The importance of magnesium in the production of palm oil
**Introduction**

Oil palm has a high Mg requirement which even exceeds that of P. Today, the target of high palm oil yields cannot be realized without adequate supply of this essential macronutrient, especially on the sizeable and generally Mg deficient replanting areas in Malaysia. The general understanding of Mg and its functions in the soils and plants, though crucial for high efficiency and maximum return, appears to still be incomplete. Therefore, this paper attempts to summarize and visualize the role of Mg for oil palm with respect to soil/plant interactions, stressing on yield responses to Mg application, its interaction with other cations on FFB and oil formation.

**Magnesium in the plant**

Figure 1 visualizes the most important functions of magnesium in plants. Mg is integral part of the chlorophyll and as a coenzyme in the fixation of CO₂, it is essential in the photosynthesis.

Magnesium is involved in the cation-anion balance, where it is responsible for pH regulation and turgor adjustment of plant cells. 5%-10% of the Mg is bound to pectate, serving as a structural element of cell walls. The unbound Mg is highly mobile within the plant and is easily retranslocated from older to younger leaves and tissues, e.g. grains, fruits etc. Visual Mg deficiency symptoms always occur at the older leaves first. Being part of the energy transfer, insufficient Mg supply impairs starch synthesis.

On the other hand mobilization and transport of soluble carbohydrates to growing tissues and storage organs, e.g. fruits, grains, etc. is inhibited. The same is true for the loading and unloading of the phloem. This is explained by the fact that the ion pumps needed for this process can only operate under sufficient Mg supply. Hence Mg deficiency leads to an increase in starch and dry matter content in the older leaves and to an undersupply of carbohydrates in fruits, grains and particularly roots as can be shown in Figure 2.

**Figure 2. Relative distribution of carbohydrates in a plant as affected by P, K and Mg deficiency.**

Inhibited carbohydrate supply in the roots impairs their growth and causes that nutrient uptake, especially that of nutrients, which are rather immobile in the soil, e.g. P and K, is restricted. Furthermore, root growth decreases with declining pH (Figure 3). The reason is that soluble Al species are formed, whose primary effect is an impairment of root growth. This Al induced root growth depression can be alleviated by adequate magnesium supply (Figure 4).

**Figure 3. Root growth as affected by pH.**

**Figure 4. Mg alleviates Al induced root growth depression.**
The visible Mg deficiency symptoms are chlorosis of the older fronds. Strongest expression of magnesium deficiency occurs during the dry season at high solar radiation and exposure to the sunlight. Therefore, among planters the symptoms are often called heat induced sunburn and are rarely associated with Mg deficiency. The causal effects, however are that under dry conditions Mg mobility in the soil and hence uptake is reduced. Low Mg supply leads to impaired retranslocation and accumulation of starch in leaves and the activation of O₂, resulting in toxic radicals, being responsible for the chlorosis and necrosis of pinnae. “Sunburn” is hence an expression of latent Mg deficiency under high light intensities (Figure 5, 6).

![Figure 5: Mg deficient oil palm.](image)

Omitting Mg application, especially in the immature period generally leads to a drastic decline in leaf Mg contents and to losses in FFB production. This is evident from Figure 7 where clear yield responses to magnesium are observed.

![Figure 7: Changes in Mg levels in frond 17 of palms not receiving any Mg fertilizer (left) and yield response to two levels of magnesium (right).](image)

**Magnesium and oil extraction**

In recent years, when in Malaysia oil extraction rates dropped significantly, more emphasis by planters was attached to agronomic measures enhancing oil formation in oil palm. The importance of magnesium for oil production is evident from the fact that it promotes the oil in the wet pericarp (Figure 9).

![Figure 9: Magnesium promotes oil production in oil palms in Malaysia.](image)

K and Mg are essential for oil extraction. Increasing K application rates omitting Mg may lead to a decline in oil : bunch ratios (Figure 10). However, combined application of Mg and K, leads to highest oil : bunch ratios, even at K application rates larger than usually applied. Therefore, both nutrients are necessary for high oil yield, i.e. bunch production (through K) and high oil formation (through Mg).
Mg sources decide on oil palm productivity

In principle there are three different forms in which magnesium can be applied to the soil. These are the oxide form in magnesium oxide and fused lime stone, the carbonate form in magnesite and dolomite, and the sulphate form in Kieserite and other magnesium sulphates. The physicochemical properties of Mg fertilizers are crucial for their use in oil palm plantations. Among those, solubility in water is probably the most important factor with regard to crops response. Oxides and carbonates have a very low solubility, releasing the Mg at rates, inadequate for high crop uptake and only after intensive mixing with an acid soil. In contrast to these two Mg sources, Kieserite releases its nutrients (Mg + S) independent of soil pH and application technique (no mixing with an acid soil is required for their release).

Figure 11. The effect of bunch ash and magnesium source on soil exch. Mg (cmol·kg⁻¹).

The effect of a typical surface application of the two Mg carriers on soil exch. Mg was studied in oil palm. The results show that dolomite, owing to its poor solubility only increased exchangeable Mg contents of the topsoil layers, whereas substantial Mg from Kieserite penetrated to the lower soil depths (Figure 11).

Figure 12. Distribution of feeder (<2 mm) roots of Norway spruce on an acid forest soil (pH 3.7) as affected by Mg nutrition.

This has a significant effect on root growth as can be shown in a similar experiment with forest trees in Germany (Figure 12).

Kieserite promotes root growth especially in deeper soil horizons, whereas dolomite shows an inhibiting effect, restricting nutrient and water uptake from the subsoil.

This may also explain the results by Mohd Hussin et al. (1998) showing mean effects of dolomite and Kieserite on FFB yields in oil palm over a period of seven years (Figure 13).

Figure 13. FFB yields (t/ha/yr) as affected by Kieserite and GML application on a Rengam series soil (average of 7 years).

In the whole period (1990-97) the normal doses of between 0.12 - 0.36 kg MgO equal to 0.5 - 1.5 kg Kieserite per palm clearly out-yielded the equivalent treatments based on GML. Only at the higher rate of 0.48 kg/palm/year GML seemed to have an advantage over Kieserite. This may be explained by an over-application of soluble Mg without adjusting the K levels in the soil and hence creating antagonistic effects to K, depressing its uptake at the root surface. Matching the availability of K and Mg is hence crucial.
Summary
The generally low inherent Mg supply of most tropical soils in Malaysia and the large requirement of highly productive oil palms on the other hand, are the reasons for the increasing demand for this essential plant nutrient. Its major functions in the plants’ metabolism, including photosynthesis, protein and starch synthesis, furthermore its essential roles in the nutrient uptake and carbohydrate translocation, confirm the vital importance of adequate magnesium supply.

Yield responses to Mg fertilization including FFB and oil yield are generally substantial. Besides adequate supply, the Mg source is crucial. In this respect kieserite proved to be clearly superior to dolomite (GML) though the latter Mg carrier may be an important soil amendment for acid soils complimenting the effect of kieserite.

* Kieserite is a naturally occurring mineral beneficiated by K+S GmbH, Kassel, Germany.

References


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