

CALCIUM AND MAGNESIUM NUTRITION OF COCONUT PALM

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Abstract: Crop removal studies suggested that the quantitative requirements of coconut for Ca and Mg are much higher than that of P. Calcium is mainly concerned for the proper growth and functioning of stem and leaves of the palm rather than its productivity of nuts. Instances of Ca deficiency conditions of the palm were rarely found and the direct effects of Ca on growth or yield were seldom reported except when the leaf Ca levels were extremely low. The critical level of 0.3 per cent Ca (frond 14) appears to have a broader applicability as a diagnostic aid for regulating the Ca nutrition of the palm. Intensive liming is not needed for the management of the palm. Nevertheless, regulated additions of Ca through Ca-bearing fertilizers like rockphosphate, superphosphate or light additions of lime may be followed for supplying the Ca requirement of the palm.

Magnesium is observed to be one of the limiting nutrient elements in the nutrition of the palm, particularly on seedlings and young palms. Deficiency of Mg is common on soils that are poor in this element, particularly on acid sandy soils, and is also induced by high K/Mg ratio. Magnesium saturation of 15-20% of the exchange complex and exchangeable Mg/K ratio of 2.0 to 2.5 in the soil, and a foliar level of 0.2% Mg in frond 14 may be considered as critical for regulating the Mg nutrition of the palm. Application of Mg salts, usually epsom/kieserite, corrects the deficiency conditions faster while dolomite may be used for long term remedy or prevention. The increase in yield of nuts on correction can be as high as 40 per cent. Regular Mg addition in the form of magnesium sulphate (hydrated) at the rate of 500 g MgO/palm/year from the time of field planting on a Mg-deficient acid sandy soil in the west coast of Kerala had increased all the growth parameters at a highly significant level, reduced the pre-bearing age of the palm by 9.1 months and increased the initial yields up to the 14th year by 34 per cent with simultaneous improvements in soil and foliar Mg to desirable levels. However, the dose of Mg may be regulated based on the extent of limitation of Mg and the exchangeable Mg/K ratio of the soil and also the foliar Mg levels of a particular situation. The incidence of coconut root (wilt) disease did not show any relation with Ca or Mg nutrition of the palm. However, correction of Mg deficiency showed more favourable response on growth and yield of diseased palms compared to healthy.

INTRODUCTION

The quantity of Ca and Mg removed by coconut palm is much higher than that of P bringing to the forefront the need for taking adequate care for the nutrition of these two secondary nutrients, particularly in acidic soil situations. The proportion of Ca used for the development of bunches is the least while that used for the growth of stem and leaves is the highest suggesting the importance of Ca for the growth and functioning of stem and leaves. When all the major nutrients had been

regularly applied since planting in the main field, the length and breadth of leaflets were significantly increased only with Ca treatment. The studies generally indicate that in coconut palm, Ca is mainly concerned for the vegetative growth of the palm rather than its productivity of nuts (Cecil, 1981).

Irrespective of the type of the palm, the proportion of Mg removed for the growth of stem and leaves is about 60% while that exhausted through the harvest of bunches is about 40%. Thus Mg is mostly required for the effective

functioning of the leaves, and through its photosynthetic function, it regulates very much the growth as well as the productivity of the palm.

CRITICAL LEVELS

The foliar critical levels initially suggested by IRHO for Ca and Mg were 0.5 and 0.3 per cent respectively for the tall variety (Fremond, 1964). However, values lower than these levels have been widely reported on healthy plantations without any adverse effect on yield or foliar conditions (Nethsinghe, 1963; Devi *et al.*, 1973; Barrant, 1977; Manciot *et al.*, 1979b and Mangate *et al.*, 1979a). Cecil (1969) reported 0.49% Ca and 0.29% Mg in palms under excellent growth conditions, 0.38% Ca and 0.08% Mg in palms showing severe Mg deficiency symptoms, and 0.37% Ca and 0.18% Mg in apparently healthy palms without any visual symptoms of deficiency. Magat (1976) reported that the critical level of Ca and Mg initially suggested by IRHO appeared to be too high for Philippine conditions. According to him the critical level of Ca and Mg followed in the Philippines are 0.3 and 0.2 per cent respectively.

Cecil (1981) conducted a systematic study on the mineral nutrition of the palm (West Coast Tall) with special emphasis on Ca and Mg in a field fertility experiment over a period of 10 years from the time of field planting. The mean Ca levels in the absence of Ca treatment ranged from 0.32 to 0.37% which was more than the critical level of 0.3% suggested by Magat (1976). Even though there was significant improvement in the foliar Ca levels due to regular Ca treatment, the favourable effects of Ca on growth/yield appeared to be indirect. Foliar Ca values were not correlated with growth, onset of bearing or initial yields. In the absence of Mg treatment the mean foliar Mg level

was 0.18% or less. Regular Mg additions had brought about highly significant increase in leaf Mg levels and simultaneous improvements in all growth parameters which ultimately resulted in a significant increase in initial yields (Table 1) and reduction in the pre-bearing age (Table 2). The leaf Mg levels reached above 0.2% at the 5th year and onwards. Correlation analysis showed that among the major nutrients in the foliage, only Mg was significantly correlated with initial yields ($r = 0.282^{**}$) and yield attributes ($r = 0.230^*$ for the number of bunches/palm; $r = 0.276^{**}$ for the number of female flowers/bunch; $r = 0.247^{**}$ for the number of nuts/palm). The proportion of palms in flower at 74th month was also significantly correlated ($r = 0.238^*$) only with foliar Mg levels. It is suggested that the critical level of 0.3% Ca (frond 14) has a broader applicability as a diagnostic aid for regulating the Ca nutrition of the palm while that of 0.2% Mg may be adopted under west coast conditions until specific critical levels for each variety/type are established.

It was observed that regular Ca treatment had increased the percentage Ca saturation of the soil from 28.4 to 49.8 at the ninth year which resulted in

Table 1. Main effects of Ca and Mg on cumulative yield of nuts harvested up to 14th year of planting

Levels	Nuts/palm	% increase
Ca 0	346.4	
Ca 1	386.3	11.5
Mg 0	313.4	
Mg 1	419.4 ^{**}	33.8

Ca 0 = No calcium; Ca 1 = Lime requirement (pH 6.5);
Mg 0 = No magnesium; Mg 1 = 500 g MgO/palm/year

Table 2. Main effects of Ca and Mg on flowering

Levels	Proportion of palms (%) in flowering at			Pre-bearing age (months)	Leaf No.
	62 months	74 months	86 months		
Ca 0	10.5	41.8	75.2	75.1	55.7
Ca 1	14.2	49.4	80.7	72.6 [*]	54.4
Mg 0	6.2	31.4	65.9	78.4	57.9
Mg 1	18.5 ^{**}	59.77 ^{**}	90.1 ^{**}	69.3 ^{**}	52.2 ^{**}

1 The axil of which the first inflorescence opened

* Significant at 5% level

** Significant at 1% level

highly significant increase in foliar Ca levels. Mg saturation of 15-20% in the 0-50 cm soil is ideal for coconut. In the absence of Mg treatment, the values of Mg/K ratio were very low (0.6-0.7) in the 0-50 cm soil and around 1.0 in the 50-100 cm soil. The comparatively higher values in the lower layers was probably the favourable factor for the gradual decrease in the severity of Mg deficiency yellowing and the gradual improvement in foliar Mg levels with advancing age of young palms grown on Mg deficient soils, as the enlargement of the root system to lower depths increased with the age of the palm. Regular Mg treatment gradually raised the ratio to 1.3 in the 0-50 cm soil and 2.0 in the 50-100 cm soil, but did not reach the ideal value of 2.5 suggested by Manciot *et al.* (1979a). The ratio of exchangeable Mg/K is the dominant determinant factor for assessing the Mg availability of coconut soils. It is also quite probable that the palms grown on soils with low exchangeable Mg/K ratio are more susceptible to K induced Mg deficiency.

NUTRIENT INTERACTIONS

Liming of acid soils under coconut improved the foliar N levels while Mg

additions had a reverse effect. The leaf P level as well as the available soil P was increased by both Ca and Mg treatments. On the other hand, both Ca and Mg depressed the availability of K. The foliar Ca levels were generally increased by N and P treatments while K and Mg application decreased the level of Ca in leaf. A depressive effect of K on leaf Mg levels when the soil as well as the leaf Mg levels were low, was observed and when Mg was regularly supplied, the level of leaf K decreased. The action of K fertilizers on leaf Mg content largely depends upon the balance between K and Mg in the soil. More critical studies are needed to understand the problem at greater depth. Calcium treatment exerted a favourable effect on foliar Mg levels and the interaction between Ca and Mg on leaf Mg had been positive (Table 3) which reflected on growth, onset of bearing and initial yields.

Favourable effects of Ca treatment on growth of young palms and their initial yields could be noticed but the increase in yield was not significant. Magnesium has been observed to be one of the most limiting nutrient elements in the nutrition of seedlings and young palms, especially when the soil is poorly

Table 3. Ca-Mg interaction on foliar Mg (%)

	Ca 0	Ca 1	Mean
Mg 0	0.167	0.167	0.167
Mg 1	0.203	0.221	0.212**
Mean	0.185	0.194*	0.189
CD (P = 0.05)	0.012		

* Significant at 5% level

** Significant at 1% level

supplied with Mg, and the application of Mg fertilizers corrected the deficiency very well, raised the Mg levels of leaf, improved the growth and increased productivity. Manciot *et al.* (1979b) reported that the main effect of Mg could be as much as 40% when K was in the sufficiency level, but unlike K, Mg had no effect on the copra content. Cecil (1981) observed that regular Mg addition in the form of magnesium sulphate (hydrated) at the rate of 500 g MgO/palm/year from the time of field planting on a Mg deficient acid sandy soil in west coast of Kerala had increased all the growth parameters at a highly significant level, reduced the pre-bearing age of the palm by 9.1 months and increased the initial yields up to the 14th year by 34% with simultaneous improvement in soil and foliar Mg to desired levels.

ROOT (WILT) DISEASE

Most of the soil and nutritional studies conducted on the root (wilt) disease indicated that the palms in the disease affected areas, whether they were apparently healthy or visibly diseased, were in a state of imbalance, possibly the result of a relatively higher content of N, P and/or K on the one hand and a lower content of Ca, Mg and/or S on the other (Pandalai, 1959;

Varghese, 1966; Pillai *et al.*, 1975; Cecil, 1975 & 1981). Different field fertility studies showed that the disease could not be cured or prevented by mineral manuring even though beneficial effects on yield and foliar yellowing were observed in some cases, especially when treated with magnesium and calcium salts (Nair and Radha, 1959; Lal, 1964; David, 1964; Davis and Pillai, 1966; Varkey *et al.*, 1979; Cecil, 1981). Lal (1968) reported that the foliar yellowing associated with the disease was largely due to Mg deficiency which could be improved markedly when the palms were sprayed with 2.0% magnesium sulphate solution at quarterly intervals (Anon, 1966). The study of the role of Ca and Mg on the incidence and severity of the disease revealed that the disease development in young palms was independent of Ca and Mg nutrition of the palm. However, correction of Mg deficiency prevalent in disease affected areas resulted in significant increase in growth and initial yields, and the effects were more pronounced on diseased than on healthy palms. When the increase in the yield of nuts by Mg treatment in healthy palm was 37%, the corresponding increase in diseased palms was 60% (Cecil *et al.*, 1982). Such preferential response of Mg on diseased palms over healthy was reported earlier by Davis and Pillai (1966) and Varkey *et al.*, (1979). More critical studies are needed to elaborate the beneficial role of Mg in the nutrition of diseased palms.

DEFICIENCY SYMPTOMS

Heavy liming is not needed for the management of the palm. Nevertheless, regulated additions of Ca through Ca-bearing fertilizers like rock phosphate/superphosphate and/or light additions of liming materials may be followed for supplying the Ca requirement of the palm. This is all the more important in view of the heavy loss of

Ca by crop removal and also by excessive leaching under tropical conditions. Magnesium deficiency has been more common on acid sandy soils with a low Mg content, and is also induced by imbalance of nutrients like high K/Mg or Ca/Mg ratios in soils as well as leaf tissues. Prolonged use of K fertilizers, especially at high rates, depresses foliar Mg content and induces Mg deficiency conditions.

Symptoms of Mg deficiency is more common on young palms and seedlings, and is usually manifested as yellowing of the outer whorls of leaves. The very first symptom is the development of yellowing at the tip of leaflets at the distal parts of mature leaves which gradually spreads towards the basal part of the leaflet as well as the leaf. In the advancing stage, yellowing becomes intense near the periphery of the leaf blade, and only a narrow longitudinal green band parallel to the midrib on either side of the leaflet is visible. When the deficiency gets worse, yellowing intensifies, the number of green leaves becomes less, necrosis sets in at the tips of the leaflets, and numerous brown blotches develop on the yellow surface. Mg deficient leaves are more sensitive to sunlight as the part exposed to sunlight shows an intense discolouration while the shaded part of the same leaflet remains green. When the deficiency becomes severe, intense yellowing accompanied by severe necrosis and browning develops and the mature leaves wither away prematurely leading ultimately to a lesser number of functioning leaves on the crown. The frond production rate is reduced, onset of bearing is delayed, and the productivity of the palm is adversely affected.

Application of Mg salts, particularly the sulphate, corrects the deficiency very well resulting in the re-greening of the chlorotic foliage/prevention of

chlorosis accompanied by increase in foliar Mg levels and improvement in growth and yield of nuts. Amma *et al.* (1982) applied two levels of Mg viz., 500 g and 1000 g MgO/palm/year as magnesium sulphate along with three levels of NPK to D x T hybrids since planting. The second level of Mg did not generally show any significant increase over the first. However, the second level of Mg with the second level of NPK showed maximum response on the earliness of flowering. Cecil (1981) observed highly significant response on growth and initial yields of young palms with 500 g MgO/palm/year.

Even though the importance of Mg nutrition on growth and productivity of the palm has been well brought out by research carried out in different parts of the world, critical studies are needed to assess the optimum dose for different soil/agroclimatic zones as well as a cheap but effective source of Mg for economic management of the crop. More studies are also needed to elaborate the beneficial role of Mg on root (wilt) affected palms, and also to study the exchangeable Mg/K balance, in coconut soils for maintaining a favourable balance of the two important nutrients (K & Mg) which may help to avoid excessive K fertilization and prevent the loss in yield caused by Mg deficiency.

REFERENCES

- Amma, P.G.K., Cecil, S.R., Pillai, N.G., Mathew, A.S. and Nambiar, P.T.N. 1982. Performance of Dwarf x Tall hybrid coconut in root (wilt) affected areas of Kerala under different fertilizer schedules. *Proc. PLACROSYM V*, Kasaragod, India, p 405-410
- Anonymous, 1966. Annual Report 1966. Central Coconut Research Station, Kayamkulam
- Barrant, C.J. 1977. 17th Report of the Research Department. The Coconut Industry Board, Jamaica, W.Indies, p 15-37

- Cecil, S.R. 1969. Nutritional aspects of the coconut palm in health and disease. M.Sc. thesis, University of Kerala, Trivandrum
- Cecil, S.R. 1975. Mineral composition of coconut leaves in relation to root (wilt) disease. *J. Plant. Crops* 3 : 34-37
- 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
- Cecil, S.R., Pillai, N.G., Amma, P.G.K., Mathew, A.S. and Nambiar, P.T.N. 1982. Effect of major nutrients on the incidence of root (wilt) disease. *Proc. PLACROSYM V. Kasaragod, India*, p 474-481
- Davis, T.A. 1964. Contribution to the physiology of the coconut palm. *Proc. Second Sessn. FAO Tech. Pty. Cocon. Prod. Prot. & Processg. Colombo, Sri Lanka*
- Davis, T.A. and Pillai, N.G. 1966. Effect of magnesium and certain micronutrients on root (wilt) affected and healthy coconut palms in India. *Oleagineux* 21 : 669-674
- Devi, C.B., Nelliat, E.V. and Pillai, N.G. 1973. Nutritional studies on high yielding coconut genotypes. *J. Plant. Crops* 1 (Suppl) : 67-69
- Fremond, Y. 1964. The contribution of IRHO to the study of mineral nutrition of the coconut palm. *Proc. Second. Sessn. FAO Tech. Wkg. Pty. Cocon. Prod. Prot. & Processg. Colombo, Sri Lanka*
- Lal, S.B. 1964. Advances in research on the root (wilt) disease problems of Kerala. *Proc. Second Sessn. FAO Tech. Wkg. Pty. Cocon. Prod. Prot. & Processg. Colombo, Sri Lanka*
- Lal, S.B. 1968. Root (wilt) disease - Resume of work done since 1964. *Proc. Third Sessn. FAO Tech. Wkg. Pty. Cocon. Prod. Prot. Processg. Jogjakarta, Indonesia*
- Magat, S.S. 1976. Soil and leaf analysis in relation to coconut yield. *Philipp. J. Cocon. Stud.* 1 (2) : 1-9
- Magat, S.S. 1979. The use of leaf analysis in the conduct of coconut field fertilizer trials in the Philippines. *Philipp. J. Cocon. Stud.* 4 (1): 32-35
- Manciot, R., Ollagnier, M. and Ochs, R. 1979a. Mineral nutrition and fertilization of the coconut around the world. Part I. *Oleagineux* 34 : 499-515
- Manciot, R., Ollagnier, M. and Ochs, R. 1979b. Mineral nutrition and fertilization of the coconut around the world. Part II. *Oleagineux* 34 : 563-580
- Margate, R.Z., Magat, S.S., Alforja, L.M. and Habana, J.A. 1979. A long term KCl fertilization study of bearing coconuts in an inland-upland area of Davao (Philippines). *Oleagineux* 34 (5) : 235-242
- Nair, U.K. and Radha, K. 1959. Manuring-cum-spraying for the control of coconut palm diseases. *Proc. First. Conf. Cocon. Res. Workers in India. Trivandrum, India*
- Nethsinghe, D.A. 1963. Report of the Soil Chemist. *Ceylon Cocon. Q.* 14 : 8-20
- Pandalai, K.M. 1959. Some aspects of nutritional disturbances in relation to certain disorders in the coconut palm. *Proc. First. Conf. Cocon. Res. Workers in India. Trivandrum, India*
- Pillai, N.G., and Davis, T.A. 1963. Exhaust of macronutrients by the coconut palms - A preliminary study. *Indian Cocon. J.* 16 : 81-87
- Pillai, N.G., Wahid, P.A., Devi, C.B.K., Ramanandan, P.L., Cecil, S.R., Amma, P.G.K., Mathew, A.S. and Nambiar, C.K.B. 1975. Mineral nutrition of root (wilt) affected coconut palm. *Proc. Fourth Sessn. FAO Tech. Wkg. Pty. Cocon. Prod. Prot. & Processg. Kingston, Jamaica*
- Varghese, E.J. 1966. Fertility status of coconut soils with special reference to the leaf and root (wilt) diseases of the coconut palm in Kerala. *Agric. Res. J. Kerala* 4 (2) : 49-60
- Varkey, T., Amma, P.G.K., Ramanandan, P.L. and Nambiar, P.T.N. 1979. Foliar yellowing of coconut palms in healthy and root (wilt) affected areas. *J. Plant. Crops* 7 (2) : 117-120