

# FERTILIZER RECOMMENDATIONS FOR COCONUT BASED ON SOIL AND LEAF ANALYSES\*

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The paper presented the rationale and considerations in the use of either leaf analysis or soil analysis for a specific coconut area/farm. Also included are guides on: (1) the critical and satisfactory levels of soil properties on coconut production; (2) the critical and satisfactory levels of leaf nutrients of coconut; and (3) the average nutrient requirements by age and corresponding fertilizer needs based on research findings.

In addition, maintenance and corrective fertilization, as well as the limitations of fertilizer recommendations based on these diagnostic tools (soil analysis and leaf analysis), are discussed in relation to coconut farming.

**Keywords:** Coconut fertilization; soil analysis; foliar diagnosis; critical and satisfactory levels of soil properties; critical and satisfactory concentrations of leaf nutrients; recommended rates of N, P, K, Cl, S, Mg by age of coconut.

## INTRODUCTION

Fertilizer is considered worldwide as one of the single most important inputs that can immediately improve production of most agricultural crops like coconut and oil palm. Toward this end, soil and leaf analyses are utilized as faster tools in the absence of field experiments and trials.

For coconut, the advantage of leaf analysis over soil analysis as a basis of fertilizer recommendation is now largely accepted. This has been so as leaf analysis reveals amounts (concentrations) of nutrients absorbed by the crop, and diagnosis is not highly dependent on varying concepts of soil nutrient 'availability' or exchange reactions (highly dynamic in behavior). Thus, with the strong consideration that nutrient levels or concentration in a plant part like the leaf is directly related to its (coconut) growth and/or yield, leaf analysis has been successfully developed as a diagnostic tool to predict the fertilizer needs of the crop.

In the Philippines, several studies have shown

the beneficial effects of fertilization (Mendoza and Prudente 1972; Magat et al. 1975; Prudente and Mendoza 1976; Margate et al. 1978; Magat et al. 1981), increasing copra yields as high as three tons per hectare per year. Magat (1978) revealed the usefulness of leaf analysis as an effective and rapid tool in determining the qualitative needs and estimating the fertilizer rates of coconut in the country based on results of several fertilizer trials. Results obtained by Magat (1978) were reviewed by Manciot et al. (1979) with the conclusion that leaf analysis or foliar diagnosis is undoubtedly a very effective tool in predicting fertilizer needs of existing stands.

Moreover, further analysis done on soil, leaf and yield data of the Philippine Coconut Authority (PCA) survey (1975-80) collected from 1,131 sampling areas (57 coconut provinces) with diverse agro-climatic conditions showed that leaf analysis could give a better predictive value of the nutrient needs of the coconut and that leaf nutrients (N, P, K, Ca, Cl, and S) are more closely associated with coconut yields (nuts, copra) compared to soil properties and yields (Cosico and Fernandez 1983; Limbaga 1986).

## SOIL ANALYSIS AND FERTILIZER NEEDS

In soil analysis, the following data are required:

- (1) the chemical properties (physical properties sometimes needed) as determined by capable laboratories following acceptable methods;
- (2) a guide on suggested critical levels or satisfactory levels of soil properties for coconut; and
- (3) a guide on the average nutrient and fertilizer needs based on nutrient uptake and extensive mineral nutrition and fertilization research.

Items 2 and 3 are presented in Tables 1 and 2a to 2f and may be used as references for determining the qualitative needs and estimating the fertilizer rates for a particular farm or area under study or evaluation.

The rates of fertilization in Tables 2a, 2b, 2c, 2d, 2e, and 2f may be considered as the ones recommended under moderate levels of nutrients, that is, those slightly above the critical levels. When levels of nutrients are about equal or lower than the critical level, rates of nutrient and fertilizer application should be increased to at least 20%-50% of values in

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the reference tables, while when levels of nutrients are higher than the critical, the rates of nutrients and corresponding fertilizers should be lower by at least 20%-50% of reference values (Tables 2a to 2f). Under high levels of soil fertility, fertilization is not usually required except for periodic maintenance.

TABLE 1. Suggested critical levels\* of some soil properties

Property	Reference	
	PCA	IRHO (Ollagnier 1979)
pH:		
lower limit	5	5
higher limit	8	8
OM (%)	1.5	-
Organic C (%)	-	1
N (%)	-	1
C/N ratio	-	10-12
Cations (m.e./100g soil)		
exchangeable K	0.5	0.15-0.20
total K (ppm)	300-500	-
exchangeable Ca	10-15	-
exchangeable Mg	1-1.5	0.20-0.50
exchangeable Na	0.25?	-
Available ppm P (Olsen's)	15	-
Micronutrient (ppm)		
available Mn	15	-
available Fe	5	-
available Zn	5	-
available Cu	0.7	-
available B	0.5	-

\* Lower value considered satisfactory.

The best estimate depends to a great extent on the user's (for example, agronomist) strong background, experience, and understanding of the field conditions and agro-economic considerations as well.

For instance, the chemical analysis of the soil samples collected from a 25 year old bearing coconut plantation shows the following results:

soil pH 6.0; organic matter, 1.8%; available P, 25ppm; exchangeable K, 0.25 m.e./100 g; exchangeable Ca, 18 m.e./100 g; exchangeable Mg, 2.5 m.e./100 g.

Comparing these values with the suggested levels (Table 1), referenced to PCA, the former indicate satisfactory levels of soil acidity, available P, exchangeable K, Mg, while both N (organic matter as basis) and K are likely at low to moderate levels. This suggests the need to apply both N and K, and using Table 2a (N fertilization) and Table 2c (K fertilization), the suggested rates of K and N are 0.40 kg and 1 kg, respectively. These required nutrients can be satisfied by 2 kg 21-0-0 or 0.90 kg urea plus 2.0 kg 0-0-60. In cases where information on soil Cl and S levels are not known, the use of 21-0-0 and 0-0-60 are recommended as coconut usually needs

these nutrients widely in the country.

## LEAF ANALYSIS AND FERTILIZER NEEDS

In leaf analysis or foliar diagnosis, the following data are required:

- (1) the results of chemical analysis of the concentration of nutrients (N, P, K, Ca, Mg, Na, Cl, S, B, and micronutrients) of a particular leaf reference, such as leaf 14 for bearing palms, analyzed by a qualified laboratory. The PCA has a specialized laboratory, the Tissue Analysis Laboratory (TAL) based at the Head Office, Diliman, Quezon City;
- (2) a guide on the suggested critical levels and optimum levels (if available);
- (3) a guide on the average nutrient and corresponding fertilizer needs based on average nutrient uptake and substantial mineral nutrition and fertilization research (Tables 2a-2f).

For item 2, Table 3 may be used as reference for tall varieties, and Table 4 for coconut hybrids, particularly the dwarf x tall types, using the 'MAWA' or Port Bouet 121 as a guide.

As in the soil analysis technique in diagnosing fertilizer recommendations, the rates of fertilization in Tables 2a, 2b, 2c, 2d, 2e, and 2f could be considered as the ones recommended under moderate levels of nutrients (N, P, K, Cl, Mg, and S), slightly above the critical levels. When levels of nutrients are about equal or lower than the critical levels, rates of nutrient and fertilizer application should be increased to at least 20%-50% of the values in the reference tables. On the contrary, when levels of nutrients are higher than the critical concentrations, the rates of nutrients and corresponding fertilizer sources should be decreased by at least 20%-50% of the reference values (Tables 2a to 2f). Under very high levels of soil fertility, regular fertilizer application is not normally practiced except for periodic maintenance.

In fertilizer management, the maintenance fertilization rate corresponds to the fertilizer amounts necessary to maintain the available reserves at constant level, while corrective fertilization rate is the difference between optimum fertilization and maintenance fertilization. The optimum level depends on economic conditions, as well as the response obtained under field experimentation in a particular soil type or area.

The degree of accuracy and reliability of recommending the best fertilizer amounts (as close to the optimum rates) for the maximum economic yield (MEY) depends much on the knowledge and experi-

TABLE 2a. Recommended rate of nitrogen fertilization (tree/year) at different ages of coconut

Age	N rate (per tree)	Fertilizers (tree/year) <sup>a</sup>			
		Ammonium sulfate <sup>b</sup> (21-0-0) (A)	Ammonium chloride (25-0-0) (B)	Urea (45-0-0) (C)	Complete 14-14-14 (D)
Field planting	30 g	150 g	120 g	66 g	200 g
6 mo	40 g	200 g	160 g	88 g	266 g
1 yr	0.10 kg	0.50 kg	0.40 kg	0.22 kg	0.67 kg
2 yr	0.15 kg	0.75 kg	0.60 kg	0.33 kg	1.0 kg
3 yr	0.20 kg	1.0 kg	0.80 kg	0.44 kg	1.33 kg
4 yr	0.30 kg	1.5 kg	1.20 kg	0.66 kg	2.00 kg
5 yr or older	0.40 kg	2.0 kg	1.60 kg	0.89 kg	2.67 kg

<sup>a</sup> Percentage of N: A, 21%; B, 25%; C, 45%; D, 14%.

<sup>b</sup> Most common N source for coconut.

TABLE 2b. Recommended rate of phosphorous fertilization (tree/year) at different ages of coconut

Age	P rate (per tree)	Fertilizers (tree/year) <sup>a</sup>			
		Solophos (0-20-0) <sup>b</sup> (A)	Ammophos (16-20-0) (B)	Complete (10-5-20) (C)	Complete (14-14-14) (D)
Field planting	13 g	150 g	150 g	590 g	209 g
6 mo	22 g	250 g	250 g	1.00 kg	355 g
1 yr	44 g	0.50 kg	0.50 kg	2.00 kg	0.70 kg
2 yr	63 g	0.70 kg	0.70 kg	2.86 kg	1.01 kg
3 yr	72 g	0.80 kg	0.80 kg	3.27 kg	1.16 kg
4 yr	87 g	1.00 kg	0.0 kg	3.95 kg	1.40 kg
5 yr or older	131 g	1.50 kg	1.50 kg	5.95 kg	2.11 kg

<sup>a</sup> Percentage of P: A, 9%; B, 9%; C, 2.2%; D, 6.2%.

<sup>b</sup> Most common P source for coconut.

TABLE 2c. Recommended rate of potassium fertilization (tree/year) at different ages of coconut

Age	K rate (per tree)	Fertilizers (tree/year) <sup>a</sup>			
		Potassium chloride (0-0-60) <sup>b</sup> (A)	Potassium sulfate (0-0-50) (B)	Complete (10-5-20) (C)	Complete (14-14-14) (D)
Field-planting	75 g	150 g	182 g	468 g	536 g
6 mo	125 g	250 g	304 g	781 g	1.13 kg
1 yr	0.30 kg	0.60 kg	730 g	1.87 kg	2.72 kg
2 yr	0.45 kg	0.90 kg	1.09 kg	2.81 kg	4.09 kg
3 yr	0.60 kg	1.20 kg	1.46 kg	3.75 kg	5.45 kg
4 yr	0.80 kg	1.60 kg	1.95 kg	5.00 kg	7.27 kg
5 yr or older	1.00 kg	2.00 kg	2.43 kg	6.25 kg	9.09 kg

<sup>a</sup> Percentage of K: A, 50%; B, 41%; C, 16%; D, 11%.

<sup>b</sup> Most common source of K for coconut.

TABLE 2d. Recommended rate of chlorine fertilization (tree/year) at different ages of coconut

Age	Cl rate (per tree)	Fertilizers (tree/year) <sup>a</sup>				
		Potassium chloride (0-0-60) <sup>b</sup> (A)	Sodium chloride (Common salt) <sup>b</sup> (B)	Ammonium chloride (25-0-0) (C)	Complete (10-5-20) (D)	Complete (14-14-14) (E)
Field-planting	66 g	150 g	132 g	110 g	412 g	600 g
6 mo	111 g	250 g	222 g	185 g	693 g	1.00 kg
1 yr	260 g	0.60 kg	0.52 kg	0.43 kg	1.62 kg	2.36 kg
2 yr	400 g	0.90 kg	0.80 kg	0.67 kg	2.50 kg	3.64 kg
3 yr	530 g	1.20 kg	1.60 kg	0.88 kg	3.31 kg	4.82 kg
4 yr	700 g	1.60 kg	1.40 kg	1.17 kg	4.37 kg	6.36 kg
5 yr or older	800 g	2.00 kg	1.80 kg	1.50 kg	5.62 kg	6.18 kg

<sup>a</sup> Percentage of Cl: A, 44%; B, 50%; C, 60%; D, 16%.

<sup>b</sup> Common sources of chloride for coconut.

TABLE 2e. Recommended rate of magnesium fertilization (tree/year) at different ages of coconut

Age	Mg rate (per tree)	Fertilizers (tree/year) <sup>a</sup>		
		Dolomite <sup>b</sup> (A)	Kieserite <sup>b</sup> (B)	Epsom Salt (C)
Field planting	30 g	300 g	176 g	315 g
6 mo	50 g	500 g	294 g	526 g
1 yr	75 g	0.75 kg	0.44 kg	0.79 kg
2 yr	150 g	1.50 kg	0.88 kg	1.58 kg
3 yr	0.20 kg	2.00 kg	1.17 kg	2.10 kg
4 yr	0.25 kg	2.50 kg	1.47 kg	2.63 kg
5 yr or older	0.30 kg	3.00 kg	1.76 kg	3.15 kg

<sup>a</sup> Percentage of Mg: A, 10%; B, 17%; C, 9.5%.

<sup>b</sup> Common source of Mg for coconut.

TABLE 2f. Recommended rate of sulfur fertilization (tree/year) at different ages of coconut

Age	S rate (gram per tree)	Fertilizers (tree/year) <sup>a</sup>				
		Ammonium sulfate (21-0-0) <sup>b</sup> (A)	Calcium sulfate <sup>b</sup> (gypsum) (B)	Potassium sulfate (gypsum) (C)	Magnesium sulfate (epsom salt) (D)	Complete (14-14-14) (E)
Field-planting	36	150 g	200 g	200 g	276 g	327 g
6 mo	49	200 g	266 g	266 g	369 g	436 g
1 yr	120	0.50 kg	0.67 kg	0.67 kg	0.92 kg	1.09 kg
2 yr	180	0.75 kg	1.0 kg	1.0 kg	1.38 kg	1.64 kg
3 yr	240	1.00 kg	1.33 kg	1.33 kg	1.85 kg	2.18 kg
4 yr	360	1.50 kg	2.0 kg	2.0 kg	2.77 kg	3.27 kg
5 yr or older	480	2.00 kg	2.67 kg	2.67 kg	3.69 kg	4.36 kg

<sup>a</sup> Percentage of S: A, 24%; B, C, 18%; D, 13%; E, 11%.

<sup>b</sup> Common sources of sulfur for coconut.

ence of the one using foliar diagnosis. This means historical records and agronomic data and information available helps improve the reliability of the method.

**TABLE 3. Guide on coconut leaf critical levels (% of dry matter) for tall (Typica) variety**

Nutrient/Leaf No	T.R. H.O	Reference		
		Unilever (1)	Kanapathy (2)	PCA (3)
<b>MACRONUTRIENT</b>				
<b>Nitrogen (%)</b>				
Leaf 1	1.70	1.60	-	-
4	2.20	1.80	-	-
9	2.20	1.95	-	-
14	1.8-2.0	2.00	1.80	1.80
<b>Phosphorus (%)</b>				
Leaf 1	0.160	0.17	-	-
4	0.138	0.16	-	-
9	0.130	0.15	-	-
14	0.120	0.14	0.12	0.12
<b>Potassium (%)</b>				
Leaf 1	2.20	2.00	-	-
4	1.75	1.70	-	-
9	1.15	1.30	-	-
14	0.8-1.00	1.00	0.8-1.10	0.80
<b>Calcium (%)</b>				
Leaf 1	-	0.30	-	-
4	-	0.34	-	-
9	-	0.44	-	-
14	0.50	0.55	0.15-0.30	0.30
<b>Magnesium (%)</b>				
Leaf 1	0.20	0.22	-	-
4	0.22	0.23	-	-
9	0.24	0.25	-	-
14	0.24-0.28	0.26	0.30	0.20
<b>Sodium (%)</b>				
Leaf 1	-	0.10	-	-
4	-	0.12	-	-
9	-	0.17	-	-
14	0.40	0.20	-	-
<b>Chloride (%)</b>				
Leaf 1	-	-	-	-
4	-	-	-	0.40-0.70
9	-	-	-	0.30-0.55
14	0.50	-	-	0.30-0.40*
<b>Sulfur (%)</b>				
Leaf 1	-	-	-	-
4	-	-	-	-
9	-	-	-	-
14	0.15-0.20	-	-	0.12*
<b>MICRONUTRIENT:</b>				
<b>Boron (ppm)</b>				
Leaf 1	-	12	-	-
4	-	13	-	9.13
9	-	14	-	-
14	-	14	-	9.11
<b>Manganese (ppm)</b>				
Leaf 1	-	100	-	-
4	-	130	-	-
9	-	165	-	-
14	60	185	60	-
<b>Iron (ppm)</b>				
Leaf 1	-	80	-	-
4	-	90	-	-
9	-	100	-	-
14	50	115	50	-
<b>Zinc (ppm)</b>				
Leaf 1	-	20	-	-
4	-	18	-	-
9	-	15	-	-
14	60	15	60	-
<b>Copper (ppm)</b>				
Leaf 1	-	13.5	-	-
4	-	18.5	-	-
9	-	13	-	-
14	-	12.5	-	-

- (1) Friend (1975). The Solomon Islands and Levers Pacific Plantations Proprietary Limited Joint Coconut Research Scheme, 1971-74.
- (2) Kanapathy (1971). Preliminary work on foliar analysis as a guide to the manuring of coconut. Conference on Cocoa and Coconuts, (Incorporated Society of Planters) Kuala Lumpur, Malaysia.
- (3) Magat (1979). The use of leaf analysis in the conduct of field fertilizer trials in the Philippines. Plant nutrition 1978. New Zealand DSIR Info. Series 134: 299-311. Also in Phil. J. Coconut Studies 4 (1): 32-39.

**TABLE 4. A guide on coconut leaf critical levels (% of dry matter) for hybrids**

Nutrient/Leaf No.	IRHO <sup>1</sup> Critical level	Reference PCA <sup>2</sup>	
		Critical level	Optimum level
<b>Nitrogen</b>			
Leaf 1	1.7	-	-
4	2.2	1.95	2.2
9	2.2	1.80	2.0
14	2.2	1.80	2.0
<b>Phosphorus</b>			
Leaf 1	0.16	-	-
4	0.14	0.13	0.15
9	0.13	0.12	0.13
14	0.12	0.12	0.13
<b>Potassium</b>			
Leaf 1	3.0	-	-
4	2.0	1.70	1.90
9	1.7	1.0	1.17
14	1.4	0.90	1.10
<b>Calcium</b>			
Leaf 1	-	-	-
4	-	0.35	0.41
9	-	0.34	0.38
14	-	0.32	0.35
<b>Magnesium</b>			
Leaf 1	0.27	-	-
4	0.24	0.25	0.29
9	0.23	0.30	0.33
14	0.20	0.30	0.33
<b>Sodium</b>			
Leaf 1	-	-	-
4	-	0.30	0.37
9	-	0.20	0.25
14	-	0.15	0.17
<b>Chlorine</b>			
Leaf 1	-	-	-
4	-	0.65	0.74
9	-	0.55	0.60
14	-	0.45	0.52
<b>Sulfur</b>			
Leaf 1	-	-	-
4	-	0.17	0.19
9	-	0.15	0.17
14	-	0.15	0.16

<sup>1</sup> Manciot et al. (1979).

<sup>2</sup> First Approximation (Magat 1988).

For instance, the leaf sample (leaf 14) from a 30 year old coconut (local tall variety) has the chemical analysis below as reported by the laboratory:

N, 1.65%; P, 0.13%; K, 0.35%; Ca, 0.55%; Mg, 0.35%; Na, 0.15%; Cl, 0.10%; S, 0.11%; and B, 11 ppm.

By comparing the values with the guide on critical levels (PCA as reference), the coconut area represented by this sample is likely suffering from moderate deficiencies in N and S, and strong deficiencies in K and Cl, while P, Ca, Mg, Na, and B are well above satisfactory levels or very adequate for the palms. The nutritional needs (per tree per year) are very likely 0.40 kg N, 1.3 kg K, 1.2-1.3 kg Cl, and

0.48 kg S. These can be supplied by 2 kg 21-0-0 and 2.5 kg KCl per palm per year.

In cases where K and S are adequate, NaCl and  $\text{NH}_4\text{Cl}$  (25-0-0) have been found to be very effective and are cheaper sources of chloride, a macronutrient for coconut.

### SUMMARY AND CONCLUSION

1. Both the soil analysis and leaf analysis can be used as basis of fertilizer recommendations for coconut, and these complement each other.
2. As leaf analysis is not affected by soil nutrient 'availability' and exchange reactions, it is a more reliable method.
3. For macronutrients as Cl, S, and N, leaf analysis is a more accurate tool as these elements are highly mobile in the soil.
4. In both methods, availability of guides on: critical or satisfactory values (soil analysis); critical and optimum levels (leaf analysis); and average nutrient and fertilizer needs, under different stages/ages of the coconut should improve reliability of recommendations.
5. Reference critical levels (soil and leaf) should be evaluated under local conditions before wider use.

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