RESIDUAL EFFECTS OF SODIUM CHLORIDE (Common Salt) FERTILIZERS ON YIELD AND LEAF NUTRIENTS, OF COCONUTS, GROWN ON AN INLAND SOIL OF DAVAO (Mindanao, Philippines)

by

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ABSTRACT

The beneficial residual effects of the previous regular applications of sodium chloride fertilizers on mature coconuts were evaluated in a long-term experiment conducted in an inland Tugbok soil (typic Tropudalfs) of Davao, Mindanao (Philippilines). Sodium chloride (common salt) at increpasing rates of 0.0, 0.88, 1.76, 3.52. and 7.04 kg/tree per tree was tested.,

At higher rates of NaCl fertilizer (1.76-7.04 kg/tree per year) applied regularly for 5 years, the residual respofise in terms of nuts and copra yield tended to, occur for a longer period of 5 years. Except soil Na, soil. properties were not significantly affected by NaCl application.

Implications of the findings are discussed in relation to sound coconut crop agronomy and soil management.

1. INTRODUCTION

The growth and yield response or performance of the current stands of crop to fertilizers applied previously to the same stands is usually considered as residual effect(s). This is common on crops and soils applied with fertilizers containing N, P, K and Na as these elements tend to accumulate in the soil and plant systems, particularly at high levels and continuous application. In some instances, the residual effect from earlier fertilizer application may be depressive, probably due to nutrient imbalance (toxic) levels.

Even in recent years, very little attention has been made to the residual effects of the anion components of fertilizers as Cl, particularly with KCI and NaCl (as source of K and Cl nutrients) application on coconut. This is attributed to the belief that negatively charged ions like Cl-, NO^{3-}, SO_4^{-2} are not adsorbed by the soil, thus easily leached down the soil profile. This is not exactly true as Magat (1985) confirmed the capability of soils to retain Cl by absorption in the fine structural soil regate (Tucker, 1982). After a two years cropping of *Beta vulgaris* der beet), high concentrations of Cl, Na and K resulting from the application of KCI and NaCl were still found in the top soil (20-40 cm) wo silt loarn soils of New Zealand (Magat, 1985).

This paper presents an evaluation of the residual effects of two rate long-term fertilizer studies on coconut conducted at the PCA's Davao Research Center, situated in an inland area of Mindanao. Implications of the findings should be useful in the rehabilitation of ting stands of coconut; in the fertilizer management of replanted farms, as well as new plantings.

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MATERIALS AND METHODS

2.1. Environmental Conditions

Details of the location, climate and soil conditions of the experimental sites (both studies) have been reported (Magat et al, 1975, Magat and Padrones, 1984, Magat et al, 1987). It is located about 11 km (inland) from the coast, 120-160 m above sea level, with a deep and well-drained soil classified as typic Tropudalfs. The soil has : average pH of 6.5; 0.45 meq K, 0.11 meq Na, 5.7 meq Mg/100g; 70% base saturation ; clay loam surface soil and clay sub-soil (Table 1).

2.2. Experimental Palms

Laguna tall variety (30-35 year old) planted in 8 m x 8 m square were used as experimental trees.

2.3. Fertilizer Treatment

The Study involved the same trees used earlier for the KCI rates study (1975-80). The five rates of NaCl are : 0.0, 0.88, 1.76, 3.52 and 7.04 kg/tree per year with corresponding Cl rates 0.0, 0.48, 0.97, 1.94 and 3.87 kg/tree, respectively were used. Palms received 2 kg/tree blanket application of $(NH_4)_2SO_4$, as N and S are also limiting coconut yields in Davao.

Fertilizers were applied in split-application at six months interval by broadcast and incorporation method, within the 1.0-1.5 m circle-weeded area of palms.

2.4. Experimental. Design

The five (5) NaCl rates replicated three times were laid out in RCBD, consisting of nine palms per treatment (plot size).

2.5. Harvesting and Yield Estimates

Matured nuts were harvested every 45 days (8 times per year) at which 20 nuts/plot were sampled for copra weight/nut as basis of copra yield (yield/tree x copra/nut).

2.6. Sampling of Leaves and Soil

Periodic sampling'of leaves (leaf #14) following the procedures of Magat and Froilan, (1976) Was 'done, and samples were immediately submitted to the PCA's Tissue Analysis Laboratory. Samples were analyzed usually for concen rations of N, P, K, Ca, Mg, Na, Cl, and S. Soil sampling was done for soil analyses (some soil properties).

3. RESULTS AND DISCUSSIONS

Earlier (5 years ago), this study revealed that application of NaCl (0.0, 0.88, 1.76, 3.52 and 7.04 kg/tree/yr), corresponding to 0.0, 0.48, 0.97, 1.94 and 3.87 kg Cl/tree/yr, on local tall Taguna' coconuts grown on the Cl-deficient Tugbok soil (Typic Tropudalfs) increased nut production, copra weigth/nut and copra yield/tree but not oil content (Magat et al, 1988). Leaf-N (% of dry matter, (Leaf No. 14) is the main cleterminant of nut production while leaf Cl, the one positively related to and main determinant of copra/nut and copra yield.

Table 1. Average chemical and physical properties of the Inland Tugbok clay loan soil (Typic Tropudalf), PCA-Davao Research Centre

PROPERTIES	SURFACE SOIL	SUBSOIL
Chemical		
pH (1:1/soil:H_2O)	6.50	6.70
Organic matter %	1.73	1.40
Available P (ppm)	19.00	11.00
Total K (ppm), hot H_2SO_4 extractable	624.00	687.00
Exchangeable cations (meq/100 g soil)		
Ca	11.40	12.30
Mg	5.30	6.40
Na	0.08	0.18
K	0.45	0.29
CEC (m.e/100 g soil)	25.20	26.70
Base saturation (%)	68.30	71.50
Physical		
Textural grade	Clay loan	Clay
% sand	32.90	23.30
% silt	33.30	28.90
% clay	33.90	47.80
Bulk density (g/cc)	1.58	1.45
Total Porosity (%)	40.60	45.35
Moisture retention capacity		
Field capacity (%)	32.60	40.60
Permanent wilting point (%)	17.60	26.70
Available moisture (%)	14.90	13.80

[1]Bago-Oshiro, Davao City, analyzed by the Bureau of Soils, Davao City

Moreover, the study showed that the optimurn econornic rate was 3.8 kg NaCl/tree/year (yielding 125 nuts/tree/year, 22.6 g copra/nut and 25.9 kg copra/tree or 112 % increase over control palms). It was also noted that even at a low rate of 1 kg NaCl/tree, palms produced about 18 kg copra/tree, while the average yield of farms in the country is about 0.85 ton copra per ha (8 kg.tree/yar).

In the judicious use of common salt (substituting KCl as source of chloride on coconuts), it should be important to understand the post effects (residual effcts) after several years of regular application as basis of a practical and economic fertilizer management.

3.1. Nut Production

Generally, nut production of fertilized palms remained at higher levels compared to unfertilized palms (Figure L a). However, after five years of non-application of NaCl (even at higher rates 3.52 and 7.04 kg/tree), nut production dropped drastically and these were similar to nut yields of the control palms. This suggests the positive residual effects in terms of nut production lasts only up to four years after fertilization was stopped. As nitrogen is more positively correlated to nut production than chlorine, and thus the former is the main cleterminant (Magat et al, 1988). The residual effect on nut production may be partially attribut6d to the blanket application of 2 kg $(NH_4)_2SO_4$ received by palms earlier for five years.

3.2. Copra Weight per Nut

Figure 1.b shows that even for five years of non-application of NaCl fertilizers, palms applied with higher rates of NaCl (1.76-7.04 kg/tree) apparently maintained higher cogra weight/nut (220-260 g/ nut) compared to the control palms (140-170 g/nut). This result indicates that longer positive residual effects on copra weight per nut takes place (5 years at least), especially at higher rates (> = 1.76 kg NaCl/tree).

3.3. Copra Yield

High levels of copra yields, particularly for high rates of NaCl 1.76 kg/tree) were maintained up to four years of nonapplication of fertilizers (Figure Lc). Control palms consistently produced the lowers copra yields, however at five years after fertilization was stopped, yield of these palms were not significantly different from the NaCl-applied palms.

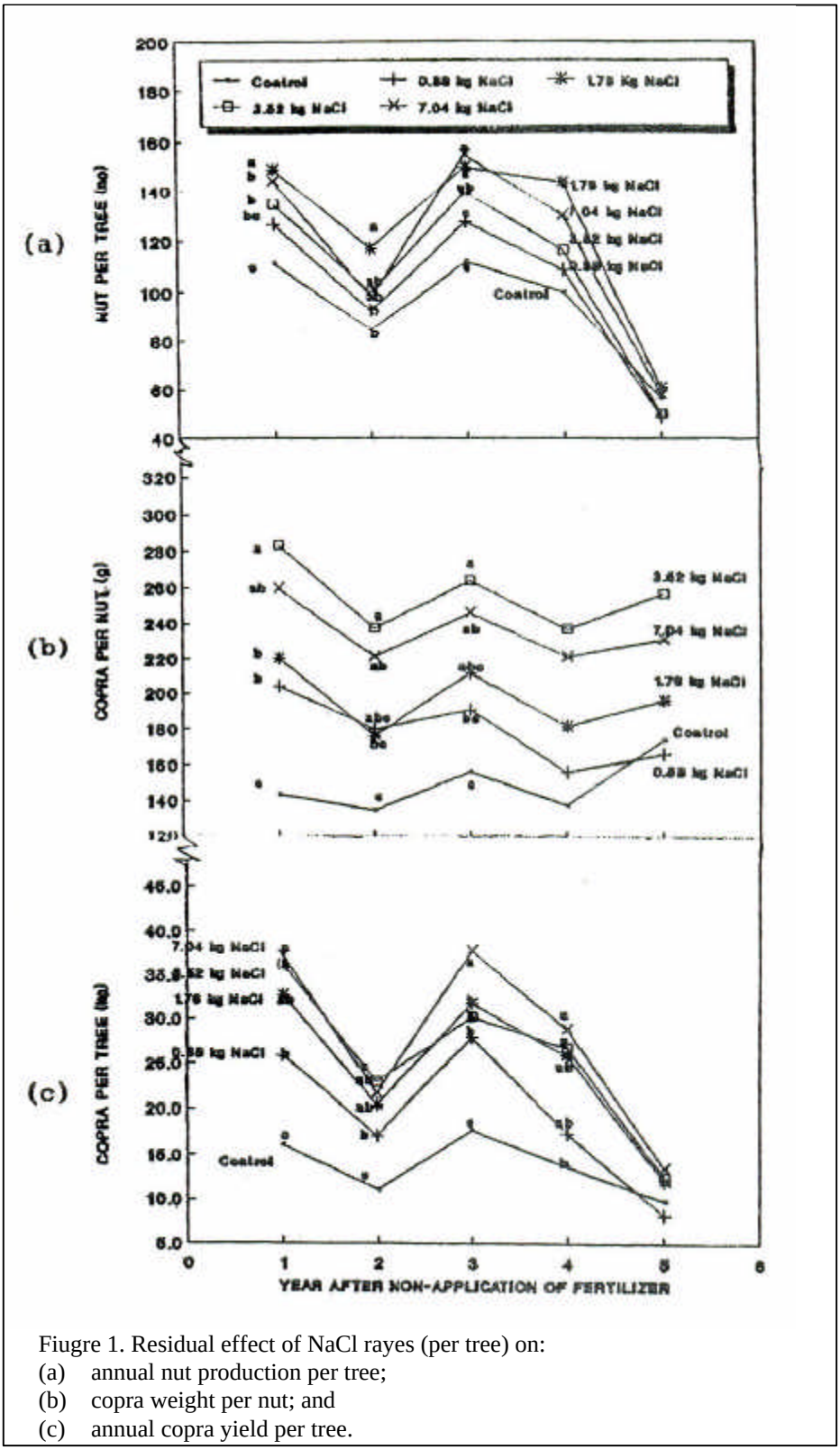
As copra yield per tree is a function of both nut production and copra/nut, the decline in nut production during the fifth year (Figure l.c) affected copra yield, even if copra weight/nut still remained high (especially at high NaCl rates), it therefore appears that the clear positive residual effects of NaCl application is stronger at higher rates of fertilization and tends to persist up to five years after the cut in the regular NaCl fertilization.

3.4. Leaf Nutrient Status

Although concentrations of N, K and S in coconut leaves (leaf #14) at 1, 2, and 3 years after NaCl fertilization was stopped were lower in the control palms (no previous NaCl applied), these levels were not significantly different from those applied with NaCl (0.887.04 kg/tree) as- shown in Figures 2.a, 2.b and 3.b. Leaf N, K and S in these years were all above the critical levels (1.8 % N, 0.8 % K and 0.12 % S) in all treatments including -control palms. This suggests that the previous blanket-application (5 years) of 2 kg $(NH_4)_2SO_4$ had maintained adequate levels of N and S; and the Tugbok soil used had adequate supply of K (0.45 meq ha/100-g soil) for high yields.

However, leaf-Cl of palms applied pireviously (for 3 years) with high rates of NaCl (1.76, 3.52 and, 7.04 kg/tree) then stopped, were within the optimum levels of Cl. (0.50-0.60%) (Figure 3.a). The low level of leaf-Cl in control palms (0.08-0.15%) and palms receiving only 0.80 kg NaCl (especially at the third year) were below the critical level of (0.30%). These resulted in very low copra weight per nut and copra yield of palm as mentioned earlier (Section 3.2 and 3.3). At higher rates of NaCl (1.76-7.04 kg/tree), longer positive residual effects was reached mainly due to higher concentrations of leaf-Cl maintained by palms, associated with significantly higher copra weight (per nut) and copra yield (per tree).

Clearly, palms without sodium chloride application remained strongly deficient in Cl (0.10% Cl) over the observation period. Moreover, the nutrient Cl absorbed by palms from the fertilizer applied to soil has a very long persistency in the coconut plant system, resulting to at least 5 years positive residual effect on coconut. Leaf Cl is positively correlated with high copra yield (Ollagnier and Ochs, 1971; Uexkull, 1972; Mendoza and Prudente, 1972; Magat et al, 1975, Margate et al, 1979).



Fiugre 1. Residual effect of NaCl rayes (per tree) on:
(a) annual nut production per tree;
(b) copra weight per nut; and
(c) annual copra yield per tree.

3.5. Some Soil Properties

Five years after the NaCl fertilization cut, soil properties (topsoil and subsoil) as pH, organic, matter, electrical, conductivity, waterholding capacity, CEC, available P, total K, exchangeable bases (Ca, Mg and K) were not significantly different from the control, even in treatments applied with high rates of NaCl (3.52 kg and 7.04 kg/tree/year) (Tables 2.1 and 2.2). However, for soil Na, especially at the two higher rates, levels remained still high, but the soil bulk density did not significantly vary, indicating that the rates applied of NaCl (0.88-7.04 kg/tree) did not result in destruction of soil structure as reflected through the bulk density (1.41-1.51 g/cc) (Table 2. 1).

The levels of salinity and Na as indicated by electrical conductivity (EC) and exchangeable Na are considered way below the critical or excessive levels of EC 40 mmhos/cm and > 0.50 Na meq/100 g soil.

The clear increased in soil acidity (decreased pH) in all treatments including the control was likely due to the earlier application (5 years) of 2 kg $(NH_4)_2SO_4$. At pH 5, coconut still grows and produce normally. Moreover, it strongly appears that soil P and exchangeable bases (K, Ca, Mg) are still highly adequate for the palms.

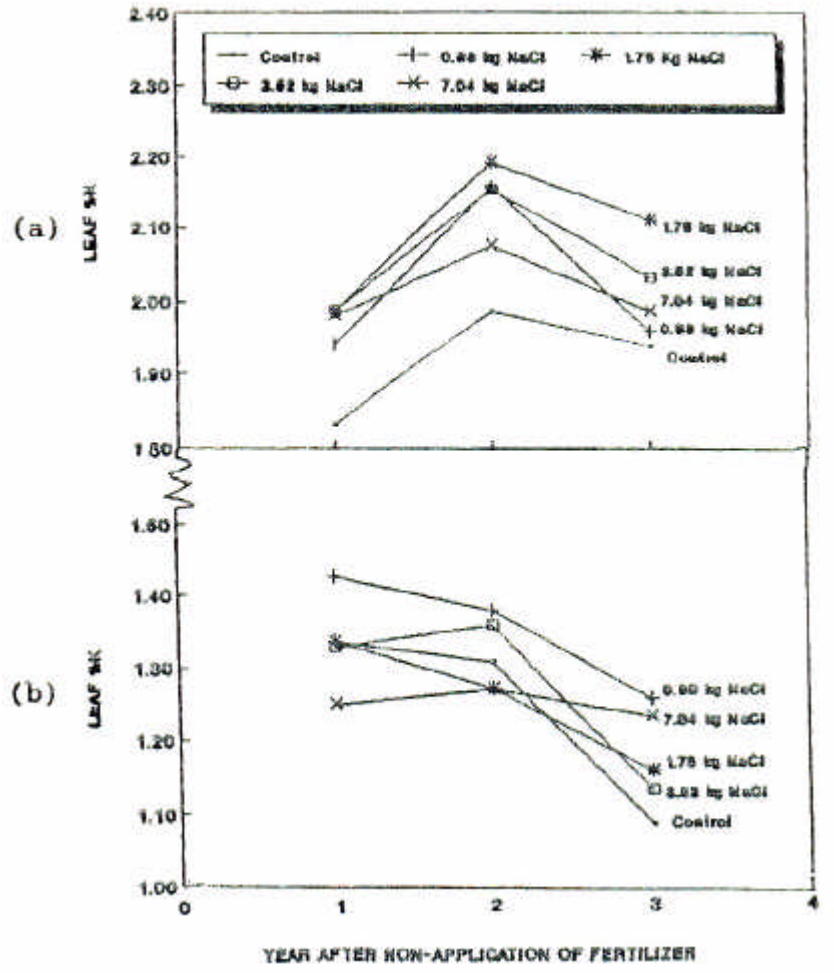


Figure 2. Residual effect of NaCl rates (per tree) on:
(a) leaf % N (leaft #14); and
(b) leaft % K (leaft #14).

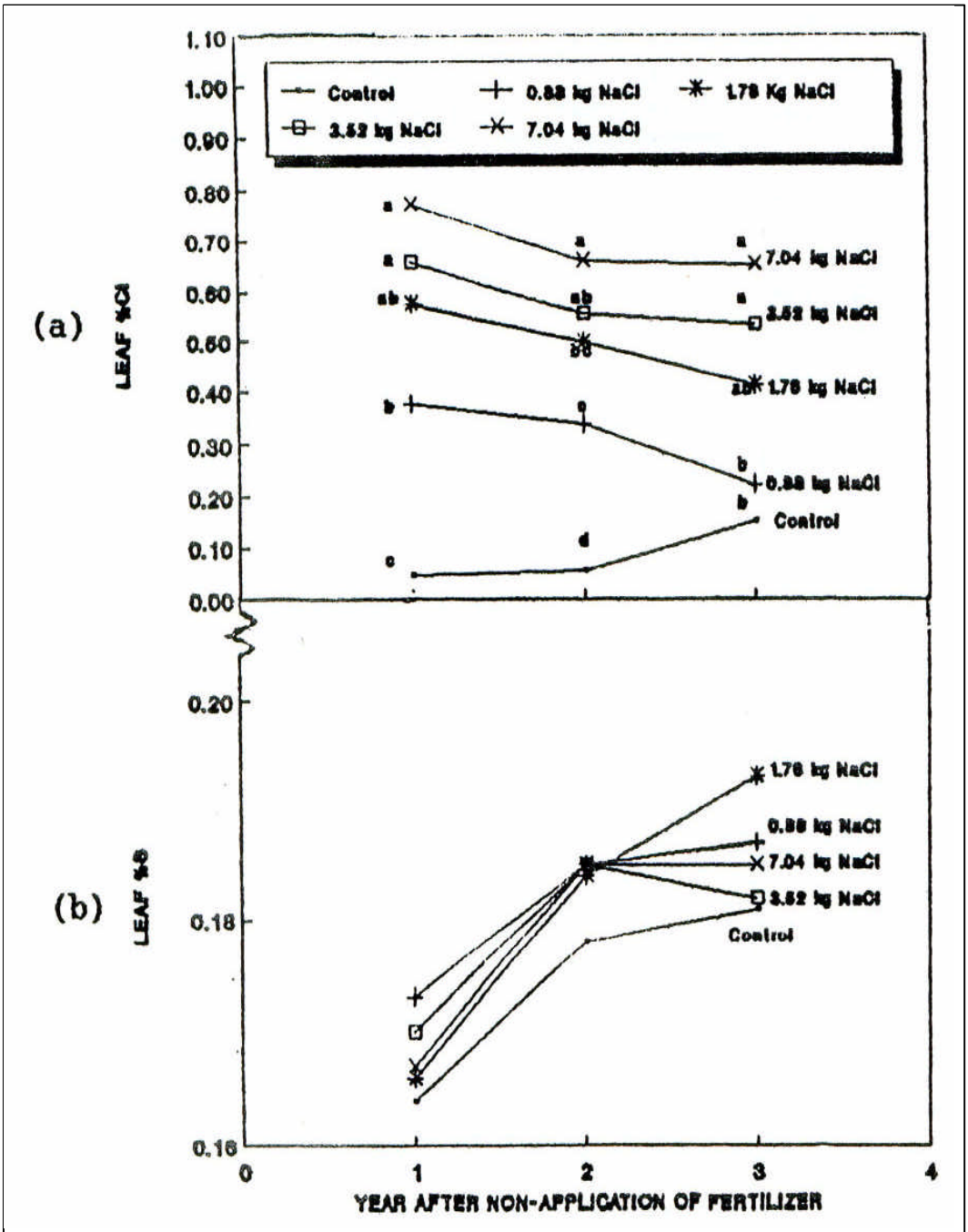


Figure 3. Residual effect of NaCl rates (per tree) on
(a) leaf %Cl (leaf #14); and
(b) leaf %S (leaf #14)

Table 2.1 Soil Properties as effected by previous NaCl application (5 years) at increasing rates as observed 5 years after, February 1991

NaCl RATE (Kg/tree/yr)	SOIL PROPERTIES			
	Soil pH		Organic matter (%)	
	Topsoil	Subsoil	Topsoil	Subsoil
0.0	4.96	5.50	2.05	1.28
0.88	5.10	5.50	1.95	1.39
1.76	5.13	5.56	2.01	1.36
3.52	5.20	5.50	1.95	1.22
7.04	5.03	5.43	2.21	1.34
S.E. mean	0.17	0.13	0.16	0.07
C.V. (%)	5.80	4.01	13.40	9.20
	EC (mmhos/cm)		Exchangeable Na (meg/100 g)	
	Topsoil	Subsoil	Topsoil	Subsoil
0.0	0.227	0.203	0.12ab*	0.34
0.88	0.207	0.223	0.08b	0.23
1.76	0.230	0.230	0.15ab	0.27
3.52	0.217	0.247	0.30a	0.39
7.04	0.213	0.257	0.24ab	0.71
S.E. mean	0.016	0.069	0.04	0.11
C.V. (%)	12.3	9.2	43.0	52.0
	WCH (%)		Bulk density (g/cc)	
	Topsoil	Subsoil	Topsoil	Subsoil
0.0	61.30	64.30	1.48	-
0.88	64.20	65.30	1.51	-
1.76	61.00	64.50	1.43	-
3.52	62.40	66.50	1.41	-
7.04	61.70	66.40	1.50	
S.E. mean	1.26	1.16	0.03	-
C.V. (%)	3.5	3.1	3.3	-

* Means followed with same letter(s) are not significantly differenct (5% level of statistical significance)

Table 2.2. Soil Properties as affected by previous NaCl application (5 years) at increasing rates, as observer 5 years after, February 1991

NaCl RATE (Kg/tree/yr)	SOIL PROPERTIES			
	CEC meg/100 g		Available P ppm (Olsen)	
	Topsoil	Subsoil	Topsoil	Subsoil
0.0	23.80	24.10	20.30	16.60
0.88	24.10	34.70	13.30	11.30
1.76	24.10	25.90	32.60	23.00
3.52	24.10	23.70	15.00	16.00
7.04	23.70	23.50	18.00	14.60
S.E. mean	0.76	3.89	5.40	3.80
C.V. (%)	5.5	25.5	47.8	40.8
	Total K (ppm)		Exchangeable Ca (meg/100 g)	
	Topsoil	Subsoil	Topsoil	Subsoil
0.0	880	746	9.07	9.73
0.88	1053	973	7.76	9.00
1.76	783	686	8.79	10.25
3.52	1116	750	8.37	9.65
7.04	586	1326	7.95	7.51
S.E. mean	267	176	0.83	0.72
C.V. (%)	52	34	17.1	13.9
	Exchangeable Mg (meg/100g)		Exchangeable K (meg/100g)	
	Topsoil	Subsoil	Topsoil	Subsoil
0.0	2.05	2.92	2.07	2.33ab
0.88	2.77	3.31	1.56	0.88c
1.76	2.24	2.42	1.60	1.45bc
3.52	2.55	3.08	1.82	1.86bc
7.04	1.14	1.96	2.69	3.22a
S.E. mean	0.43	0.63	0.28	0.22
C.V. (%)	34.3	38.1	25.7	19.8

4. CONCLUSION

With NaCl application, the positive residual effects on copra (weight/nut and yield/tree/year) could last for longer period (4-5 years) at fertilization rates of > = 1. 76 kg NaCl/tree (0. 97-3.87 kg Cl/tree/year).

Based on the soil bulk density, exchangeable Na and salinity index (EC), even at higher NaCl rate (3.52 kg and 7.04 kg/tree), no apparent adverse effects are, observed. The maintenance or persistence of beneficially high levels of leaf-Cl in coconuts as a.result of the previous application could either or both be likely due to nutrient recycling within the soil and crop systems, common in long-term, cropping or production of perennials.

In the rehabilitation of existing stands of coconut or newly established farms, findings of this study on the existence of positive residual effects of Sodium chloride fertilization implies that with 3-5 years of regular fertilization, the next 3-5 years very likely requires no fertilization at all due to the build-up of nutrients within the plant system, physiologically and agronomically speaking.

Because of the savings from non-fertilization, margin of profit should be expected, considering also that high nut and copra yields are maintained due to the positive residual effects of sodium chloride fertilizers.

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