

## EFFECT OF N, P, K, Ca AND Mg ON LEAF NUTRIENT CONTENT AND YIELD OF YOUNG COCONUT

S. ROBERT CECIL

### ABSTRACT

The effect of graded doses of nitrogen, phosphorus, potassium, calcium and magnesium on the yield, yield attributes and leaf nutrient concentration of young coconut palms of West coast Tall variety is presented hereunder. Application of all the nutrients except phosphorus increased the concentration of these nutrients in the leaf. However, the effects of nitrogen and potassium were significant only in the initial years. Applied phosphorus had only marginal influences on leaf phosphorus. Higher levels of nitrogen, phosphorus and potassium had no significant influence over the lower levels on the yield and yield attributes. The main effect of magnesium was significant on the yield and yield attributes. The direct and indirect effects of soil and leaf nutrient concentrations on the yield are also discussed.

### INTRODUCTION

Foliar analysis has been considered as the most useful of all diagnostic aids for assessing the nutritional status of perennial plants (Bould, 1963; Goodall and Gregory, 1947; Smith, 1962). The practicability of using specific nutrient levels in the plant as indicators of the uptake pattern of nutrients and their consequent effects on growth and yield, has been widely established and has been found highly useful for studying the fertiliser responses of perennial crops (Bould, 1963; Hardy et al., 1935;

Chapman, 1941; Prevot and Ollagnier, 1954; Reuther et al., 1958; Ziller and Prevot, 1962). The present paper deals with the effect of application of graded levels of N, P, K, Ca and Mg on leaf nutrient concentrations and the yield of young coconut palms of the West coast Tall variety.

#### MATERIALS AND METHODS

The study was carried out in a field fertility experiment started in 1970 with newly planted West coast Tall seedlings on the experimental farm of CPCRI, Regional Station, Kayangulam. The soil is loamy sand (Entisol) developed from marine alluvium (Sankaranarayanan and Verghese, 1961) pale brown to light yellowish brown, very deep and well drained, and the area has nearly level to flat topography.

The design of the experiment was in a split plot, where the main plot treatments were combinations of three levels of N, P and K in a 33 confounded factorial arrangement confounding  $NP^2K^2$ , and sub-plot treatments were factorial combinations of two levels of Ca and Mg with single replication. The main plot consisted of 24 palms and the sub-plot six palms.

Three levels each of nitrogen (500, 750 and 1000 g N), phosphorus (300, 450 and 600 g  $P_2O_5$ ) and potassium (1000, 1500 and 2000 g  $K_2O$ ) and two levels each of calcium (Zero and lime requirement) and magnesium (0 and 500 g MgO) were applied per palm per year. The young palms were fertilised at the rate of one-third adult palm dose in the first year after planting, two-third in the second year and the full dose in the third year and onwards. The nutrients were given in the form of amorphous (16 : 20) plus urea for N and P, muriate of potash for K, slaked lime for Ca and magnesium sulphate (hydrated) for Mg. The annual dose of NPK and Mg fertilisers was applied by broadcasting in circular basins of the palms in two splits, one-third in April and May (pre-monsoon) and two-thirds in August and September (post-monsoon) every year. The lime requirement of the soil was estimated (Shoemaker et al., 1961) and the quantity of lime required to maintain the pH of 0-50 cm layer of soil around 6.5 was broadcast uniformly over the entire sub-plot area including the palm basins during June and ploughed in. A basal application of 50 kg well rotten cattle manure was

given to all the experimental palms during August every year since 1973.

Composite leaf samples representing each sub-plot were collected and prepared by standard methods (Anonymous, 1961; Prevot and Bachy, 1962) during the month of March before the application of the first dose of fertilisers. Nitrogen was estimated by the modified Kjeldahl method (Jackson, 1973). Wet oxidation of the leaf tissues by triacid mixture was employed for estimating P, K, Ca and Mg. Phosphorus was estimated by the vanadomolybdic phosphoric yellow colour method described by Jackson (1973). Potassium was estimated flame photometrically, and Ca and Mg by the versene titration method (Jackson, 1973). Sulphur was extracted by wet oxidation with 2:1  $\text{HNO}_3\text{-HClO}_4$  diacid mixture and was estimated by the turbidimetric method described by Jackson (1973). The yield of nuts was recorded during harvests. Female flower production was recorded by counting the number of nuts and the number of scars of shed flowers in the harvested bunches.

## RESULTS AND DISCUSSION

### Leaf nutrient levels

The main effects of treatments on foliar nutrient levels are presented in Tables 1 to 4.

1) *Nitrogen*: Increased rates of N application had increased the leaf N levels, but the increase was significant only up to the fifth year. Even at the first treatment level of N, the palm had been able to maintain an adequate N nutrition as evidenced by the foliar N values in comparison with the critical level of 1.8 to 2.0 per cent reported by different workers (Fremont et al., 1966; Smith, 1968; Kanapathy, 1971; Magat, 1979; Manciot et al., 1979). These results support the present recommendation of 500 g N per adult palm per year. The influence Ca (liming) was invariably positive and the effect was significant in all the years except in 1977. This might be due to the influence of Ca on pH and other soil factors for better absorption of the added nitrogen by the palm (Cecil, 1981).

2) *Phosphorus*: Increased rates of P application had increased the foliar P levels but not to a significant level. Treatment with Ca improved the P content while that with Mg showed the maxi-

*Table 1. Main effects of treatments on foliar nutrient levels (in per cent dry matter) of young West coast Tall Palms*

Year of sampling : 1973 (3rd year)

FronD number : 4

Nutrients level	Nutrient content in per cent					
	N	P	K	Ca	Mg	S
N1	1.94	0.162	1.68	0.373	0.146	0.149
N2	1.99*	0.163	1.70	0.373	0.140	0.146
N3	1.96	0.165	1.70	0.379	0.159	0.146
P1	1.95	0.164	1.66	0.383	0.146	0.140
P2	1.95	0.160	1.69	0.371	0.150	0.150
P3	1.99*	0.166	1.73	0.371	0.149	0.151
K1	1.97	0.165	1.64	0.383	0.154	0.158
K2	1.99*	0.166	1.67	0.381	0.149	0.146
K3	1.93	0.159	1.76	0.361	0.141	0.137
C.D (P=0.05)	0.03	NS	NS	NS	NS	NS
Ca <sub>0</sub>	1.93	0.163	1.70	0.364	0.149	0.146
Ca <sub>1</sub>	2.00**	0.164	1.69	0.386**	0.148	0.148
Mg <sub>0</sub>	1.95	0.159	1.72	0.387	0.118	0.137
Mg <sub>1</sub>	1.98	0.167**	1.66**	0.362**	0.179**	0.157**
C.D (P=0.05)	0.03	0.002	0.04	0.011	0.011	0.007
General mean	1.96	0.163	1.69	0.375	0.148	0.147

\* Significant at 5 per cent level.

\*\* Significant at 1 per cent level.

NS = Not significant.

*Table 2. Main effects of treatments on foliar nutrient levels  
(in per cent dry matter) of young West coast Tall Palms*

Year of sampling : 1975 (5th year)  
Frond number : 9

Nutrients level	Nutrient content in per cent					
	N	P	K	Ca	Mg	S
N1	1.95	0.192	1.90	0.389	0.185	0.142
N2	1.99	0.194	1.85	0.387	0.192	0.142
N3	2.02*	0.194	1.82	0.373*	0.191	0.141
P1	1.99	0.188	1.84	0.384	0.202	0.140
P2	2.00	0.195	1.84	0.369	0.194	0.138
P3	1.97	0.196	1.90	0.396	0.171**	0.146
K1	1.99	0.195	1.81	0.379	0.193	0.142
K2	2.01	0.191	1.87	0.384	0.193	0.137
K3	1.96	0.192	1.90*	0.386	0.182	0.145
C.D (P=0.05)	0.06	NS	0.08	0.014	0.019	NS
Cao	1.97	0.192	1.86	0.355	0.185	0.144
Ca1	2.01*	0.194	1.85	0.411**	0.194*	0.139
Mgo	1.98	0.189	1.86	0.379	0.167	0.137
Mg1	1.99	0.197**	1.86	0.387	0.212**	0.146
C.D (P=0.05)	0.04	0.006	NS	0.011	0.008	NS
General mean	1.99	0.193	1.86	0.383	0.189	0.142

\* Significant at 5 per cent level.

\*\* Significant at 1 per cent level.

NS = Not significant.

*Table 3. Main effects of treatments on foliar nutrient levels (in per cent dry matter) of young West coast Tall Palms*

Year of sampling : 1977 (7th year)  
 Frond number : 14

Nutrients level	Nutrient content in per cent					
	N	P	K	Ca	Mg	S
N1	1.97	0.254	2.29	0.399	0.202	0.228
N2	1.97	0.251	2.21	0.400	0.194	0.226
N3	1.99	0.256	2.23	0.393	0.201	0.223
P1	1.98	0.253	2.20	0.396	0.192	0.227
P2	1.95	0.253	2.23	0.397	0.198	0.220
P3	2.00	0.253	0.230	0.400	0.208	0.231
K1	1.93	0.252	2.18	0.382	0.193	0.231
K2	1.97	0.260	2.25	0.407	0.207	0.221
K3	2.02	0.249	2.30	0.404	0.196	0.225
C.D (P=0.05)	NS	NS	NS	NS	NS	NS
Cao	1.97	0.253	2.23	0.367	0.195	0.227
Ca1	1.98	0.254	2.26	0.429**	0.203	0.223
Mgo	1.98	0.243	2.21	0.407	0.179	0.222
Mg1	1.97	0.263**	2.28	0.389	0.217**	0.230
C.D (P=0.05)	NS	0.011	NS	0.019	0.015	NS
General mean	1.97	0.253	2.24	0.398	0.199	0.226

\* Significant at 5 per cent level.

\*\* Significant at 1 per cent level.

NS = Not significant.

*Table 4. Main effects of treatments on foliar nutrient levels (in per cent dry matter) of young West coast Tall Palms*

Year of sampling : 1979 (9th year)  
Frond number : 14

Nutrients level	Nutrient content in per cent					
	N	P	K	Ca	Mg	S
N1	1.94	0.214	2.14	0.384	0.206	0.219
N2	1.96	0.224	2.07	0.381	0.195	0.227
N3	2.00	0.222	2.06	0.373	0.202	0.213
P1	1.96	0.214	2.08	0.377	0.204	0.210
P2	1.96	0.222	2.13	0.385	0.201	0.222
P3	1.98	0.223	2.07	0.376	0.198	0.228
K1	1.97	0.217	1.99	0.390	0.195	0.219
K2	1.97	0.218	2.11	0.381	0.211	0.220
K3	1.95	0.224	2.17	0.366	0.197	0.220
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Cao	1.91	0.216	2.09	0.350	0.194	0.219
Ca1	2.02**	0.224	2.09	0.408**	0.208**	0.220
Mgo	1.97	0.210	2.07	0.382	0.177	0.212
Mg1	1.96	0.230**	2.11	0.376	0.225**	0.228*
C.D. (P=0.05)	0.05	0.011	NS	0.016	0.009	0.012
General mean	1.97	0.220	2.09	0.379	0.201	0.220

\* Significant at 5 per cent level.

\*\* Significant at 1 per cent level.

NS = Not significant.

num increase throughout the period. The interaction between P and Mg was positive and the effect was pronounced at higher levels of P.

*P-Mg interaction on foliar P in 1973*

	P1	P2	P3	Mean
Mg <sub>0</sub>	0.162	0.156	0.160	0.159
Mg <sub>1</sub>	0.166	0.163	0.172	0.167**
Mean	0.164	0.160	0.166	0.163

\*C.D (P = 0.05) for two Mg means at the same level of P = 0.004 at the same level of P = 0.004 C.D (P = 0.05) for two P means at the same or different levels of Mg = 0.007.

The foliar P levels were not significantly correlated with available soil P, but they were positively correlated (Cecil, 1981) with the exchangeable Mg in soil in 1977 ( $r = 0.237^*$ ) and 1979 ( $r = 0.269^{**}$ ). There was also a strong positive correlation between leaf P and Mg contents in 1973 ( $r = 0.346^{**}$ ), 1977 ( $r = 0.194^*$ ) and 1979 ( $r = 0.363^{**}$ ).

Smith (1968) observed similar improvement of leaf P by Mg treatment. De Silva et al. (1973) reported that translocation of P from root to shoot was adversely effected when the supply of Mg was low. It is well known that Mg plays an important role as a 'carrier' in the transport of P in plants (Jacob, 1958).

The effect of P on yield increases in coconut, was not very common, and the effect was visible only after the continued application of P for longer periods (Menon and Pandalai, 1958; Smith, 1968; Child, 1974; Rosenquist, 1980). The results of Manciot et al., 1979 generally show that only when the foliar P levels were below 0.12 per cent response to P treatments on yield was significant. In a field fertility experiment at CPCRI, Kasaragod, on sandy loam soil, the skipping of P application continuously for a period of five years did not affect adversely the yield or leaf P status even though the available soil P was reduced from a level of 90 ppm to 62 ppm, but the foliar P levels were well above the critical level (Anonymous, 1981).

It is evident from Tables 1 to 4 that the P contents were well above the critical level in all the years even at the first treat-

Table 5. Main effects of treatments on initial yields and yield attributes of young West coast Tall Palms

Nutrient level	No. of bunches per palm				No. of female flowers/bunch				Nut set (per cent)				No. of nuts per palm			
	up to Dec. '77	in '78	in '79	in '77	up to Dec. '77	in '78	in '79	in '77	up to Dec. '77	in '78	in '79	in '77	up to Dec. '77	in '78	in '79	
	2	3	4	5	6	7	8	9	10	11	12	13				
1	3.7	7.9	9.5	10.6	21.4	23.3	24.2	23.0	22.2	13.8	41.04	48.0				
N1	4.5	8.8	10.1	10.5	19.9	24.1*	25.5	23.1	21.9	17.8	41.5	51.2				
N2	4.3	8.2	10.0	10.4	17.4	21.1	26.7	23.8	23.4	18.7	36.3	49.0				
N3	4.1	8.5	10.1	10.2	19.8	22.9	28.0	22.4	21.9	15.5	40.0	47.5				
P1	4.9	8.7	10.0	11.7	19.4	23.9	27.2	24.3	24.4	22.3	43.1	56.8				
P2	3.5	7.7	9.5	9.6	19.3	21.8	21.2*	23.2	21.3	12.4	35.6	43.9				
P3	4.0	7.9	9.7	10.1	19.2	20.1	27.9	25.3	24.2	17.6	39.8	47.2				
K1	4.4	8.9	10.5	10.8	19.5	24.7*	22.7	22.0	21.3	17.7	40.4	52.2				
K2	4.1	8.1	9.4	10.6	19.8	23.7*	25.7	22.6	22.1	14.9	38.5	48.8				
K3	NS	NS	NS	NS	NS	2.8	6.8	NS	NS	NS	NS	NS				
C.D. (P=0.05)	3.8	8.0	9.5	9.4	19.4	21.7	26.7	22.6	22.6	14.9	36.2	46.0				
CaO	4.5	8.6	10.2	11.6	19.7	24.0	24.2	24.1	22.5	18.6	43.0	52.7				
CaI	2.5	6.6	8.9	8.9	18.3	21.7	19.4	21.8	22.5	9.5	27.8	41.7				
MgO																

(Contd.)

Table 5. Continued

	1	2	3	4	5	6	7	8	9	10	11	12	13
Mg/l		5.8**	9.9**	10.8**	12.1*	20.8	24.0	31.5**	24.8	22.5	24.0**	51.4**	57.1**
C.D. (P=0.05)		1.2	1.1	0.8	2.5	NS	NS	5.8	NS	NS	6.1	8.1	7.4
General Mean		4.2	8.3	9.9	10.5	19.5	22.8	25.5	23.3	22.5	16.8	39.6	49.4

\* Significant at 5 per cent level.

\*\* Significant at 1 per cent level.

NS = Not significant.

ment level of 300 g P<sub>2</sub>O<sub>5</sub> per palm per year. There was no significant response to higher levels of P on growth and on onset of bearing (Cecil, 1981) or on initial yields (Table 6). In view of this high leaf P levels, the rate of P fertilisation to coconut needs to be regulated based on leaf P levels and growth/yield responses.

3) *Potassium*: Higher levels of K had improved the leaf K levels, but the increase was significant only in the early years of growth. Correlation analysis (Cecil, 1981) showed that there was a significant correlation between leaf K and soil K in 1973 ( $r = 0.368^{***}$ ), but in 1977 and 1979 the correlations were not significant. The K levels observed in the present study were well above the critical level of 0.8-1.0 per cent (Manciot et al., 1979) even at the first treatment level of 1000 g K<sub>2</sub>O per palm per year, and there was no significant response on growth (Cecil, 1981), or, initial yields to higher levels of K. Treatment with K fertilisers, particularly on soils poor in K, had increased the leaf K levels and there was a spectacular increase in yield of nuts as well as copra per nut (Menon and Pandalai, 1958; Kanapathy, 1971; Child, 1974; Magat, 1976; Manciot et al., 1979). The present results show that the continued use of K fertilisers for the first few years had built up a sufficient leaf content even at the first treatment level. Prolonged use of K fertilisers, particularly at high rates, had been reported to induce Mg deficiency conditions in the palm (Child, 1974; Manciot et al., 1979; Cecil, 1981). As in the case of P, the K fertilisation also needs to be regulated based on foliar K levels and growth yield responses as suggested by Magat (1979).

4) *Calcium*: An addition of Ca increased leaf Ca at a significant level in all the years while Mg had a depressive effect. Even in the absence of Ca treatment, the Ca levels in frond nine and 14 were comparable to the critical level of 0.3 to 0.4 per cent as suggested by Manciot et al. (1979) while Magat (1979) suggested 0.3 per cent Ca as critical for the tall variety. The mean leaf Ca in the absence of Ca treatment ranged from 0.35 to 0.367 per cent. Values as high as 0.43 were observed with Ca treatment. Even though the Ca treatment increased foliar Ca and improved some of the growth factors of these young palms (Cecil, 1981), they were not correlated with growth and the onset of varying or initial yield. This suggests that the increased

Table 6. Main effects of treatments on yield of newly planted West coast Tall Palms

(Date of planting : October, 1970)

Nutrient level	Number of nuts per palm harvested							
	up to Dec. '77	in 1978 (8th yr)	in 1979 (9th yr)	in 1980 (10th yr)	in 1981 (11th yr)	in 1982 (12th yr)	Total up to Dec. '82	
	2	3	4	5	6	7	8	
1								
NI	13.8	41.0	48.0	44.5	61.9	53.1	262.3	
N2	17.8	41.5	51.2	46.5	68.7	53.0	278.7	
N3	18.7	36.3	49.0	43.6	58.0	50.3	255.9	
P1	15.5	40.0	47.5	42.8	61.2	52.8	259.8	
P1	22.3	43.1	56.8	48.6	70.8	56.3	297.6	
P3	12.4	35.6	43.9	43.2	56.7	47.3	238.8	
K1	17.6	39.8	47.2	42.5	59.1	53.0	259.3	
K2	17.7	40.4	52.2	44.5	65.1	52.4	272.3	
K3	14.9	38.5	48.8	47.6	54.5	51.0	265.3	
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
CaO	14.9	36.2	46.0	41.2	59.9	50.3	248.5	
CaI	18.6	43.0	52.7	48.5*	65.9	54.0	282.7	
MgO	9.5	27.8	41.7	38.2	56.6	46.6	220.4	(Contd.)

	1	2	3	4	5	6	7	8
Mg/l		24.0**	51.4**	57.1**	51.5**	69.2**	57.6**	310.8
C.D (P=0.05)		6.1	8.1	7.4	6.7	8.2	8.0	—
General mean		16.8	39.6	49.4	44.8	62.9	52.1	265.6
Percentage response of Mg over Mgo		152.6	84.9	36.9	34.8	22.4	23.6	41.0

\* Significant at 5 per cent level.

\*\* Significant at 1 per cent level.

NS=Not significant.

leaf Ca contents had not been a function of growth or initial yields. The good effects obtained by Ca treatment appear to be indirect and not of its own improvement in the foliar status.

Instances of Ca deficiency in coconut were rarely reported. Manciot et al. (1979) reported an instance in Malayan yellow Dwarfs in the Ivory Coast when the leaf Ca levels were below 0.10 per cent. They suggested that no improvement on growth or yield could be expected from calcic fertiliser application when the leaf Ca levels were sufficient. The present data agree with the critical level of 0.30 per cent in frond 14 suggested by Magat (1979) and this may be followed under West coast conditions for tall variety. The data also suggest that heavy liming, as had been done in the present trial, is not necessary for the management of the palm. Nevertheless, regulated addition of Ca through Ca bearing fertilisers like rock phosphate/superphosphate, or light additions of liming materials may be followed for supplying the Ca requirement of the palm.

5) *Magnesium*: Levels of N, P and K had no consistent influence on leaf Mg content. Addition of Ca had increased, but the effect of Mg was highly significant in all the years. The Ca Mg interaction was also positive and this had been very much reflected on growth, onset of bearing and initial yields of these young palms (Cecil, 1981).

*Ca-Mg interaction on foliar Mg in 1975*

	Ca <sub>0</sub>	Ca <sub>1</sub>	Mean
Mg <sub>0</sub>	0.167	0.167	0.167
Mg <sub>1</sub>	0.203	0.221	0.212**
Mean	0.185	0.194*	0.189

C.D. (P=0.05) for Ca Mg = 0.012.

The results of Nair Achuthan and Sreedharan (1983) show that in a similar trial with oil palm, the main effect of Ca was more than that of Mg in improving the leaf Mg content. It appears that the positive responses obtained by Ca treatment might be due to its indirect effect by improving foliar Mg levels.

Correlation analysis showed that among the major nutrients, only leaf Mg contents were significantly correlated with initial

yields and yield attributes (Table 7). Leaf Mg contents were highly correlated with all the growth characters of these young palms in 1973, 1977 and 1979 (Cecil, 1981). The number of palms flowered at 74 months (Dec. 1976) was significantly correlated ( $r=0.238^*$ ) with only foliar Mg levels. The foliar Mg levels were positively correlated with soil Mg in 1973 ( $r=0.213^*$ ), 1977 ( $r=0.373^{***}$ ) and 1979 ( $r=0.544^{***}$ ) and the correlation was strengthened by continued treatment (Cecil, 1981).

The leaf Mg levels in the absence of Mg treatment were less than 0.20 per cent and the palms showed characteristic Mg deficiency symptoms with reduction in growth, and these values could be considered to be in the deficiency level, particularly when K was present at a higher level. Treatment with Mg had brought about highly significant increases in leaf Mg contents and simultaneous improvements in all growth factors which ultimately resulted in a significant reduction in the pre-bearing age (Cecil, 1981) and a highly significant increase in initial yields and yield attributes (Tables 5 and 6). Further the leaf Mg levels in frond nine and 14 were above 0.20 per cent which is considered as the critical level of Mg for tall variety (Magat, 1979).

The data show that, among the major nutrients, Mg was found to be limiting in the experimental area. Judicious manuring with Mg salts like magnesium sulphate from the time of planting in the main field was found to be highly beneficial for the successful growth and higher productivity of the palm. A level of 500 g Mg (3.0 kg magnesium sulphate) per adult palm per year is found to be a satisfactory dose for areas with agroclimatic conditions comparable to those of the experimental area. However, the dose may be regulated based on the extent of limitation in the availability of Mg in the soil. The foliar concentration of 0.20 per cent Mg in frond 14 may be considered as critical for regulating the Mg status of the palm.

6) *Sulphur*: Sulphur did not form a treatment in the present trial, but when P and Mg were supplied in the form of Factamfos (15 per cent) and magnesium sulphate (13 per cent S) respectively, sulphur was added incidentally to the palm. Higher levels of P showed some improvement while Mg treatment increased the S content significantly. Manciot et al. (1980) reported similar improvement of sulphur due to Mg additions in the form of *kieserte*. Sulphur was not found to be limiting in the present trail as it

Table 7. Correlation of leaf nutrient contents with yield and yield attributes in 1979

Nutrients level	No. of bunches per palm	No. of female flowers per bunch	No. of nuts per bunch	Nut set (per cent)	Weight of copra per nut	No. of nuts per palm
N	0.142	-0.088	-	0.024	-0.030	0.001
P	0.030	0.062	0.127	0.044	-0.020	0.123
K	-0.019	-0.022	0.084	0.064	0.023	0.097
Ca	-0.048	0.057	0.121	0.093	0.080	0.071
Mg	0.230*	0.276**	0.247**	-0.094	0.055	0.282**

(d.f. = 107).

\* Significant at 5 per cent level.

\*\* Significant at 1 per cent level.

was not correlated with growth (Cecil, 1981) or initial yield and yield attributes (Table 7). According to Cecil and Pillai (1976) sulphur deficiency does not seem to be an immediate problem for coconuts in the west coast of Kerala, and they suggest the inclusion of any one of the S-bearing fertilisers in the fertiliser schedule for coconut as a preventive measure. The present data show that, even without magnesium sulphate treatment, the S content in frond 14 had reached to a level of 0.22 per cent by the continued application of a S-bearing phosphatic source which is more than the critical level of 0.15 to 0.20 per cent S (Manciot et al., 1980). These data show that the sulphur nutrition of the palm can be incidentally taken care of if any of the S-bearing fertiliser is used for fertilising the palm.

#### **Yield and yield attributes**

The main effects of treatments on yield and yield attributes recorded up to December 1979 are given in Table 5 and those on the yield of nuts up to December 1982 are given in Table 6. The correlation of leaf nutrients with yield and yield attributes is given in Table 7. The results show that higher levels of N, P and K had no significant response over the first on yield and yield attributes. Reviewing the mineral nutrition and fertilisation of coconut around the world, Manciot et al. (1979, 1980) reported highly significant increases in the yield of nuts/tree, copra/nut and copra/tree due to N, P and K fertilisation when the availability of these nutrients was not sufficient for optimum production.

Addition of Ca had been giving positive responses on yield and yield attributes, but the effects were not significant except the yield of nuts in 1980. Among the treatments, only the main effect of Mg showed significant and consistent influence on initial yields and yield attributes. The increased yield was mainly due to the production of a higher number of bunches per palm. Since Mg treatment favoured early growth and early flowering (Cecil, 1981) of these young palms, the response on nut yield in the early period was more compared to subsequent years. Similar yield response by Mg was reported by Manciot et al. (1979). The cumulative yield of nuts up to 1982 (Table 6) shows that the initial yield of nuts was increased by about 40 per cent by systematic treatment with magnesium sulphate right

from the time of planting in the main field.

Correlation analysis showed that only soil and leaf Mg contents were significantly correlated with yield in 1979. Path analysis was carried out (Cecil, 1981) with nutrient content as independent characters (causes) and yield as the dependent characters (effect). It was found that the path coefficient of exchangeable Mg content of soil on yield was 0.274 when the correlation coefficient ( $r$ ) between exchangeable Mg and yield was 0.240\*\*. Similarly the path coefficient of foliar Mg content on yield was 0.265 when the correlation coefficient was 0.282\*\*\*. The magnitude of the path coefficients and correlation coefficients between soil and foliar Mg levels on the one hand and yield on the other were found to be nearly equal. This observation further emphasises the direct contribution of Mg in enhancing the nut yield.

#### ACKNOWLEDGEMENTS

The author thanks Shri M.V. George, Scientist (Statistics) CPCRI, Kasaragod, for the help rendered in the statistical lay-out of the trial and Shri P.T.N. Nambiar, Scientist (Statistics), CPCRI, Kasaragod, for his help and cooperation in the statistical analysis of the data. He also thanks Dr. K.V.A. Bavappa, Director, CPCRI, Kasaragod, Dr. N.M. Nayar, formerly Director, CPCRI, Kasaragod, Dr. N.P. Jayasankar, Joint Director and Dr. N.G. Pillai, formerly senior Scientist (Soil Science) CPCRI, Regional Station, Kayangulam, for the encouragement and facilities provided for the study.

#### REFERENCES

- Anonymous, 1961. General directions for coconut leaf analysis (communicated by IRHO, Paris). *Proc. First Sessn. FAO Tech. Wkg. Pty. Cocon. Prod. Prot. & Processg.*, Trivandrum, India.
- Anonymous, 1981. Annual Report, 1980. Central Plantation Crops Research Institute, Kasaragod.
- Bould, C. 1963. Mineral nutrition of plants in soils. In: *Plant Physiology*, Vol III. (Ed.) F.C. Steward, Academic Press, New York, pp. 16-96.
- Cecil, S.R. and N.G. Pillai, 1976. Role of sulphur in coconut

- nutrition. *Cocon. Bull.* 7 (3): 1-3.
- Cecil, S.R. 1981. "Mineral Nutrition of the Coconut Palm (*Cocos nucifera* L.) in Health and Disease With Special Emphasis on Calcium and Magnesium." Ph.D. Thesis, University of Kerala, Trivandrum.
- Chapman, G.W. 1941. Leaf analysis and plant nutrition. *Soil Sci.* 52: 63-81.
- Child, R. 1974. *Coconuts*. Second Ed., Longman Group Ltd., London, 335 pp.
- De Silva, N.A.T., V. Abeywardena, G.D. George and K. Balasubramanian, 1973. Nutritional studies on initial flowering of coconut (var. *Typica*). I. Effect of magnesium deficiency and Mg-P relationship. *Ceylon Cocon. Q.* 24: 107-13.
- Fremond, Y, R. Ziller and M. De Nuce De Lamothe, 1966. The Coconut Palm. International Potash Institute, Berne, Switzerland.
- Goodal, D.W. and F.G. Gregory, 1947. Chemical composition of plants as an index of their nutritional status. *Imp. Bur. Hort. Tech. Commn.* No. 17.
- Hardy, F., J.A. McDonald and G. Rodriguez, 1935. Leaf analysis as a means of diagnosing nutrient requirements of tropical orchard crops. *J. Agric. Sci.* 25: 610-27.
- Jackson, M.L. 1973. *Soil Chemical Analysis* Eastern Economic Edition. Prentice-Hall of India Pvt. Ltd., New Delhi, 498 pp.
- Jacob, A. 1958. *Magnesium the Fifth Major Plant Nutrient*, Staples Press Ltd., London, England.
- Kanapathy, K. 1971. Preliminary work on foliar analysis as a guide to the manuring of coconuts. Paper No. 33. *Proc. Conf. Cacao & Cocon., Kuala Lumpur*.
- Magat, S.S. 1976. Soil and leaf analysis in relation to coconut yield. *Philip. J. Cocon. Studies* 1 (2): 1-9.
- Magat, S.S. 1979. The use of leaf analysis in the conduct of field fertilizer trials in the Philippines. *Philipp. J. Cocon. Studies* 4 (1): 32-39.
- Manciot, R., M. Ollagnier and R. Ochs, 1979. Mineral nutrition and fertilisation of the coconut around the world. Part I. *Oleagineux* 34 (11): 499-515.
- Manciot, R., M. Ollagnier and R. Ochs, 1979. Mineral nutrition and fertilisation of the coconut around the world. Part II. *Oleagineux* 34 (12): 563-80.

- Manciot, R., M. Ollagnier and R. Ochs, 1980. Mineral nutrition and fertilisation of the coconut around the world. Part III. *Oleagineux* 35 (1): 13-27.
- Menon, K.P.V. and K.M. Pandala, 1958. *The Coconut Palm—A Monograph*. Indian Coconut Committee, Ernakulam.
- Muliyar, M.K. and E.V. Nelliath, 1971. Response of coconut palm to N.P. and K application on the West Coast of India. *Oleagineux* 26 (11): 687-91.
- Nair Achuthan, M. and C. Sreedharan, 1983. Effect of nutrition on leaf nutrient concentration in oil palm. *J. Plant Crops* 11 (2): 109-14
- Nelliath, E.V. 1973. NPK nutrition of the coconut palm—A review. *J. Plant. Crops* 1 (Suppt.): 70-80.
- Prevot, P. and M. Ollagnier, 1954. Peanut and oil palm foliar diagnosis. Interrelation of nitrogen, phosphorus, potassium, calcium and magnesium. *Plant Physiol.* 29: 26-34.
- Prevot, P. and A. Bachy, 1962. Foliar diagnosis in coconuts. The effect of leaf position and vegetative growth on the content of various elements. *Oleagineux* 17: 451-58.
- Reuther, W., T.W. Embleton and W.W. Jones, 1958. Mineral nutrition of tree crops. *Ann. Rev. Plant. Physiol.* 9: 175-206.
- Rosenquist, E.A. 1980. A coconut fertiliser trial on the podsolic soils of North Sumatra. *Oleagiuenx* 35 (5): 241-46.
- Sankaranarayanan, M.P. and E.J. Verghese, 1961. Classification and characteristics of soils of the Central Coconut Research Station, Kayangulam. *Indian Cocon. J.* 14: 163-73.
- Shoemaker, H.E., E.O. Mclean and P.F. Pratt, 1961. Buffer methods for determining lime requirement of soils with appreciable amounts of extractable aluminium. *Soil Sci. Soc. Am. Proc.* 25: 274-77.
- Smith, P.F., 1962. Mineral analysis of plant tissues. *Ann. Rev. Plant. Physiol.* 13: 81-108.
- Smith, R.W. 1968. Effect of fertilizer on the early growth and yield of Malayan Dwarf coconuts in Jamaica. *Proc. Third Sessn. FAO Tech. Wkg. Pty. Cocon. Prod. Prot. & Processg.* Jogjakarta, Indonesia.
- Ziller, R. and P. Prevot, 1962. Foliar diagnosis: A method of studying mineral nutrition and its application to the coconut palm. *Indian Cocon. J.* 15: 156-59.

**DISCUSSION**

**Q :** You found that there is no response for N, P and K. Based on this can we conclude that application of these nutrients is not needed for coconut palms?

**Ans:** Increasing of doses of these nutrients beyond the lowest dose tried may not be beneficial.

**Q :** Can you attribute the response to Mg to that nutrient alone since sulphur was also added along with Mg?

**Ans:** In this study, the effects of sulphur and Mg are confounded.