SODIUM CHLORIDE (Common salt) FERTILIZATION OF BEARING COCONUTS. I: EARLY YIELD RESPONSE

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ABSTRACT

A study to determine the influence of increasing rates of sodium chloride (0, 0.83, 1.76, 3.52,and 7.04 kg NaCl/palm) on the yield and leaf nutrient concentrations ofcoconuts grown in achlorine (Cl)-deficient Typic Tropudalf soil was initiated in 1981.

The increasing rates of NaCl significantly increased linearly nut production, copra weight per nut,and copra yield per palm over a three year period. The leaf analysis showed that leaf Na and Cl concentrations were increased significantly by NaCl application,while other elements remained unaffected. Only leaf Cl was highly correlated with the three yield indices mentioned above, indicating that the increase in yield was mainly due to the correction of Cl deficiency by NaCl application.

The economic analysis showed that the net profit increased with increasing rates of NaCl but the highest benefit-cost ratio of 3.97 was obtained with the application of 1.76 kg NaCl/palm, suggesting that this rate may be the optimum rate of NaCl for coconuts grown in the Tugbok clay loam and those grown in similar conditions.

INTRODUCTION

The 1970's marked the worldwide recognition of chloride as a beneficial element and macronutrient of coconuts and oil palms. Shortly before the end of the decade, Manciot et al. (1979) reviewed a report on the use leaf analysis in the conduct of fertilizer trials in the Philippines (Magat, 1978) and concluded that foliar diagnosis is a highly effective technique in predicting the fertilizer needs of coconuts in the country. The discovery of the existence of chloride deficiency of both oil palms in Columbia (Ollagnier and Ochs, 1971), and coconuts in the Philippines (Uexkull, 1972; Mendoza and Prudente, 1972) used leaf analysis as diagnostic tool.

Few years later in the Philippines, potassium chloride (KCl) was shown in several experiments to correct chloride deficiency in inland coconuts and increase yield subsequently (Magat et al., 1975; Prudente and Mendoza, 1976; Margate et al., 1979). Because of the consistent price increases of imported KCl, other chloride sources such as sodium chloride (NaCl), and ammonium chloride (NH_4Cl) were tested using field fertilizer trials. Since 1978, positive yield responses to NaCl application have been reported (Magat et al., 1978; Magat et al., 1980). However, these earlier studies were limited only to single rate application.

Thus, considering the information gap,and to have a clearer understanding of the effects of NaCl on the yield and nutritional status of coconuts, a study was initiated in 1981 involving five rates of NaCl applied on chloride deficient palms grown on the Tugbok clay loam soil.

The purpose of this paper is to present the early yield response (first three years of fertilization) and the estimated optimum rate of NaCl fertilization which deserve immediate and serious attention in the sound fertilizer management in coconut farming.

MATERIALS AND METHODS

Soils and climatic condition

The soil used in this study is a reddish brown Tugbok clay loam soil classified as Typic Tropudalf (Labarcon, 1980), well drained externally and internally. The soil is slightly acidic (pH 6.5 – 6.7), with 11-19 ppm Olsen-P, exchangeable K of 0.29 – 0.45 meq/100 g soil, C.E.C. of 25-27 meq/100 g,and base saturation of 68-72%. The area situated 8 km from the seacoast has an average rainfall of 2400 mm (well distributed throughout the year); with adequate sunshine and satisfactory relative humidity (78-85%).

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Experimental palms

Laguna tall palms about 28 years old distanced at 8 x 8 m square were used as experimental trees. The palms were formerly used for KCl experiment.

Fertilizer treatment

Five rates of NaCl (0, 0.88, 1.76, 3.52, and 7.04 kg per tree per year) with blanket application of 2.0 kg ammonium sulfate (21-0-0-24% S) were tested and applied in split doses at six months interval by broadcasting and fork-in method around the 2-meter weeded area at the base of the palms. These treatments were applied as a continuation of the former KCl experiment considering the same amount of Cl.

Experimental design

The experiment was laid out in a randomized complete block design with five treatments replicated three times, consisting of nine palms per plot.

Harvesting and sampling of nuts

Harvesting of nuts was done at 45 days cycle and 20 nut samples were gathered every harvest in each plot for copra yield evaluation.

Leaf sampling

Leaf samples were collected from each plot prior to initial fertilization and annually thereafter for chemical analysis. Leaf samples were analyzed for concentrations of N, P, K, Ca, Mg, Na, Cl, and S at the Tissue Analysis Laboratory of the Philippine Coconut Authority, Diliman, Quezon City, Metro Manila.

Data processing

The variance, trend, correlation, and regression analysis were done using the Genstat (Rothamsted Experimental Station-developed) package programme, processed with VAX 110/780 computer at Lincoln College, University of Canterbury, New Zealand.

RESULTS AND DISCUSSION

Effects on nut production

The application of NaCl at the rate of 0.88 kg per tree per year up to 7.04 kg per tree annually linearly increased nut production significantly ($P \leq 0.01$) over the three-year period (Table 1). As shown in Figure 1, the average nut yield for three years linearly increased with increasing rates of NaCl fertilization. With the addition of 1.76 kg NaCl (medium rate), nut yield improved significantly ($P \leq 0.01$) by 38% over the control.

Table 1. **Effect of increasing NaCl rate on copra yiel (kg per tree) over a three-year period.**

NaCl Rate (kg/tree) (1)	Year 1	Year 2	Year 3 (3)	Average
0.	111.8	87.1	67.7	88.8
0.88	129.3	102.1	87.8	106.4
1.76	151.1	116.3	99.6	122.3
3.52	130.6	114.3	93.8	112.9
7.04	144.1	139.8	99.2	127.6
(2)				
Stat. Sig.	**	**	**	**
SE (mean)	5.1	2.8	2.7	1.5
HSD .05	17.6	25.3	9.5	10.4
.01	26.1	37.5	14.1	15.3
Trend: Linear	**	**	**	**
Quadratic	*	NS	*	*

(1) contains 39% Na, 61% Cl
(2) NS – not significant
** – highly significant
* – significant
(3) consists of 7 harvests only

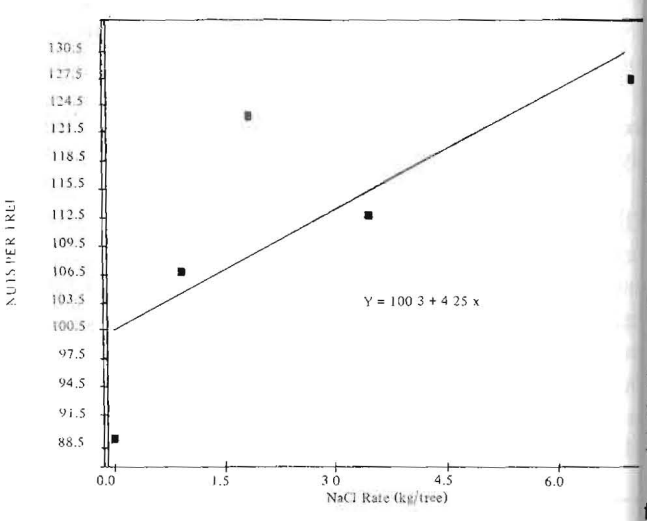

Figure 1. Effect of increasing rates of NaCl on nut yie per palm (average of 3 years).

Table 2. **Effect of increasing NaCl rate on average copra weight per nut (g) over a three year-period.**

NaCl Rate (kg/tree)	Year 1	Year 2	Year 3	Average
0	146.8	149.4	126.7	141.0
0.88	202.6	209.0	167.4	193.0
1.76	205.2	240.2	199.4	214.9
3.52	237.6	236.4	214.9	229.6
7.04	255.5	266.6	219.9	247.3
Stat. Sig.	**	**	**	**
SE (mean)	12.7	12.9	11.3	11.6
HSD .05	44.1	44.7	39.3	40.1
.01	65.4	66.2	58.3	59.4
Trend: Linear	**	**	**	**
Quadratic	NS	NS	NS	NS

Effects on copra weight per nut

For the first three years of fertilization, the copra weight per nut linearly increased significantly ($P \leq 9.01$) (Table 2). This relationship is clearly presented in Figure 2. using the average copra weight per nut over the three-year period. Fertilizing the palms with 1.76 kg and 7.04 kg NaCl per tree resulted to 215 g and 247 g copra per nut respectively, indicating a highly appreciable increase over the unfertilized palms (with only 141 g copra per nut).

Effects on copra yield

As with nut production and copra weight per nut, the addition of NaCl linearly increased significantly ($P \leq 0.01$) the copra yield per tree for all years (Table 3). Likewise, Figure 3 shows the highly significant relationship of NaCl application and average copra yield over the first three years of fertilization. The moderate level of NaCl application (1.76 kg per tree) significantly increased copra yield from 13.3 kg to 26.1 kg per tree per year or a 97% improvement over the unfertilized coconuts.

Effects on Leaf nutrient status

To assess the influence of fertilizer application on the levels of nutrients on the palms, leaf samples were collected annually and chemically analyzed at the PCA Tissue Laboratory.

As shown in Table 4, only leaf-Na and Cl were significantly affected by NaCl application, while the concentration of other nutrients, i.e. N, P, K, Ca, Mg, and S remained unaffected. The addition of NaCl significantly increased leaf Cl linearly ($P \leq 0.01$) as predicted by the equation in Figure 4. With the suggested leaf Cl critical level set at 0.50% (Magat, 1978), the application of even the lowest NaCl rate (0.88 kg/tree/year) corrected the Cl deficiency of the palms.

Correlation and regression analysis

Except for leaf Cl, all the other leaf nutrients are not related significantly with the three yield indices: Nuts/tree, copra/nut, and copra/tree (Table 5). The highly significant increase in leaf Cl as a result of NaCl application is highly correlated not only with nut production but also with copra yield as well. Apparently, chloride deficiency exists and its correction, as manifested in the highly significant improvement in leaf Cl of the palms, resulted to highly appreciable increase in nut and copra yield (Figures 5 and 7).

Very likely, the increase in copra yield is both attributed to higher nut production and the highly significant increase in weight of copra per nut, which correlated significantly ($P \leq 0.01$) with leaf Cl (Figure 6).

Table 3. **Effect of increasing NaCl rate on copra yield (kg per tree) over a three-year period.**

NaCl Rate (kg/tree) (1)	Year 1	Year 2	Year 3 (3)	Average
0	16.45	14.79	8.57	13.27
0.88	28.42	21.42	14.74	21.53
1.76	31.05	28.36	19.02	26.15
3.52	36.65	26.50	21.13	28.20
7.04	38.36	35.03	21.81	31.73
(2)				
Stat. Sig.	**	**	**	**
SE (mean)	1.89	1.74	1.64	1.57
HSD .05	6.55	6.05	5.69	5.44
.01	9.71	8.94	8.42	8.06
Trend: Linear	**	**	**	**
Quadratic	*	NS	NS	NS

(1) contains: 39% Na; 61% Cl
(2) NS – not significant
** – highly significant
* – significant
(3) consists of 7 harvests only

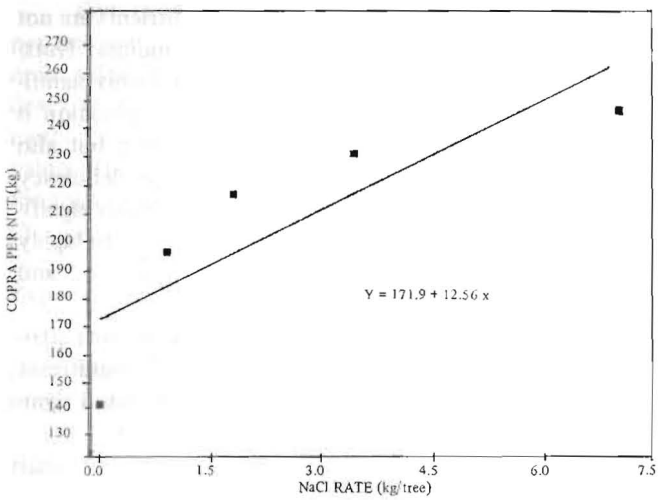

Figure 2. Effect of increasing rates of NaCl on copra weight (g/nut) (average of 3 years).

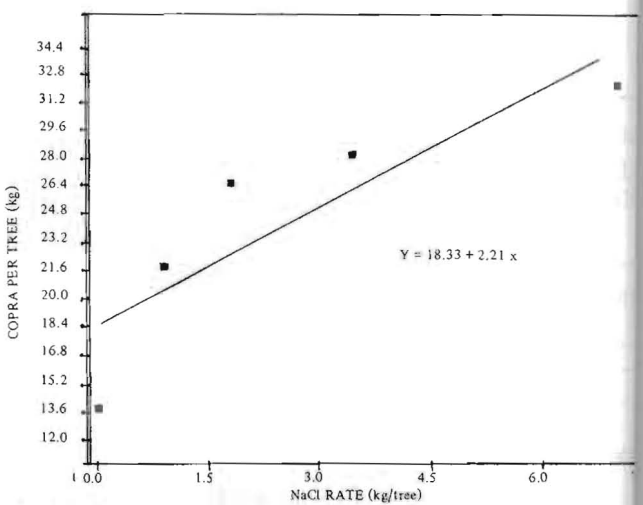

Figure 3. Effect of increasing rates of NaCl on cop yield (kg/palm) (average of 3 years).

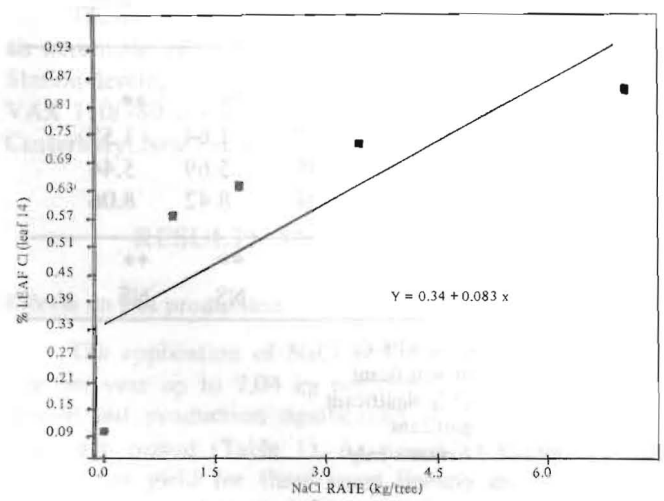

Figure 4. Effect of increasing rates of NaCl on leaf Cl concentration (%) (sampled December 1982).

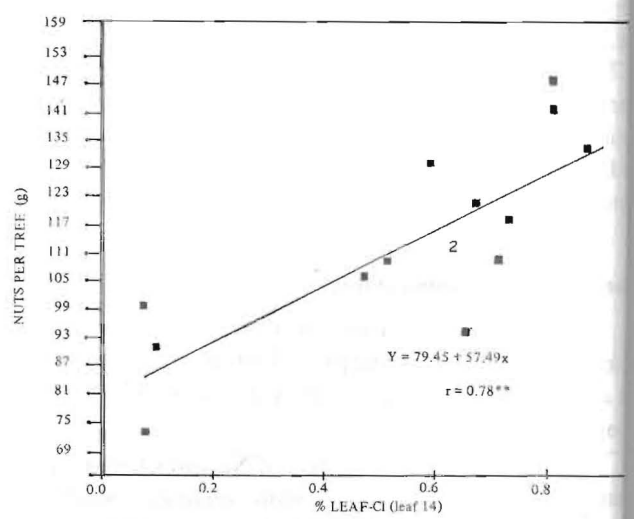

Figure 5. Relationship of leaf Cl and nut yield (year

Table 4. Effect of increasing NaCl rates on leaf nutrient levels of coconuts, sampled December 1982.

NaCl Rate (kg/tree)	Leaf Nutrient (% D.M. leaf 14)							
	N	P	K	Ca	Mg	Na	Cl	S
0	1.73	0.14	1.33	0.41	0.24	0.05	0.08	0.17
0.88	1.86	0.15	1.34	0.43	0.23	0.10	0.55	0.18
1.76	1.89	0.15	1.21	0.47	0.23	0.07	0.62	0.19
3.52	1.90	0.14	1.31	0.44	0.23	0.07	0.70	0.18
7.04	1.77	0.14	0.30	0.47	0.25	0.07	0.84	0.17
Stat. Sig.	NS	NS	NS	NS	NS	*	**	NS
SE (mea)	0.04	0.003	0.06	0.03	0.02	0.008	0.02	0.007
HSD .05	–	–	–	–	–	0.028	0.07	–
.01	–	–	–	–	–	–	0.11	–
Trend: Linear	NS	NS	NS	NS	NS	NS	**	NS
Quadratic	NS	NS	NS	NS	NS	NS	*	NS

Table 5. Correlation of yield parameters and leaf nutrient levels (% D.M., leaf 14) year 2 (leaf samples collected Dec. 1982).

Leaf Nutrient[1]	Nut/ Tree	Copra/Nut	Copra/ Tree
N	0.390	0.252	0.396
P	–0.402	0.078	–0.224
K	–0.108	–0.136	–0.087
Ca	0.199	0.423	0.257
Mg	–0.239	–0.081	–0.313
Na	–0.084	0.201	–0.077
Cl	0.785**	0.890**	0.807**
S	0.119	0 169	0.204

df - 13 **highly significantly correlated

[1] Analyzed at the Tissue Analysis Laboratory, Philippine Coconut Authority, Metro Manila.

Table 6. Economic analysis of NaCl fertilization on per tree basis (average of three years fertilization from 1981-1983).

Treatment	Fertilizer Cost		Labor Cost				Total Expenses	Average Copra Yield (kg)	Gross Income	Net Income	% income over control	Benefit-Cost Ratio
	NaCl	$(NH_4)_2SO_4$	Ring Weeding	Fertilizer Application	Harvesting	Copra Husking						
$NaCl_0$	–	₱4.00	₱3.00	₱1.25	₱1.33	₱2.00	₱11.58	13.27	₱39.81	₱28.23	–	₱ 2.43
$NaCl_1$	₱0.88	4.00	3.00	1.25	1.60	3.30	14.03	21.53	64.59	50.56	79	3.60
$NaCl_2$	1.76	4.00	3.00	1.25	1.83	3.92	15.76	26.15	78.45	62.69	122	3.97
$NaCl_3$	3.52	4.00	3.00	1.25	1.69	4.23	17.69	28.20	84.60	66.91	137	3.78
$NaCl_4$	7.04	4.00	3.00	1.25	1.91	4.76	21.96	31.73	95.19	73.23	159	3.33

Basis:

(a) Fertilizer price:

Sodium chloride (common salt) = ₱1.00/kilo
Ammonium sulfate (21-0-0) = ₱2.00/kilo

(b) Ring weeding (30 palms/man-day at ₱15.00/day)= ₱0.50/tree x 6 operations annually = ₱ 3.00/tree/yr.
(c) Fertilizer application (broadcasting of fertilizer and fork-in) 24 trees/man day at ₱15.00/day = ₱ 1.25/tree/yr.
(d) Harvesting = ₱15.00/1000 nuts
(e) Copra making = ₱150.00/1000 kilos
(f) Copra price = ₱3.00/kilo

Economic analysis

Since the response of the coconut palms to increasing rates of NaCl follows a highly significant linear trend, the optimum rate of fertilization may be determined by simple benefit-cost analysis or maximum profit approach, considering the price of NaCl as the principal variable cost. Although the study shows a positive direct relationship between the rate of NaCl applied and the yield, it may not be a sound practice to use higher rates of fertilization. In other words, the decision should be based on the maximum return at least cost or highest benefit/cost ratio.

Table 6 shows the output-input analysis of NaCl fertilization using the average copra yield for three years as the basis of economic analysis. Application of 1.76 kg NaCl showed to be the most economical rate, giving the highest return per peso investment.

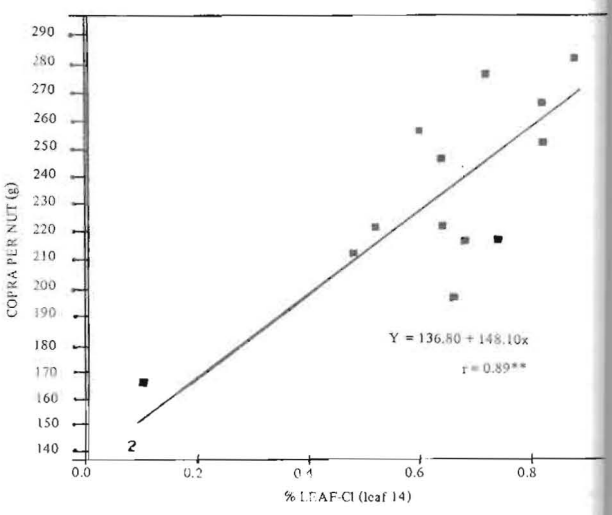

Figure 6. Relationship of leaf Cl and copra weight nut (year 2).

SUMMARY AND CONCLUSION

A study to investigate the influence of five rates of sodium chloride on the yield and leaf nutrient concentra-

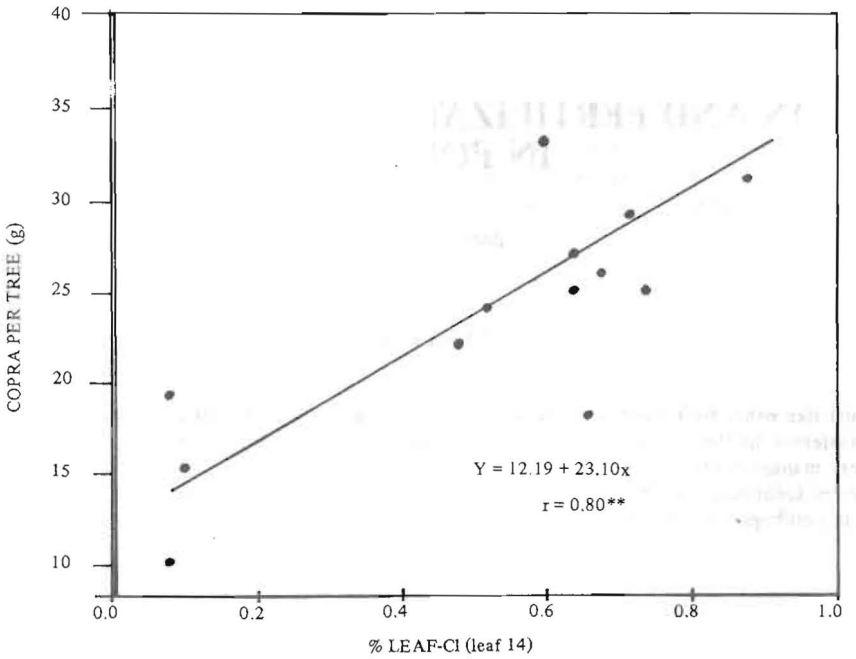

Figure 7. Relationship of leaf Cl and copra yield per tree (year 2).

tions of coconuts was initiated in 1981. The NaCl rates: 0, 0.88, 1.76, 3.52, and 7.04 kg/tree/year were applied in split doses at six months interval. These treatments were the continuation of the previous KCl treatments using the same rates of Cl to determine if NaCl can substitute for KCl.

Results show that increasing rates of NaCl linearly increased significantly ($P \leq 0.01$) nut production, copra weight per nut, and copra yield per palm over a three-year period.

Leaf analysis revealed that only Na and Cl were significantly increased in all NaCl treated palms while other nutrients remained unaffected. Of all the elements analyzed, only the leaf Cl levels were highly correlated with the three yield indices being observed, apparently indicating that the increase in yield was due to the correction of Cl deficiency.

Based on the average yield and production cost for three years, the application of 1.76 kg NaCl showed to be the most economical rate, giving the highest return per peso investment.

Further study is needed to know the yield response of coconuts to the long term application of NaCl.

LITERATURE CITED

LABARCON, A.D. 1980. Soil Classification of the Davao Research Center. Annual Report. Agricultural Research. Philippine Coconut Authority. p. 17-33

MAGAT, S.S., V.L. CADIGAL and J.A. HABANA. 1975. Yield improvement of coconut in elevated inland area of Davao by KCl fertilization. Oleagineux 30(10): 423-428. *Also in* Phil. J. Crop Sci. 1(1): 60-63.

MAGAT, S.S. 1978. The use of leaf analysis in the conduct of coconut field fertilizer trials in the Philippines. Phil. J. Coconut Studies 4(1): 32-39. *Also in* DSIR (New Zealand) Info: Series 134(1): 299-311.

MAGAT, S.S., J.N. MARAVILLA and G.D. PADRONES. 1980. Increasing productivity of inland coconuts by nitrogen, chloride and sulfur fertilization. Phil. J. Crop Science 4(4): 177-182.

MANCIOT, R., OLLAGNIER and R. OCHS. 1979. Nutrition minerale et fertilisation du cocotier dans le monde. *Oleagineux* 34(11): 499-515; 34(2): 563-579; 35(1): 13-27.

MARGATE, R.Z., S.S. MAGAT, L.M. ALFORJA and J.A. HABANA. 1979. A long-term KCl fertilization study of bearing coconuts in an inland-upland area of Davao. *Oleagineux*. 34(5): 235-240. Also in Phil. J. Coconut Studies 3(4): 1-14.

MENDOZA, A.M.R. and R.L. PRUDENTE. 1972. Influence of NPK fertilizers on the growth of coconuts from transplanting. Proceedings, third Annual Conference Crop Science Society of the Philippines, Cagayan de Oro City.

OLLAGNIER M. and R. OCHS. 1971. Chlorine, a new essential element in oil palm nutrition. Oleagineux 26: 1-15.

PRUDENTE, R.L. and A.M.R. MENDOZA. 1976. Response of inland coconuts to inorganic fertilization from field-planting. Phil. J. Coconut Studies 1(1): 27-36.

VON UEXKULL, H.R. 1972. Response of coconuts to (potassium) chloride in the Philippines. *Oleagineux* 27: 13-19.