# FERTILIZER RESPONSE WITH COCONUTS IN COASTAL PAPUA

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## ABSTRACT

*A trial on a relatively old stand of coconuts on the south-east coast of Papua gave good responses to potassium despite a high magnesium/potassium soil ratio. The soil, which was representative of some of the coconut-growing areas of Papua, was a deep alluvial sandy loam. A surface clay-silt layer overlies the sandy loam in some cases and this layer is especially high in magnesium.*

*At the time the trial finished* (1973) *both rates of potassium chloride* (1.1 *and* 2.2 *kg/palm*) *gave net profits with the lower rate being more economical. In* 1976, *however, fertilizer use would be unprofitable as in most cases total production costs would exceed the copra price.*

*Although a significant yield response to sulphur over potassium was not detected, tissue analyses suggested that sulphur levels were often marginal or deficient so a sulphur component in the fertilizer is suggested.*

*Provided economic conditions for copra production are adequate it is recommended that* 1.5 *kg of potassium sulphate be broadcast evenly over a circle* 4 *m to* 5 *m in diameter around the base of the palms annually.*

*There was no detectable yield difference between palms where fertilizer was broadcast over a circle* 4 *m* 5 *m in diameter around the palm base or when fertilizer was broadcast evenly over the whole area.*

## INTRODUCTION

The appearance of palms together with the results of soil and tissue analyses indicated that potassium may well be deficient on an area of deep sandy loam soil of alluvial origin.

The area in which the trial was located is part of a large, almost level, alluvial area which was once probably a flood plain. The site is underlain by a dark brown sandy loam to at least a depth of 150 cm. This underlying sandy loam was probably once sand dune formations of marine origin. This fact gives some explanation as to why the soils of the whole area vary from sandy loams to heavy clays, since it would appear that with the recession of flood waters, small scattered stretches of silt and clay-laden water would become trapped in the depressions between the dunes. Removal of the excess water either by evaporation or infiltration via the sandier soil, would consequently deposit the clay and silt fractions. It is within these clay overlays that the high exchangeable magnesium levels (12 to 19 milli-equivalents per cent) are found. The lower exchangeable magnesium values are to be found in those plots containing a much sandier topsoil. It was thought that high magnesium levels might limit the effectiveness of soil potassium applications. It was decided to test two economically feasible potassium rates.

The trial was conducted on a variable stand of palms that were over 50 years old. Palms near the sea front, on deep sandy soils, were producing quite well while those some miles inland and generally in low-lying situations were often poor and displayed potassium deficiency symptoms. The trial was carried out on a commercial plantation about 160 kilometres south-east of Port Moresby. It was thought that any results from the trial would have wide application along the Papuan coast as situations similar to that of the trial area are common. *Figure* 1 shows locations where similar assays have been recorded.

Tissue analyses from young palms near the trial area indicated severe potassium and sulphur deficiency. However at the time the trial began,

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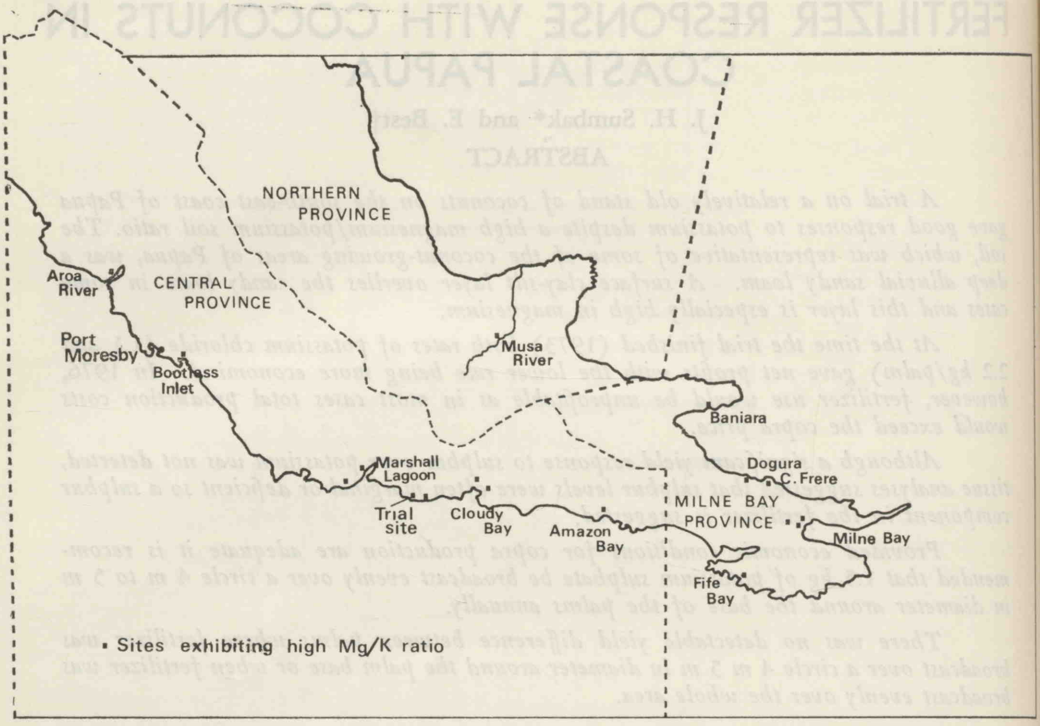


*Figure* **1.—Locations along the Papuan coast where assays similar to that of the trial site have been recorded**

the sulphur status of the palms in the trial was considered marginal to adequate.

## EXPERIMENTAL

The area selected for the trial was somewhat variable texturally and consequently chemically. Soil and plant analyses as well as plant symptoms in all replicates showed some degree of potassium deficiency with replicate 3 the worst, 1 and 2 intermediate and replicate 4 the best. Treatments were as follows—

T1 = Control (unfertilized)

T2 = 1.1 kg potassium chloride per palm annually

T3 = 2.2 kg potassium chloride per palm annually

Plots generally consisted of 7 x 7 palms on a 9.1 m square spacing with the inner 5 x 5 recorded for yield purposes. There was a common guard row between plots and four replicates were used. Except for replicate 3 the stand was relatively even. Replicate 3 had many misses.

Pretreatment counts were taken in February, 1967 and March, 1968 and fertilizer was first applied on the latter occasion. Fertilizer was again applied in April, 1969, April, 1970, April, 1971 and May, 1972.

Plots were split to compare methods of fertilizer application. Palms in three adjacent lines of each plot were fertilized by broadcasting uniformly (by hand) over the area of the subplot while three lines on the other side of the plot were fertilized evenly over a circle about 4 m to 5 m in diameter around the base of the palms. The centre row of each fertilized plot had fertilizer distributed so as to correspond to the adjacent method of application. It was thought that should magnesium/potassium antagonism occur a heavy application over a restricted area might prove more effective.

Unfortunately the method of application comparison was not carried out in April, 1969 (when all fertilizer was applied over the 4 m to 5 m circle) but it was reintroduced in April, 1970 and April, 1971. Since differences due to the method of application had not become

*Table* 1.—Average adjusted nut numbers per plot at various intervals (months) after initial fertilizer application

| Treatment | 18 | 24 | 30 | 36 | 42 | 48 | 60 | Average |
|---|---|---|---|---|---|---|---|---|
| T1 | 242 | 236 | 208 | 138 | 293 | 221 | 127 | 209 |
| T2 | 369 | 425 | 325 | 265 | 464 | 378 | 273 | 357 |
| T3 | 468 | 478 | 328 | 253 | 536 | 437 | 281 | 397 |
| LSD 5 % | 143 | 122 | 83 | 83 | 149 | 101 | 88 | |
| 1 % | 224 | 192 | 130 | 130 | 233 | 159 | 140 | |

evident by May, 1972 all fertilizer was applied in the more convenient way, i.e., broadcast over a circle, on that occasion.

During the trial, tissue analyses indicated that the sulphur status of the palms had declined to a point where it may have been affecting copra yields. Plots were split at right angles to the method of application treatment in April, 1970 and ten palms in each fertilized plot were treated with 450 kg of sulphur. Sulphur applications were repeated in April, 1971 and May, 1972.

Recordings were carried out at approximately six-monthly intervals and soil samples were obtained prior to each fertilizer application while tissue samples were collected when possible. Nut size measurements were taken on a number of occasions.

## RESULTS

Yields are estimated by counting (with binoculars) the number of nuts that will ripen over the following six months.

Nut counts, after adjustment for pretreatment differences, are shown in *Table* 1.

Estimates of copra yield and the feasibility of fertilizer use are shown in *Table* 2. As each count represents an estimate of the number of nuts ripening in the subsequent six months an overall estimate of yield is obtained by averaging the figures in *Table* 1, doubling them and taking the resulting figure as average annual production per plot.

The figures given in *Tables* 2 and 3 are based on 1973 and 1976 conditions in Papua New Guinea respectively. In 1973 the price of copra was K150/tonne, production costs (for extra copra produced due to fertilizer only) K60/tonne and fertilizer landed at the trial site K90/tonne. In 1976 the respective figures were

*Table* 2.—A comparison of the profitability of two fertilizer rates in 1973

| Item | Amount fert. applied per palm | |
|---|---|---|
| | 1.1kg KCl | 2.2kg KCl |
| Nuts/ha | 3 456 | 3 843 |
| Copra/ha (kg) | 691.2 | 768.6 |
| Additional copra over control (kg) | 286.6 | 364.0 |
| Value (K) | 42.99 | 54.60 |
| Fertilizer cost/ha (K) | 10.95 | 21.90 |
| Additional production cost (K) | 34.20 | 21.84 |
| Profit or loss/ha (K) | +14.84 | +10.86 |

*Table* 3.—A comparison of the profitability of two fertilizer rates in 1976

| Item | Amount fert. applied per palm | |
|---|---|---|
| | 1.1kg KCl | 2.2kg KCl |
| Nuts/ha | 3 456 | 3 843 |
| Copra/ha (kg) | 691.2 | 768.6 |
| Additional copra over control (kg) | 286.6 | 364.0 |
| Value (K) | 27.26 | 47.32 |
| Fertilizer cost/ha (K) | 18.25 | 36.50 |
| Additional production cost (K) | 34.20 | 43.68 |
| Profit or loss/ha (K) | 15.39 | 32.86 |

K130, K120 and K150. A 9.1 m square spacing is used (i.e., 121 palms/ha) and there are 5 000 nuts to a tonne of copra. Fertilizer costs per hectare make allowance for missing palms in the stand.

It is pointed out that responses based solely on nut counts may underestimate actual total response to fertilizer as indications are that fertilizer increases nut size. Premature nut fall may also be reduced.

Nut dimensions are shown in *Table* 4.

Nut counts did not indicate a significant additional response to sulphur over potassium although there was evidence of such a trend two years after initial sulphur application.

Adjusted nut counts are shown in *Table* 5.

The method of application comparison gave no indication at all of a difference.

Soil analyses indicated low levels of exchangeable potassium and high levels of exchangeable magnesium suggesting that magnesium/potassium imbalance was a possibility.

*Table* 4.—Average husked nut circumferences (cm) and wet meat + shell weight (g) at various times

| Measurement | Treatment T1 | T2 | T3 |
|---|---|---|---|
| Circumference (cm) | | | |
| 18 months | 35.0 | 35.7 | 36.3 |
| 24 months | 35.0 | 35.1 | 35.3 |
| 30 months | 31.6 | 32.4 | 32.9 |
| 42 months | 35.8 | 36.2 | 36.3 |
| Weight (g) | | | |
| 30 months | 476 | 522 | 526 |
| 42 months | 585 | 626 | 612 |
| 48 months | 522 | 535 | 513 |

*Table* 5.—Average adjusted nut counts (10 palms) recorded 2 years after initial sulphur application

| Treatment | 2 years +S | —S |
|---|---|---|
| T2 | 150 | 129 |
| T3 | 176 | 151 |

*Figures* 2 and 3 show soil potassium levels from 0 to 15 cm and 15 to 30 cm respectively before fertilizer application and at varying periods thereafter. Increases are largely restricted to the 0 to 15 cm layer and as expected more pronounced with the higher fertilizer rates.

Nutwater levels of potassium indicate considerable uptake from fertilizer. As found in New Ireland (Sumbak 1971) potassium levels only increased gradually taking up to four years to approach sufficiency. Uptake from the higher fertilizer rate is consistently greater. Potassium levels are illustrated in *Figure* 4.

Nutwater sulphur levels fluctuated considerably (5.3 to 22.5 ppm in control plots) with time of sampling. Sulphur applications resulted in increased sulphur uptake to levels that were considered adequate. Sulphur levels are shown in *Figure* 5.

Frond samples were collected 12, 24 and 42 months after initial fertilizer addition and analyses are summarized in *Tables* 6, 7 and 8 respectively.

Foliar analyses indicate that nitrogen levels are generally low—well below the tentative critical level of 1.7 per cent dry matter.

Phosphorus levels are generally marginal and vary little between treatments or samplings.

Potassium levels in the unfertilized plots are very low and this is generally in agreement with nutwater analyses. Although fertilized palms show higher content in the fourteenth frond, levels still remain well below tentative critical levels. On the other hand, corresponding nutwater samples indicate substantial potassium uptake, especially at the higher rate, where levels 42 and 48 months after initial fertilizer application are approaching the adequate level.

Foliar sulphur levels vary from marginal to deficient. Uptake from applied sulphur is indicated 18 months after initial sulphur application but this is much better demonstrated in nutwaters. There appears to be little consistent correlation between sulphur content of nutwater and fronds.

Levels of calcium, magnesium and trace elements are generally adequate. Potassium applications appear to suppress magnesium uptake to some degree.

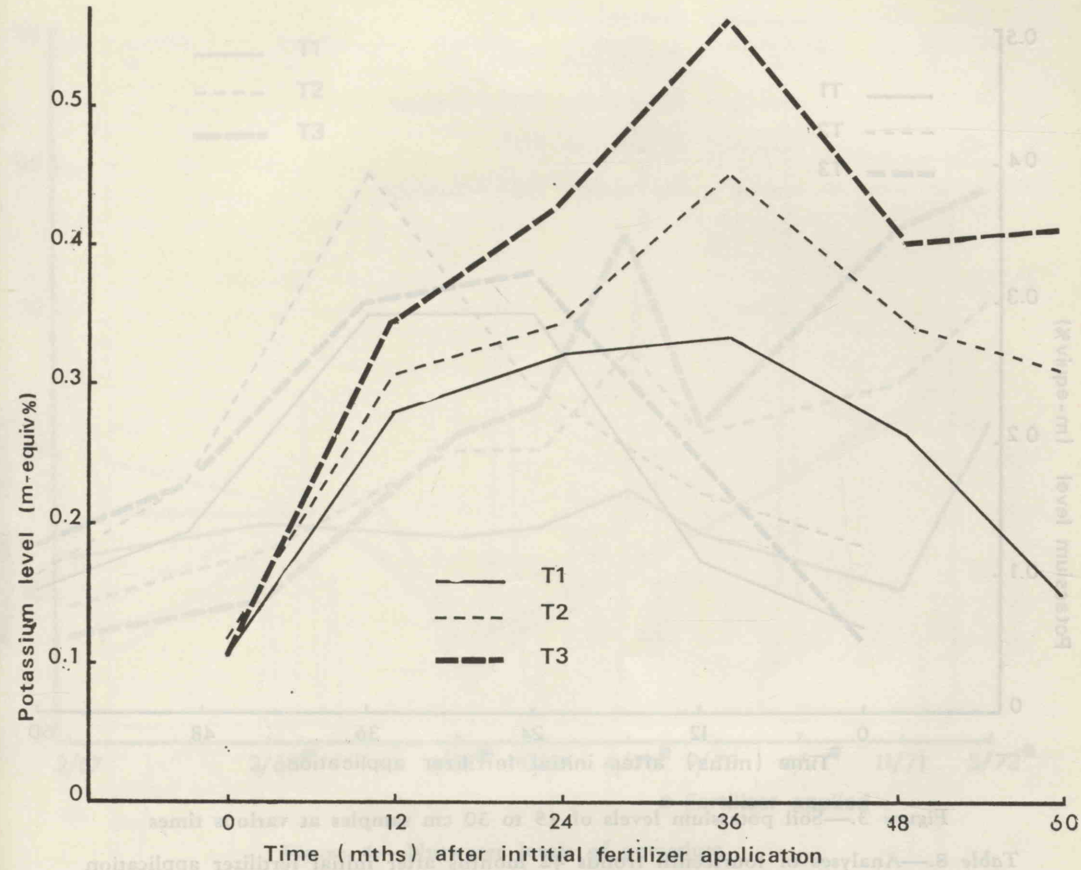


*Figure* 2.—Soil potassium levels of 0 to 15 cm samples at various times

*Table* 6.—Analyses of fourteenth fronds 12 months after initial fertilizer application

| Treatment | Percentage dry matter | | | | | ppm |
|---|---|---|---|---|---|---|
| | N | P | K | Ca | Mg | S |
| T1 | 1.32 | 0.10 | 0.16 | 0.50 | 0.72 | 148 |
| T2 | 1.26 | 0.10 | 0.18 | 0.48 | 0.76 | 171 |
| T3 | 1.29 | 0.11 | 0.20 | 0.50 | 0.73 | 195 |

*Table* 7.—Analyses of fourteenth fronds 24 months after initial fertilizer application

| Treatment | Percentage dry matter | | | | | ppm | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | Ca | Mg | S | Mn | Fe | Zn | Cu | B |
| T1 | 1.30 | 0.11 | 0.18 | 0.45 | 0.68 | 99 | 80 | 90 | 19 | 8 | 21 |
| T2 | 1.66 | 0.12 | 0.23 | 0.34 | 0.58 | 108 | 59 | 60 | 23 | 8 | 17 |
| T3 | 1.62 | 0.12 | 0.31 | 0.39 | 0.58 | 160 | 69 | 59 | 24 | 15 | 11 |

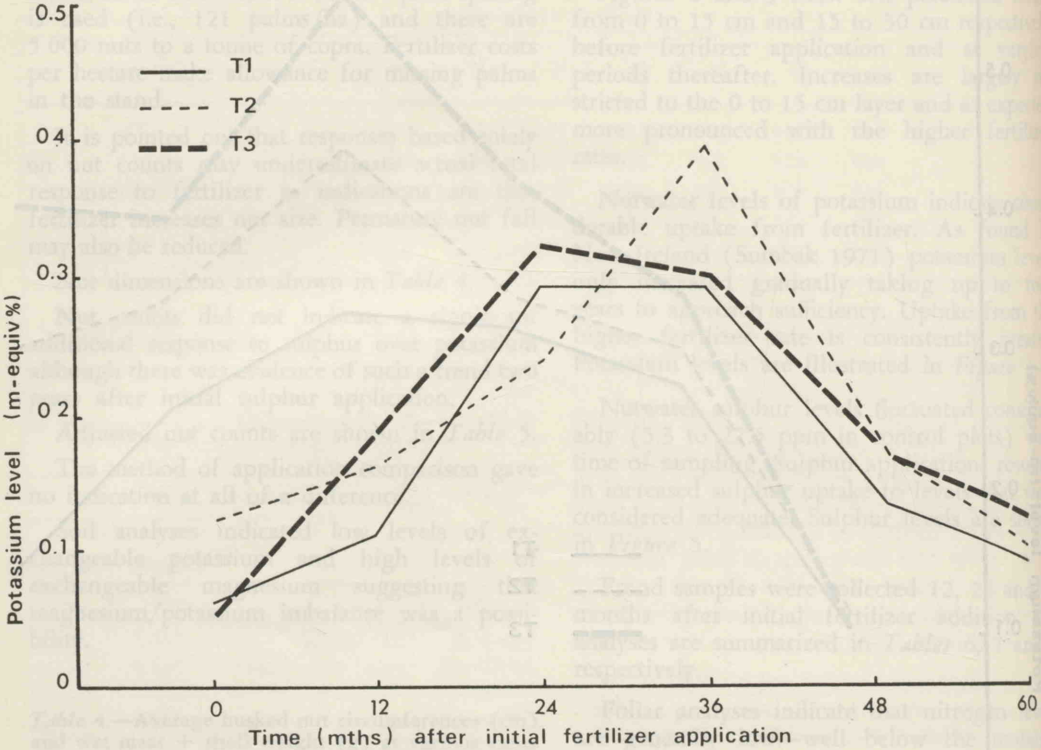


*Figure* 3.—Soil potassium levels of 15 to 30 cm samples at various times

*Table* 8.—Analyses of fourteenth fronds 42 months after initial fertilizer application

| Treatment | Percentage dry matter | | | | | ppm | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | Ca | Mg | S | Mn | Fe | Zn | Cu | B |
| T1 | 1.54 | 0.09 | 0.26 | 0.33 | 0.42 | 94 | 58 | 100 | 17 | 3 | 23 |
| T2 -s | 1.45 | 0.09 | 0.32 | 0.34 | 0.42 | 76 | 80 | 84 | 23 | 4 | 20 |
| T2 +s | 1.55 | 0.10 | 0.34 | 0.33 | 0.40 | 90 | 66 | 86 | 31 | 3 | 17 |
| T3 -s | 1.46 | 0.09 | 0.33 | 0.34 | 0.36 | 90 | 79 | 84 | 25 | 4 | 18 |
| T3 +s | 1.54 | 0.09 | 0.36 | 0.46 | 0.36 | 111 | 77 | 94 | 28 | 3 | 19 |

## DISCUSSION

Despite the high soil magnesium/potassium ratio, application of potassium raised yields substantially. Soil and tissue analyses confirmed increase in potassium levels and increases were generally related to the amounts applied.

At the time the trial was terminated the lower fertilizer rate proved economical resulting in a net increase in income of about K15 per hectare per year while the higher rate resulted in a lower profit. This is almost certainly an underestimation of profitability, as it does not allow for reduced premature nutfall or increases in nut size which are likely to be associated with fertilizer use. With very substantial increases in production costs and decreases in the price of copra, fertilizer use (and in fact, the production of copra generally) would prove unprofitable. At current Papua New Guinea cost structure the price of copra would need to approach K200 on a well-run plantation before fertilizer use is worthwhile.

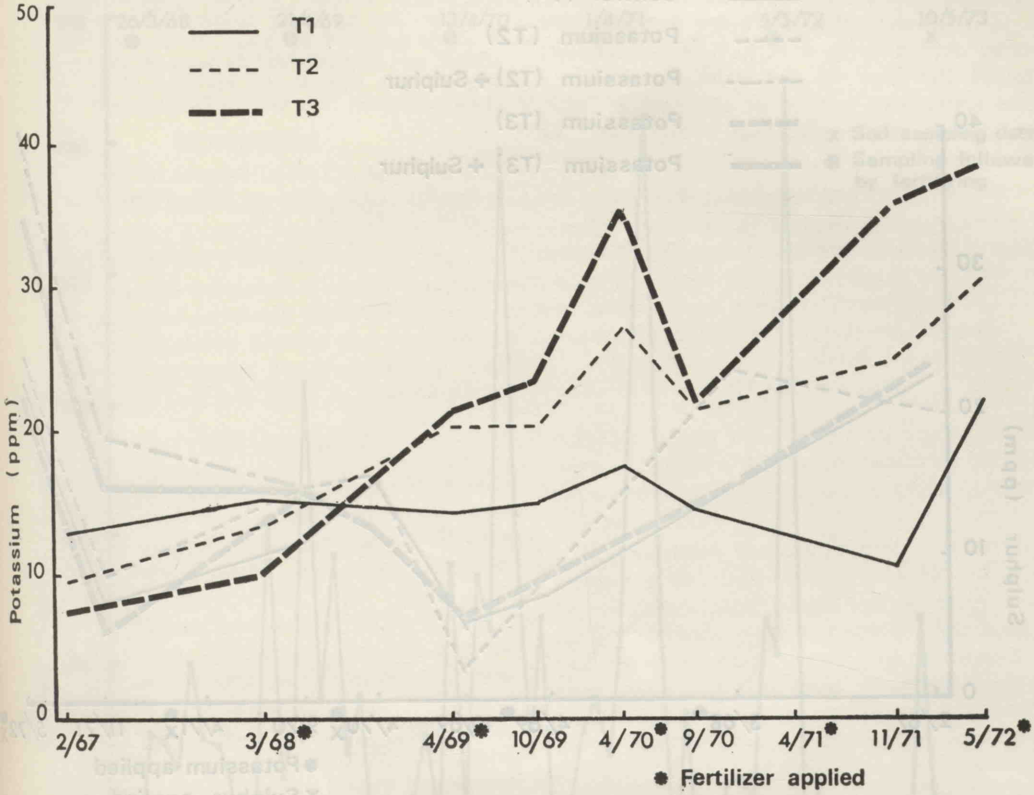


*Figure* 4.—Nutwater levels of potassium

It is interesting to note that yield increases in Papua were not as great as encountered in a New Ireland potassium-NPK-cultivation trial (Sumbak 1971). Yield responses at 1.1 kg potassium chloride per palm were 287 kg and 453 kg/hectare/year respectively for Papua and New Ireland. High water-tables on occasions and lower nitrogen and phosphorus availability as well as the greater age of palms in Papua would no doubt be contributing factors. There were also more palms per unit area in New Ireland (a maximum of 138 per hectare compared to 121). The New Ireland trial was interplanted with cacao, but it is debatable whether the grass competition present in the Papuan trial outweighed cacao competition in New Ireland.

Soil and tissue analyses generally indicate increased potassium availability. Any effect the applied potassium had on soil reserves appears to be restricted to the 0 to 15 cm layer although there does seem to be a slight beneficial effect in the 15 to 30 cm zone for those plots receiving 2.2 kg KCl per palm.

One interesting point is that the exchangeable potassium content of the control plots increased steadily during the first 36 months of the trial whereupon they then decreased over the next 24 months, more or less returning to their initial content. Changes in environmental conditions during the course of the trial may have had some bearing on this change in soil potassium content; however, no satisfactory explanation can be given.

The decline in potassium levels in the fertilized plots can be explained to some extent.

During the prolonged wet period the water-table in the area rises to a shallow depth and in some instances can become exposed in the more low-lying areas. The water-table quickly falls after cessation of the rain. Examination of the rainfall data (*Figure* 6) will reveal that for the years 1971 and 1972 substantial amounts of rainfall were recorded immediately following

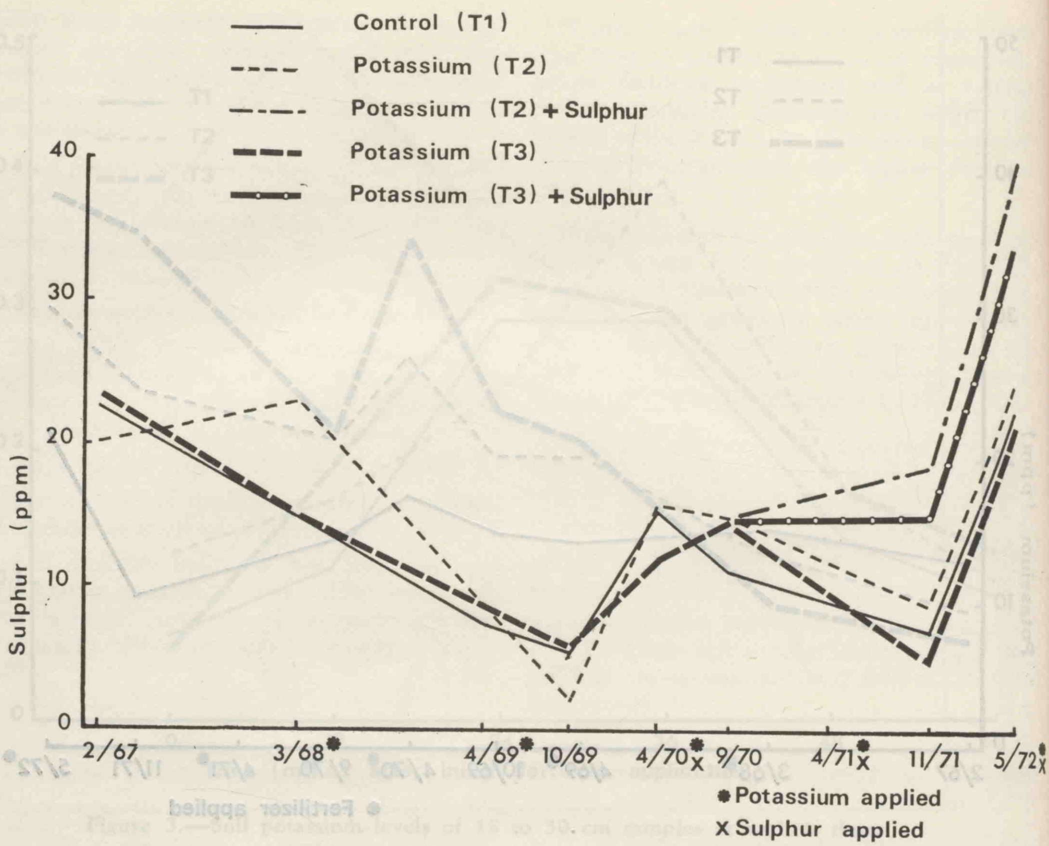


*Figure* 5.—Nutwater levels of sulphur

fertilizer application. It would therefore appear that the bulk or all of the applied potassium fertilizer was lost from the immediate 30 cm of soil by excessive leaching. The additional reduction in exchangeable potassium content is probably due to plant removal.

Nutwater analyses are much in line with New Ireland trial results where at least three and a half years lapsed before potassium levels approached adequacy. Foliar analyses indicated potassium uptake but levels were still much below the Department's tentative critical levels. Again nutwater samples appear to be a more sensitive indication of potassium uptake and although there appears to be a good case for lowering the foliar critical level for potassium one must bear in mind that plant tissues of different physiological age are being compared. A better correlation may be obtained between nuts and their subtending fronds.

Sulphur levels in unfertilized palms varied very considerably with time from apparently quite adequate to deficient. Nutwater analyses indicated substantial uptake of applied sulphur while foliar levels, although indicating some uptake, remained comparatively low. There appeared to be little correlation between foliar and nutwater levels of sulphur. A consistent relationship between the two types of analyses remains to be established.

The lack of significant additional response to sulphur over potassium may possibly be attributed to a lack of experimental precision. Only ten possible positions in each plot were fertilized and there were misses. On the basis of tissue analyses and palm appearance it is felt that sulphur applications are necessary. It would probably be best to apply 1.5 kg of potassium sulphate annually instead of 1.1 kg of potassium chloride. This is equivalent to

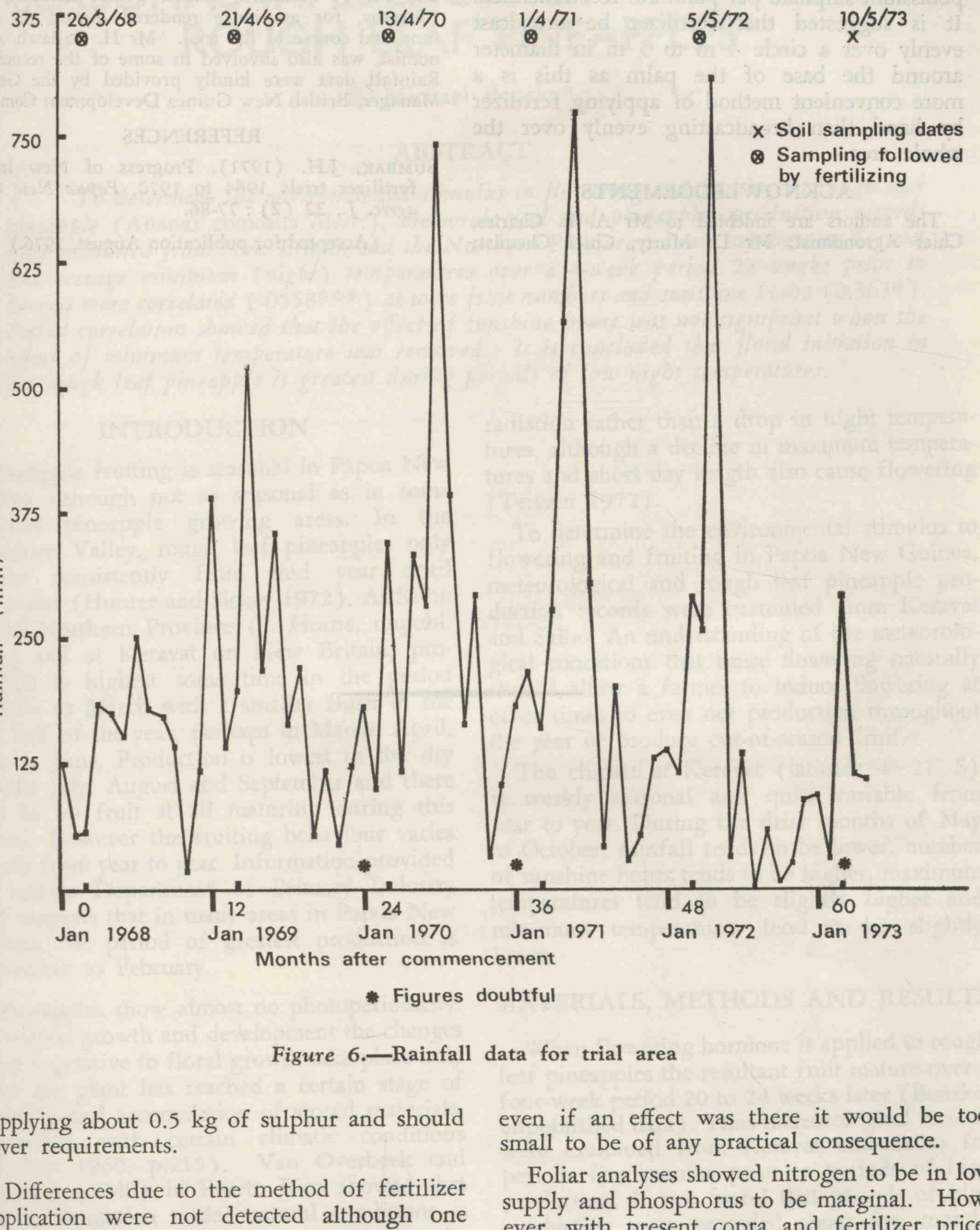


*Figure* 6.—Rainfall data for trial area

supplying about 0.5 kg of sulphur and should cover requirements.

Differences due to the method of fertilizer application were not detected although one could postulate that more concentrated applications would be desirable in a soil where magnesium/potassium antagonism is likely. The failure to carry out the application comparison when fertilizer was added for the second time was unfortunate and may have prevented the detection of a treatment effect but, in any case, even if an effect was there it would be too small to be of any practical consequence.

Foliar analyses showed nitrogen to be in low supply and phosphorus to be marginal. However, with present copra and fertilizer prices and the level of maintenance of many coconut plantings it is certain that the use of nitrogen and phosphorus fertilizer would be uneconomic.

## RECOMMENDATIONS

Provided economic conditions are satisfactory annual applications of 1.5 kg of potassium sulphate per palm are recommended. It is suggested that fertilizer be broadcast evenly over a circle 4 m to 5 m in diameter around the base of the palm as this is a more convenient method of applying fertilizer by hand than broadcasting evenly over the whole area.

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