heavy rain in December, 1972, or (2) nutritional.

Rainfall

There was a good correlation between rainfall and growth for the ten months March, 1972 to December, 1972 inclusive (r (Tui) = 0.89***, f (Giant Cavendish) = 0.78**, r (Dwarf Cavendish) = 0.89***). Monthly rainfall figures as indicated in *Figure 1* were adjusted so as to give an accurate figure for rainfall between actual times growth recordings were made. After December soil moisture was most likely not the limiting factor

to growth and it was decided not to include these in the correlation studies.

This indicates that growth of the three varieties at Lejo was very susceptible to periods of water stress. Figures were of course taken during an exceptionally dry period and it is possible that normal seasonal reduction in growth would not approach that observed in this trial.

Much work overseas has indicated that the water requirements of bananas are high (Simmonds 1972, Wardlaw 1961, Green and Kuhne 1970, Turner 1972). Turner (1972) found that physiological activity and yields were reduced when available soil moisture fell below 70 per cent. Trachoulas (1971) observed that highest yields were obtained when soil water was kept near field capacity. The higher the soil moisture level, the greater the hand number, fruit number and grade (fruit filling) of the bunch. Any positive correlation between yield and rainfall in the present trial has been masked by presence of Sigatoka. However, with more efficient control of Sigatoka it is highly likely that both growth and production would be improved by supplementary irrigation during the dry season. In the absence of irrigation, removal of young suckers and slashing of the cover crop, if present, should economize on use of available water.

Variation of growth with age of plant

A study of the monthly growth rates throughout the life of a plant yielded significant differences for Tui and Dwarf Cavendish, but not for Giant Cavendish (Figure 6). When comparing the grouped mean of months 1 and 2 with the grouped mean of months 3, 4 and 5 for Tui there was found to be significant difference at the 5 per cent level. A high degree of significance occurred when comparing the group mean of months 3, 4 and 5 with the group mean of months 6, 7, 8, 9, 10 and 11 ($P = .01$).

The growth rate of the first month of Dwarf Cavendish was found to be significantly different ($P = 0.05$) than the group mean of months 2, 3 and 4. When considering the group mean of months 2, 3 and 4 with the group mean of months 5, 6 and 7 there is a high degree of significance ($P = 0.01$).

The significant lower initial growth rate of the suckers for Tui and Dwarf Cavendish could suggest an influence of the parent plant as described by Champion (1963) (cited by Turner 1970b) and Wardlaw (1961). Champion (1963) (cited by Turner 1970b) found that in the giant varieties this parental dominance existed until the parent plant was harvested while the effect was not so long lasting in the Dwarf Cavendish type.

During the trial at Lejo it was normal to leave two suckers plus a mother plant per stool. The youngest sucker would therefore be 2-4 months old when the parent or mother plant was harvested. It is possible then that the mother plant did exert a dominating effect on young suckers considered.

There does not appear to be much evidence of parental dominance with Giant Cavendish. However the figures obtained are too variable for a true assessment.

Walmsley and Twyford (1968) have shown that phosphorus can be translocated from a sucker corm to a mother corm and vice versa. It may therefore be possible that photosynthates and nutrients needed for fruit filling are also taken out of the corm of the sucker. As the total amount in the young sucker is relatively small the effect would be greater than on a much older sucker. Another reason for this parental dominance could be shading or some hormonal effect.

The growth rate of Tui appears to be greatest during its third-fifth month whereas growth during the first four months of Dwarf Cavendish is significantly greater than the following months. Figures for Giant Cavendish are again not significant although there appears to be a tendency towards a greater growth rate during the early months.

The growth patterns produced particularly for Tui and Dwarf Cavendish generally agree with the findings of other workers (Simmonds 1959, Turner 1970b). They also indicate the importance of the early months of a banana stem. It is generally accepted that fertilizers applied in the latter part of the life of a single stem will not be utilized to the same extent as if applied in the early phase (Summerville 1944, Simmonds 1959).

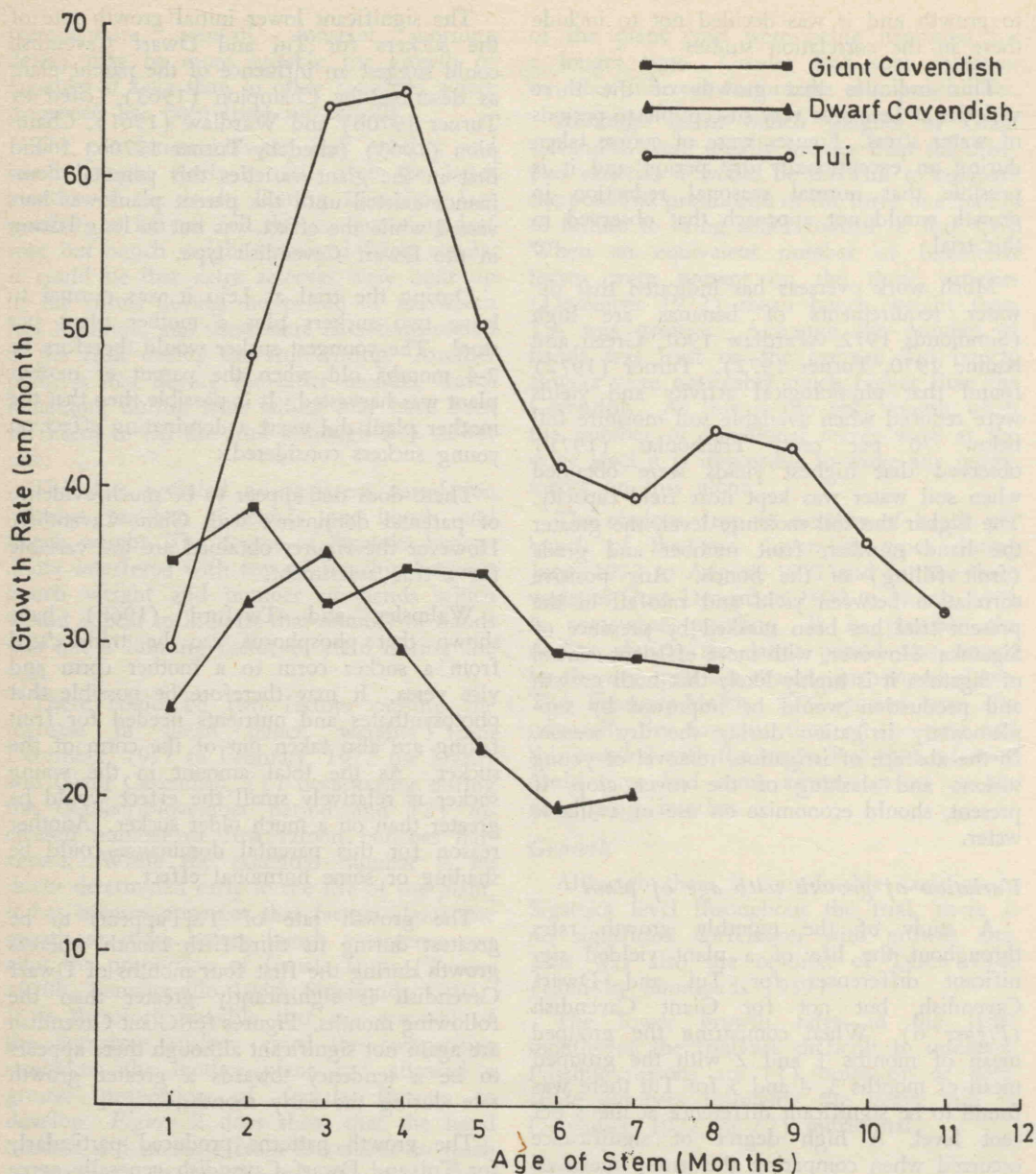


Figure 6.—Variation of growth rate with age of stem under no water stress.

Sucker emergence—bunch emergence

Figures indicate that as the variety gets taller, it takes longer to throw a bunch. This would indicate a decisive advantage for the shorter varieties in a commercial situation. It must be remembered that the figures taken in this trial were taken over a period which

included a drought and severe leaf spot infection. Time at which the drought affected the plants' growth did not appear to significantly alter the length of time taken to bunch emergence although it is highly possible that the dry spell did in fact lengthen this time. Actual times may vary from year to year depending on a range of factors.

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