THE CHLORINE NEEDS OF COCONUTS

by

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ABSTRACT

A study designed to determine the nutritional needs of coconut from nursery to full-bearing was conducted from 1974 to 1988 in a Cl-deficient soil (Topic Tropudalf) of Davao, Southern Philippines.

At nursery stage, only chlorine application improved the growth of the seedlings based on girth size which was highly correlated with increased leaf Cl. During the first five years in the field, K and Cl significantly influenced the growth of the palms which were positively correlated to ail growth parameters, i.e. girth, number of leaflets, living fronds and leaf production. During the fifth year, Cl-fertilization resulted in 115% more flowering palms than the unfertilized ones. From then on, Cl application consistently increased nut production, copra weight per nut and copra yield per tree which was correlated with leaf Cl. However, the positive effects of other nutrients like N, K and Mg on yield as well as interaction effects were inconsistent over the years.

The nutritional needs of palms for Cl at the nursery stage is 30 g Cl per seedling. Under field condition, the requirement increases with age from 40 g to 1,000 g per palm leveling off at fifth year from planting.

INTRODUCTION

Several studies have been conducted on coconut fertilization in the country and elsewhere. Nevertheless the nutritional balance particularly in N, K, Mg and Cl for growth and production from nursery to full-bearing stages has not been established, particularly in inland coconuts.

The need for C1 in the vegetative and reproductive growth of coconut palms was initially demonstrated at the Davao Research Center (Mendoza and Prudente, 1972). They later confirmed that palms fertilized with KCl together with either N or NP produced significantly more nuts with thicker meat and more copra per palm than the unfertilized ones (Prudente and Mendoza, 1976). Related studies revealed that most inland coconuts apparently respond to N and Cl (Magat et al, 1975) and that the positive effect of Cl is manifested more in terms of copra weight per nut (Magat and Prudente, 1975; and Margate et al, 1978).

Studies on the effect of Cl on coconut seedlings indicated that both KCl and NaCl positively influence the growth of seedlings and increase their resistance to leaf spot disease (Abad et al 1978; Magat et al, 1977).

During the period 1974 to 1988 an experiment was conducted at the Davao Research Center to assess the Cl nutritional needs of coconuts. Specifically, under field conditions it was designed to determine the coconut's critical and optimum level for Cl and the need for N, K and Mg using a Cl-deficient soil.

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MATERIALS AND METHODS

Planting Materials and growing conditions

The planting materials used in the study belong to the tall 'Laguna' variety. The seedlings were raised in a polybag nursery (60 cm x 60 cm triangular system, N-S orientation) for seven months and were field planted in August 1974 at a spacing of 9 m x 9 m in triangular pattern, following a N-S orientation.

The soil in the experimental area is classified as Tugbok day loam (Typic Tropudalf) with physical and chemical properties as shown in appendix Table 1. It has an acceptable internal and external drainage.

Rainfall is almost evenly distributed throughout the year; and sunshine, relative humidity and temperature at satisfactory levels for coconuts. For the past ten years, average rainfall and relative humidity were respectively 2, 102 mm (annual) and 80.5% (monthly).

Layout and treatments

A 3^3 factorial experiment in a split-plot, incomplete block design was adopted in the study. The split plots were either with or without Cl, with 27 main plots and 54 sub-plots. The three other factors being investigated were N, K and Mg. There were 12 palms per elementary plot with common guard rows. The elements being studied and their sources were as follows:

1) N - $(NH_4)_2SO_4$, NH_4C)
2) K - KCl and K_2SO_4
3) Mg - $CaMgCO_3$ (dolomite)
4) Cl - KCl and NH_4Cl

In the course of the study, an unusual yellowing of the fronds was observed two years from planting. This was confirmed later to be due to S deficiency. To avert the situation, a blanket application of gypsum at the rate of 2 kg per palm per year was done starting October 1976.

The annual fertilizer rates (Table 1) were applied in split at equal doses during the months of February and August.

Parameters

Data on growth characters such as girth, leaf emission and count, number of leaflets (rank 3), trunk height, flowering precocity and yield were variedly taken, depending on the age of the palms. Leaf samples were collected and analyzed periodically for concentrations of N, P, K, Ca, Mg, Na, Cl, S and B, at the PCA's Tissue Analysis Laboratory, HQ, Diliman, Quezon City.

RESULTS AND DISCUSSION

Effect of nutrients on growth of seedlings (nursery stage)

Table 2 shows a clear manifestation of the response of the seedlings to Cl application in terms of girth circumference compared with the control in ail stages of observations. Nitrogen and Mg did not have any influence on the growth of the seedlings. But K at a lower level, gave some positive effect. The findings reveal that the application of both K and Cl is beneficial to coconut seedlings. This positive response to Cl strongly indicates the deficiency of the Tugbok soil in this element, more so that the site of the study is far (8 km away) from the sea. Results were consistent with earlier studies of Magat et. al. (1977): Maravilla et al (1978) and Oguis et al (1979).

Effect of nutrient on young field-planted palms

As early as six months from field planting up to the second year, practically all palms exhibited yellowish-orange leaves especially on older ones. After a close investigation, it was confirmed to be due to S deficiency more particularly in palms applied with Cl due to Cl-S antagonism. So, starting October 1976, a blanket application of gypsum ($CaSO_4$. NH_2O) as a source of S was made. Henceforth, the subplots were changed from +Cl and +S to +Cl and –Cl.

Six months after application of fertilizers, treatments KI, Mgl and Cl significantly increased the girth of the palms (Table 3). Similarly in succeeding years the palms showed significant response to K, Mg and Cl application. The effects were more manifested in the girth and number of leaflets of the palms. In older palms, both K and Cl treated plots consistently produced palms with more living fronds, higher leaf production, more accumulated leaf production and taller palms. The lack of positive response to N application is very likely due to the benefits obtained from the well-established cover-crops which could have maintained a high soil level of N.

Details of the results in the nursery and in young field planted palms were earlier reported (Magat and Oguis, 1979).

Effect of nutrient on yield

a. Nut per palm - For the last five years (1984-88) of production (Table 4) it was only Cl (1 kg/palm) that gave consistent trend of response over the minus Cl treatment. Other elements like N, K, and Mg did not produce any significant effect on nut production in ail the years. The nut production of the Cl-fertilized palms ranged on the average at 47-85 nuts per year while the minus Cl palms with 26-63 nuts, corresponding to a 50% increase in nuts due to Cl-fertilization. The results generally indicate that Cl is the major limiting factor in the area of study.

b. Copra weight per nut - Table 5, shows the effect of the different treatments on copra weight per nut. Again, in ail the years of production Cl significantly improved the weight of copra per nut over the minus Cl treatment. Over the years, average copra per nut of 231 g and 300 g of unfertilized and Cl-fertilized palms, respectively were noted. This indicates a 30% increase in copra weight per nut with Cl fertilization. Magnesium did not produce any effect at ail while K1 (425 g K) and K2 (850 g K) significantly increased the weight of copra per nut except in 1985 and 1987. However, compared to Cl application (30% increase), K application increased copra weight per nut by only 7% over unfertilized palms. Nitrogen at N2 (140 g N) produced significant improvement especially for the last four years of production, while N, had been very inconsistent.

c. Copra weight per palm - Just like nut yield. the response was more clue to Cl (1 kg Cl) fertilization in ail years (last 5 years) (Table 6). With Cl-fertilization, the average copra yield was 19 kg/tree or a 71% increase over the minus CI (11.2 kg copra per tree/year). Potassium application (425 g K and 850 g K) as well as N applications (140 g N and 280 g N) significantly affected copra yield in some years only. As in copra weight per nut, significant increases in annual copra yield per tree were inconsistent and lower from K and N application than due to Cl-fertilization. Magnesium did not show any significant effect at ail in all the years of production.

Table l. Fertilizer treatment applied in the nursery period and in the field (annually)

AGE/YEAR	FERTILIZER (g palm)*				
	NH_4Cl (AC)	$(NH_4)_2SO_4$ (AS)	KCl (KC)	K_2SO_4 (KS)	$CaMgCO_3$ (Col)
Nursery 2 mos. (1974)	N0 (0) N1 (5) N2 (15)	N0 (0) N1 (9) N2 (18)	K0 (0) K1 (10) K2 (20	K0 (0) K1 (12) K2 (25)	Mg0 (0) Mg1 (5) Mg2 (10)
5 mos. (1974)	N0 (0) N1 (15) N2 (30)	N0 (0) N1 (18) N2 (35)	K0 (0) K1 (20) K2 (40)	K0 (0) K1 (25) K2 (50)	Mg0 (0) Mg1 (10) Mg2 (20)
Field at planting (Aug. 1974)	N0 (0) N1 (30) N2 (60)	N0 (0) N1 (35) N2 (70)	K0 (0) K1 (40) K2 (80)	K0 (0) K1 (50) K2 (100)	Mg0 (0) Mg1 (50) Mg2 (100)
Year 1 (1975)	N0 (0) N1 (120) N2 (240)	N0 (0) N1 (140) N2 (280)	K0 (0) K1 (175) K2 (350)	K0 (0) K1 (200) K2 (400)	Mg0 (0) Mg1 (100) Mg2 (200)
Year 2 (1976)	N0 (0) N1 (300) N2 (600)	N0 (0) N1 (350) N2 (700)	K0 (0) K1 (425) K2 (850)	K0 (0) K1 (500) K2 (1000)	Mg0 (0) Mg1 (200) Mg2 (400)
Year 3 (1977)	N0 (0) N1 (450) N2 (900)	N0 (0) N1 (550) N2 (1100)	K0 (0) K1 (600) K2 (1200)	K0 (0) K1 (700) K2 (1400)	Mg0 (0) Mg1 (250) Mg2 (500)
Year 4 (1979)	N0 (0) N1 (500) N2 (1000)	N0 (0) N1 (550) N2 (1100)	K0 (0) K1 (700) K2 (1400)	K0 (0) K1 (800) K2 (1600)	Mg0 (0) Mg1 (300) Mg2 (600)
Year 5-14 (1980-1988)	N0 (0) N1 (600) N2 (1200)	N0 (0) N1 (700) N2 (1400)	K0 (0) K1 (850) K2 (1700)	K0 (0) K1 (1000) K2 (2000)	Mg0 (0) Mg1 (400) Mg2 (800)
* AC-15% N. KS-50% K20	55% Cl; 18% S;	AS-20% N. DOL-20% Mg	24% S; 40% Ca0	KC-60% K20	40% Cl

Effect of fertilization of leaf nutrient levels of bearing palms

The application of N did not significantly improve leaf N levels but increased significantly leaf Ca and Cl (Table 7). Likewise, K fertilization did not increase K contents in the leaf but improved significantly leaf Cl. This trend had been consistent for the last five years of the study.

On the other hand, the application of Mg especially at higher level did not significantly influence Mg levels but significantly depressed leaf P. Also, calcium was slightly depressed, indicating the likely existence of Ca-Mg and Mg-P negative interaction.

The only element that produced consistent response over the years is Cl. Application of which did not only increase concentration of leaf Cl content but also other elements as leaf N, P and K in some years. This manifests that Cl is an important element (macronutrient) in coconut as it enhances absorption of other elements except B which appears to be depressed indicating an antagonistic action between these two elements (Cl-B).

Table 2. Effect of fertilizer treatments on the growth of seedlings in the nursery

Growth Character	FERTILIZER TREATMENT										
	N_0	N_1	N_2	K_0	K_1	K_2	Mg_0	Mg_1	Mg_2	-Cl	+Cl
April, 1974 (pre-fertilizer treatment)											
Girth (cm)	6.87	6.82	6.92	6.87	6.98	6.88	6.87	6.81	6.97	6.90	6.89
No. of leaflets (leaf 3)	16.83	16.82	16.61	16.66	16.72	16.87	16.83	16.77	16.66	16.73	16.78
No. of leaves	3.05	3.07	3.02	2.03	3.10	3.10	3.04	3.07	3.03	3.05	3.02
August, 1974 (4 mos. After initial application)											
Girth (cm)	14.64	14.64	15.27	14.43	15.22	14.92	14.54	14.73	15.32	14.59	15.12**
No. of leaflets (leaf 3)	24.96	24.50	25.08	24.52	25.47	24.52	25.56	24.48	25.49	25.26	24.43
Height (cm)	125.84	132.59	128.25	128.84	128.30	129.54	126.67	128.30	131.71	128.69	129.09
November, 1974 (7 mos, after initial application											
Girth (cm)	21.05	22.13	21.52	20.87	22.03	21.53	21.02	21.33	22.34	20.85	22.29*
No. of leaflets (leaf 3)	34.49	34.24	34.06	34.21	34.79	33.80	34.19	34.21	34.41	34.28	34.25
No. of leaves	10.99	11.12	11.11	11.14	11.13	10.95	11.04	11.14	11.04	11.09	11.06
Height (cm)	172.40	174.50	170.26	173.33	172.69	171.09	171.97	168.87	176.28	172.04	171.70

* Significant
** Highly significant

Table 3. Effect of fertilizer treatments on the growth of young palms in the field

Growth Character	FERTILIZER TREATMENT										
	N_0	N_1	N_2	K_0	K_1	K_2	Mg_0	Mg_1	Mg_2	-Cl	+Cl
February, 1975 (6 most. From field planting)											
Girth (cm)	18.98	18.41	18.13	17.76	19.24*	18.52	17.64	18.61	19.27*	18.10	18.91**
No. of leaflets (leaf 3)	44.29	44.90	45.14	44.82	45.60	43.99	43.27	45.24	45.89	44.80	44.80
No. of leaves	11.97	12.04	11.96	11.97	12.10	11.90	11.87	12.12	11.98	12.00	11.98
Height (cm)	165.61	168.41	165.38	166.23	167.84	165.32	163.75	168.86	166.79	168.90*	164.03
February, 1976 (1.5 yrs. From field-planting)											
Girth (cm)	61.59	61.17	52.99	52.90	64.22**	62.64**	56.42	59.30	64.04*	56.89	62.95**
No. of leaflets (leaf 3)	122.25	120.15	116.44	114.83	123.05**	120.97**	116.10	118.71	124.04**	117.80	121.43*
Accumulated leaves (no.)	21.40	21.39	21.01	20.87	21.59*	21.34	20.91	21.39	21.51	21.16	21.38
Height (cm)	338.83	336.21	313.53*	302.47	347.27**	338.83*	312.49	328.31	347.77**	326.41	332.64
Living fronds (no.)	8.42	8.22	7.60**	7.63	8.31**	8.31**	7.88	8.09	8.27	7.68	8.84**
Leaves produced (no.) (1-1.5 yrs.)	4.57	4.58	4.35	4.33	4.66*	4.53	4.38	4.51	4.62	4.43	4.58*

* Significant
** Highly significant

Count's….. Table 3

Growth Character	FERTILIZER TREATMENT										
	N_0	N_1	N_2	K_0	K_1	K_2	Mg_0	Mg_1	Mg_2	-Cl	+Cl
August, 1977 (3 years)											
Girth (cm)	127.6	130.1	124.7	120.2	131.0*	131.3	125.2	128.2	128.9	122.6	132.3**
No. of leaflets accumulated	35.9	36.1	35.5	35.2	36.3	36.0	35.0	35.8	36.6*	35.0	36.6**
Height (cm)	623.6	639.7	613.4	587.1	641.7**	647.9**	616.4	625.5	634.8	611.6	639.6**
Living fronds (no.)	12.9	13.1	12.4	12.0	13.3*	13.1**	12.5	12.8	13.0	11.8	13.8**
Leaves produced (no.) (2.5-3 yrs).	5.0	5.1	4.9	4.8	5.1	5.0	4.8	5.0	5.1	4.8	5.1**
August, 1979 (5 yrs.)											
Leaves emitted (4.5-5 yrs.)	7.18	7.11	7.00	7.02	7.24**	7.03*	6.87	7.11**	7.32**	6.93	7.27**
Living fronds (no.)	21.58	22.53	22.09	21.54	22.59	22.08	21.33	22.23	22.64	20.60	23.54**
Accumulated leaves (no.)	61.97	62.31	61.42	60.64	62.93**	62.12**	60.84	62.0	63.35**	60.37	64.43**
Trunk height (cm)	91.43	101.13	93.31	79.26	103.73**	102.88**	86.19	97.47**	102.21	87.34	103.24**

* Significant
** Highly significant

Table 4. Main effect of N, K, Mg, and Cl on the annual nut production for the last 5 years

TREATMENT	1984	1985	1986	1987	1988
			N U M B E R		
N0	26.2	71.4	42.6	70.2	55.7
N1	33.3	72.5	44.8	67.6	60.2
N2	34.0	79.8*	44.0	75.6	60.9
K0	30.3	68.4	40.8	65.0	56.4
K1	30.4	77.0*	43.9	76.8*	59.4
Mg0	34.3	73.8	44.6	70.0	61.5
Mg1	29.3	72.4	42.8	72.0	56.6
Mg2	29.9	77.4	43.9	71.4	59.8
LSD 0.05	9.64	8.067	9.616	7.162	8.828
0.01	13.33	11.156	13.298	9.905	12.209
-Cl	26.0	63.4	40.0	63.1	50.8
+Cl	36.3**	85.7**	47.6*	79.2**	67.1**
LSD 0.05	5.51	5.857	7.450	5.947	6.234
0.01	7.56	8.045	10.232	8.168	8.562

* Significant
** Highly significant

Table 5. Main effect of N, K, Mg, & Cl on yearly average copra weight per nut for the last five years

TREATMENT	1984	1985	1986	1987	1988
			G R A M		
N0	275.5	237.1	280.3	237.0	237.1
N1	283.5	258.5*	294.6	245.5	253.8**
N2	297.5	267.3*	311.3*	262.4*	261.4**
K0	268.9	246.0	279.7	235.7	238.7
K1	291.7	251.7	303.8*	256.0	254.7**
K2	294.2*	265.2	302.6*	253.2	259.9**
Mg0	279.4	245.3	282.4	235.3	244.0
Mg1	282.9	256.6	298.3	255.5	254.0
Mg2	293.5	261.0	305.4	254.0	254.4
LSD 0.05	22.78	17.73	17.9	20.5	11.1
0.01	31.51	24.52	24.8	28.4	15.3
-Cl	250.4	222.8	254.7	213.4	219.8
+Cl	319.4**	285.8**	336.0**	283.2**	281.8**
LSD 0.05	16.28	13.08	18.52	14.30	14.43
0.01	22.56	17.96	25.43	19.64	19.82

* significant
** Highly significant

Table 6. Main effect of N. K. Mg & Cl on the annual copra production per tree for the last five years

TREATMENT	1984	1985	1986	1987	1988
			K I LO G R A M		
N0	7.5	17.9	12.4	17.2	13.5
N1	9.6	19.4	13.4	17.0	15.6*
N2	10.1	21.7**	13.5	20.1**	16.2*
K0	8.2	17.4	11.6	15.8	13.7
K1	9.0	20.3**	13.3	20.1**	15.4
K2	9.9	21.3**	14.4	18.5*	16.2*
Mg0	9.8	18.8	12.9	17.1	15.6
Mg1	8.5	19.6	13.1	18.8	14.7
Mg2	8.8	20.6	13.2	18.5	15.1
LSD 0.05	2.613	2.370	3.001	2.001	2.076
0.01	3.613	3.278	4.150	2.767	2.870
-Cl	6.5	14.3	10.3	13.5	11.2
+Cl	11.6**	25.1**	15.9**	22.7**	19.1**
LSD 0.05	1.706	1.863	2.575	1.826	1.918
0.01	2.343	2.558	3.536	2.508	2.634

* Significant
** Highly significant

Table 7. Effect of fertilizer treatments on leaf nutrient of bearing palms

Sampling Year/Leaf Nutrient (%)	FERTILIZER TREATMENT										
	N_0	N_1	N_2	K_0	K_1	K_2	Mg_0	Mg_1	Mg_2	-Cl	+Cl
1984 (leaf 14)											
N	1.795	1.814	1.827	1.787	1.834	1.815	1.820	1.809	1.807	1.783	1.841**
P	0.150	0.151	0.155	0.151	0.153	0.153	0.153	0.155	0.149	0.152	0.152
K	1.226	1.218	1.274	1.209	1.252	1.257	1.174	1.255*	1.288*	1.210	1.269*
Ca	0.443	0.471	0.482*	0.451	0.472	0.472	0.479	0.468	0.449	0.460	0.470
Mg	0.218	0.219	0.228	0.224	0.221	0.220	0.216	0.225	0.224	0.218	0.226
Na	0.051	0.046	0.055	0.056	0.051	0.045	0.048	0.053	0.050	0.050	0.051
Cl	0.212	0.294**	0.400**	0.239	0.314**	0.314**	0.352**	0.311	0.318	0.085	0.518*
B (ppm)	10.9	10.9	10.5	10.8	10.8	10.7	10.6	10.7	11.0	11.4	10.1
1985 (leaf 14)											
N	1.822	1.852	1.867	1.807	1.864	1.870	1.893*	1.844	1.804	1.793	1.901*
P	0.139	0.138	0.141	0.137	0.140	0.140	0.143	0.140	0.135**	0.138	0.140
K	1.556	1.544	1.532	1.535	1.567	1.530	1.546	1.538	1.548	1.540	1.548
Ca	0.327	0.342	0.348	0.336	0.335	0.345	0.335	0.336	0.325*	0.340	0.337
Mg	0.180	0.179	0.178	0.180	0.176	0.181	0.179	0.179	0.179	0.182	0.176
Na	0.177	0.227	0.327**	0.173	0.264**	0.294	0.265	0.243	0.223	0.068	0.419**
Cl	0.612	0.166*	0.170**	0.160	0.169**	0.169**	0.166	0.167	0.165	0.165	0.167
B (ppm)	9.2	9.4	8.9	9.1	9.2	9.1	9.1	9.1	9.3	9.5	8.8
1986 (leaf 14)											
N	1.996	2.004	1.003	1.993	2.012	1.998	2.106	1.998	1.990	1.966	2.036**
P	0.145	0.142	0.145	0.144	0.143	0.143	0.147	0.143	0.140*	0.142	0.145
K	1.381	1.360	1.354	1.352	1.372	1.372	1.363	1.379	1.354	1.355	1.378
Ca	0.386	0.413*	0.428*	0.397	0.411	0.419	0.420	0.405	0.403	0.403	0.415

Mg	0.182	0.191	0.192	0.187	0.182	0.195	0.194	0.183	0.188	0.189	0.187
Na	0.052	0.051	0.053	0.055	0.046	0.056	0.051	0.052	0.054	0.053	0.052
Cl	0.215	0.299**	0.373**	0.212	0.319**	0.355**	0.289	0.298	0.300	0.072	0.519
S	0.181	0.183	0.186	0.183	0.181	0.184	0.183	0.185	0.181	0.184	0.182
B (ppm)	11.2	10.6	10.6	10.8	10.9	10.7	10.9	10.5	11.0	11.3	10.2**
1987 (leaf 14)											
N	1.875	1.904	1.892	1.870	1.900	1.891	1.914	1.875	1.883	1.848	1.933**
P	0.153	0.152	0.151	0.151	0.151	0.154	0.155	0.153	0.148*	0.151	0.153
K	1.633	1.659	1.613	1.612	1.654	1.639	1.637	1.627	1.641	1.596	1.694**
Ca	0.327	0.351	0.343	0.328	0.335	0.357	0.345	0.343	0.332	0.344	0.336
Mg	0.216	0.190	0.191	0.187	0.213	0.196	0.190	0.220	0.186	0.190	0.207
Na	0.074	0.063	0.069	0.070	0.071	0.064	0.068	0.070	0.067	0.067	0.070
Cl	0.281	0.325	0.332	0.223	0.331**	0.386**	0.270	0.317	0.352	0.102	0.532**
S	0.148	0.147	0.154	0.147	0.151	0.151	0.152	0.148	0.149	0.150	0.150
B (ppm)	9.5	9.4	9.0	9.2	9.3	9.4	9.4	9.4	9.2	9.5	9.1**
1988 (leaf 14)											
N	1.987	2.036	2.012	2.012	2.023	2.015	2.020	2.009	2.007	1.959	2.064**
P	0.157	0.159	0.158	0.156	0.159	0.159	0.162	0.158	0.154*	0.155	0.166**
K	1.609	1.569	1.566	1.547	1.596	1.601	1.571	1.590	1.583	1.595	1.568
Ca	0.359	0.381*	0.385*	0.373	0.368	0.384	0.388	0.374	0.363	0.370	0.380
Mg	0.215	0.216	0.227	0.225	0.215	0.218	0.218	0.216	0.224	0.219	0.219
Na	0.043	0.045	0.048	0.049	0.045	0.042	0.045	0.047	0.044	0.046	0.045
Cl	0.211	0.296**	0.361**	0.212	0.312**	0.343	0.290	0.285	0.292	0.081	0.497
S	0.169	0.171	0.174	0.169	0.172	0.172	0.170	0.171	0.172	0.169	0.172
B (ppm)	8.8	8.5	8.4	8.6	8.6	8.5	8.1	8.1	8.8	9.0	8.2

Table 8. Correlation between coconut yield and leaf nutrient levels (1984)

	NUT/ PALM	COPRA/ NUT	COPRA/ PALM	N	P	K	Ca	Mg	Na	Cl	S	B
NUT/TREE	1.000											
COPRA/NUT	0.150	1.000										
COPRA/TREE	0.938**	0.423**	1.000									
N	0.234	0.325*	0.300*	1.000								
P	0.084	0.094	0.139	0.218	1.000							
K	1.109	0.144	0.193	-0.088	0.179	1.000						
Ca	0.340*	0.192	-0.378**	0.206	0.540**	-0.046	1.000					
Mg	-0.299	0.336*	-0.100	0.170	0.411**	0.092	0.222	1.000				
Na	-0.0421**	0.110	-0.318	0.232	0.065	0.090	-0.229	0.413*	1.000			
Cl	0.419**	0.692**	0.648**	0.309*	0.125	0.405**	0.302*	0.233**	0.034	1.000		
S	0.139	0.035	0.110	0.487**	0.294	-0.059	0.286	-0.009	-0.270	0.050	1.000	
B	-0.451**	-0.417**	-0.584	-0.124	-0.218	-0.311*	-0.174	-0.254	-0.176	-0.672*	0.030	1.000

Tabular r – values 0.05 = 0.268 0.01 = 0.353

Table 9. Correlation between cpcpmit yield and left nutrient levels (1986)

	NUT/ PALM	COPRA/ NUT	COPRA/ PALM	N	P	K	Ca	Mg	Na	Cl	S	B
NUT/TREE	1.000											
COPRA/NUT	0.386**	1.000										
COPRA/TREE	0.867**	0.664**	1.000									
N	0.260	0.473**	0.495**	1.000								
P	-0.100	0.150	0.045	0.429	1.000							
K	-0.073	-0.81	-0.023	0.049	0.128	1.000						
Ca	0.242	0.277*	0.334*	0.223	0.144	-0.240	1.000					
Mg	-0.023	0.135	-0.047	-0.186	0.033	0.397**	0.158	1.000				
Na	0.025	0.106	-0.008	0.041	0.125	-0.100	-0.285	0.174	1.000			
Cl	0.288*	0.844**	0.617**	0.492**	0.232	0.009	0.396**	0.083	0.035	1.000		
S	0.082	-0.010	0.038	0.307*	0.234	-0.021	0.029	0.068	0.059	-0.057	1.000	
B	-0.178	-0.533**	-0.337**	-0.136	-0.285	-0.019	0.043	-0.222	0.24	0.527**	-0.038	1.000

Tabular r – values 0.05 = 0.268 0.01 = 0.353

Table 10. Correlation between coconut yield and leaf nutrient levels 91988)

	NUT/ PALM	COPRA/ NUT	COPRA/ PALM	N	P	K	Ca	Mg	Na	Cl	S	B
NUT/TREE	1.000											
COPRA/NUT	0.442**	1.000										
COPRA/TREE	0.850**	0.768	1.000									
N	0.524**	0.605**	0.768	1.000								
P	-0.127	-0.167	0.605**	-0.042	1.000							
K	0.168	-0.114	-0.167	-0.056	-0.080	1.000						
Ca	0.372**	0.095	0.114	0.150	-0.045	-0.209	1.000					
Mg	-0.446	0.073	0.095	-0.180	0.004	-0.552	0.097	1.000				
Na	-0.044	0.069	0.073	0.190	-0.130	-0.238	0.187	0.229	1.000			
Cl	0.536**	0.885**	0.069	0.651**	-0.163	-0.178	0.266	0.078	0.153	1.000		
S	0.329*	0.436**	0.885**	0.459**	0.187	-0.049	0.080	-0.004	0.074	0.437**	1.000	
B	-0.147	-0460**	0.460**	-0.393**	-0.108	-0.018	-0.089	-0.071	-0.236	-0.492**	-0.238	1.000

Tabular r – values 0.05 = 0.268 0.01 = 0.353

Table 11. Suggested guide on Cl needs (nursery to full bearing) of coconuts, local tall variety

STAGE AND AGE	Cl/PALM (g)	FERTILIZER SOURCE* (g)		
		KCl	or	NaCl
Nursery:				
2 mos.	10	25		20
5 mos.	20	50		40
Field:				
Field-planting	40	100		80
6 mos.	100	230		200
1 yr	200	450		400
2 yrs	400	900		800
3 yrs	600	1,400		1,200
4 yrs	800	1,800		1,600
5 yrs & above	1,000	2,250		2,000

* KCl = 44% Cl, 50% K NaCl = 50% Cl

Correlation and analysis

The correlation analyses (Tables 8, 9, 10) show that in general both leaf N and CI were positively and significantly related with nut per palm, copra per nut and copra per palm with leaf-Cl effect very consistent over the years. Calcium was correlated with nut and copra yield but the relationship was inconsistent over the years. Sulfur is also correlated to nut and copra yield but was only observed in the last year of the study. On the other hand leaf-Mg was negatively correlated with yield which is surprising because aside from the low levels of Mg in the leaves and although no main effects of Mg was observed, it interacted with N in improving copra yield per nut. Boron is another element which was negatively related with yield which could be due also to its antagonistic reaction with Cl.

A stepwise regression analysis made for the year 1988 indicated that Cl is the main determinant for each of the three production parameters nut/palm, copra/nut and copra/palm, accounting for 29, 78 and 68% contribution, respectively. These results suggest that the yield improvement observed in this study was primarily due to the correction of Cl deficiency. This generally improved the physiology and nutrient utilization efficiency (conversion to economic yield as nuts and copra) of the palms. Several workers reported positive correlation of leaf CI and copra yield (Ollagnier and Ochs, 1971; Vexkull, 1972; prudente and Mendoza, 1976).

Suggested nutritional Needs

Based on the results of this study, a suggested guide on the nutritional needs of local tall palms for Cl from nursery to full bearing is presented in Table 11. During the nursery stage, a total of 30 g Cl per seedling; while in the field, the requirement increases with age of coconut (40 g to 1,000 g per palm), leveling off at 5 years from field planting. Thus at bearing stage and onwards l kg Cl per tree is the estimated Cl need of the coconut for normal development and production. In normal years, under Davao conditions the average yields of coconut was 70 nuts per tree/year (20.7 kg copra per

tree/year) with adequate Cl nutrition as in this study. So, at the average plant population of 110 trees/ha this means an annual yield of 77,00 nuts or 2.3 tons copra per ha. The information presented in this report may serve as a useful reference in the fertilization of coconuts, particularly in inland areas.

SUMMARY AND CONCLUSION

It is indispensable to know the critical levels of nutrients as they indicate the nutritional status of the palms, which serves as the basis of diagnosing the fertilizer needs of coconuts under different agro climatic conditions.

In the nursery and in the field, Cl application showed a consistent positive influence on the stem girth up to 4 years; leaflets up to 2 years; living fronds and number of leaves emitted every 6 months up to 5 years. One year from field-planting and 5 years thereafter, consistent significant response of the palms on the basis of almost ail growth characters was observed with the addition of K and Cl indicating the added advantage of KCl as source of K over $KISO_4$- Moreover, Mg addition to young palms appears to be beneficial for accelerated development. At 5 years from field-planting, Cl-applied palms had 115% more flowering coconuts than minus Cl palms. During the bearing stage (6th - 14th year) Cl application consistently increased nut production, copra weight per nut and copra yield per palm which were positively correlated with leaf Cl. The average copra weight per nut for palms applied with Cl (l kg Cl/palm/year) was 320 g, compared to 223 g per nut for minus Cl palms. The positive influence observed on N, K and Mg on yield was inconsistent over the years. Likewise, interaction effects of nutrient on yield and on leaf nutrient levels were inconsistent, indicating the adequacy of these nutrients in the soil during some years.

As suggested guide on the nutritional needs of the local tall palms for Cl from the nursery to full-bearing is presented (Table 11).

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Appendix

Table. 1 Soil analysis of Tugbok soil, PCA-Davao Research Center, Bago-Oshiro, Davao City*

PROPERTY	SURFACE SOIL (0-17cm)	SUB-SOILS (18-80cm)
Chemical		
PH (1:1/soil: H_2O)	6.50	6.70
Organic Mater (%)	1.73	1.40
Available p (ppm)	19.00	11.00
K-H_2SO_4 extractable (ppm)	624.00	677.00
Exchangeable bases (m.e./100 g):		
Ca	11.40	12.30
Mg	5.30	6.40
K	0.45	0.29
Na	0.08	0.18
CEC (M.E./100 g)	25.20	26.70
Base Saturation (%)	68.00	72.00
Physical		
Texture	Clay loam	Clay
% Sand	32.9	23.3
% Silt	33.3	28.9
% Clay	33.9	47.8
Bulk density (g/cc)	1.6	1.5
Total porosity (%)	40.6	45.3
Soil moisture (%):		
Field capacity	32.6	40.60
Permanent wilting point	17.6	26.7
Available moisture	14.9	13.8

*Analyzed at the Bureau of Soils Laboratory (Manila).