EFFECTS OF POTASSIUM AND MAGNESIUM ON LEAF AND BARK NUTRIENT CONTENTS OF YOUNG HEVEA BRASILIENSIS

By

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Summary

Leaf and bark analyses provide evidence of uptake of K and Mg from applied K and Mg fertilisers respectively. Efficiency of uptake appears to have however been influenced by the level of applied K and Mg, pre - treatment K and Mg content of the soil and sources of Mg. Significant antagonistic effects between K and Mg fertilisers on leaf K and Mg have been recorded. Both K and Mg fertilisers were also found to decrease the Ca content in the leaf except when dolomite was used as the source of Mg. It appears that bark analyses could also be used as a tool for indicating the K and Mg status of young *Hevea* plants.

Introduction

Leaf nutrient is known to be a reliable indicator of the plant nutrient status (Chapman, 1941; Beaufils, 1955; Shorrocks, 1960, 1962 and 1965; Guha and Narayanan, 1969). As with other crops (Bould, 1966; Yogaratnam 1975; Fremond 1977; Ng, 1977) leaf analysis is valuable as a method for confirming visual diagnosis of symptoms (Chapman, 1941; Bolle Jones, 1956) for assessing the nutritional status of individual stand of rubber trees (Shorrocks, 1961; Yogaratnam and Silva, 1977) and their response to fertiliser applications (Yogaratnam and Perera, 1981; Yogaratnam, Silva and Weerasuriya, 1984)

Since potassium and magnesium related deficiencies have been observed under field conditions in Sri Lanka, this paper attempts to study the effects of potassium and magnesium fertilisers on the leaf and bark nutrient contents with the view of eliminating these disorders.

Experimental

Full details of the three experiments discussed in this paper are given in the previous paper (Weerasuriya and Yogaratnam, 1988). Leaf samples were collected at 6 - monthly intervals (Anon, 1984) and the bark at 1 foot above the bud union at the time of uprooting for analyses of their N, P, K, Ca and Mg concentrations. Nitrogen and phosphorus were determined colorimetrically, potassium, using flamephotometry and calcium and magnesium using atomic absorbtion spectrophotometry (Anon 1971).

Results

Leaf Nitrogen

In experiment 1, applied K and sources of Mg significantly influenced leaf N content at 6 months, but this effect was not recorded at 12 months. At the end of 6 months, application of K showed a quadratic response on leaf N, the increase being significant ($P < 0.05$) at K1 level of potassium (table 1).

Application of Mg in the form of dolomite significantly decreased ($P < 0.05$) leaf N content. Kieserite on the other hand did not have any effect on leaf N content (table 2).

Table 1. Effect of levels of applied K on leaf N content.

Level of K	Leaf N content (%)
K 0	3. 084
K 1	3. 320*
K 2	3. 203
SED	0. 076

Table 2. Effect of sources of applied Mg on leaf N content.

Source of Mg	Leaf N content (%)
Nil Mg	3. 317
Kieserite	3. 211
Dolomite	3. 079*
SED	0. 076

In experiment 2, out of the two assessments done at 6 monthly intervals after the first treatment application, there was a significant interaction ($P < 0.05$) between applied K and clones on leaf N. (fig 1) Application of K at both K 1 and K 2 levels significantly increased leaf N in RRIC 100, but this effect was not observed in the other clones.

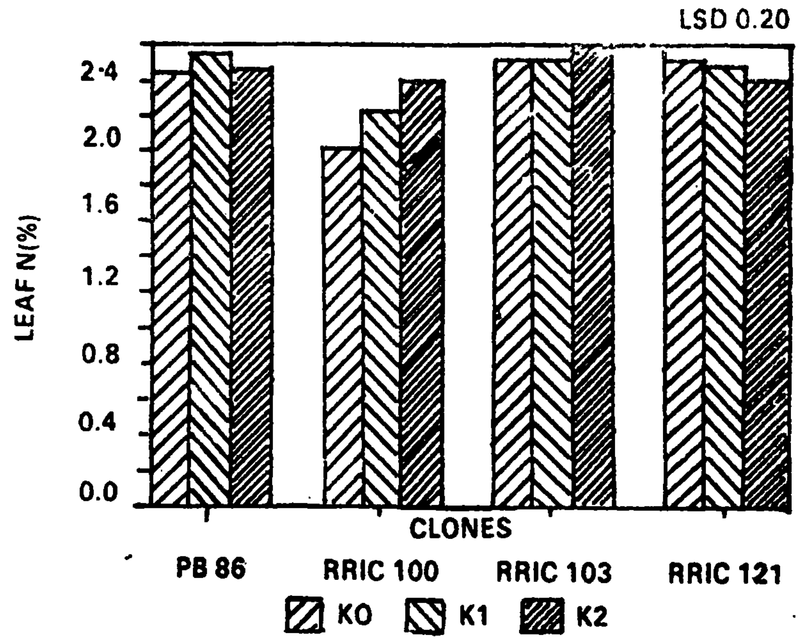

Fig. 1 Effect of levels of applied K on leaf N content of different clones.

In expriment 3. significant effects on leaf N due to applied Mg and K were observed only in the early stages (table. 3). At 10 months, leaf N showed a significant increase ($P < 0.05$). Leaf N level was increased significantly ($P < 0.05$) with the application of K at the second level at 16 months after planting.

Table 3 Effect of applied K and Mg on the leaf N content.

Level	N cotnent (%) Aug 1985	Feb 1986	Aug 1986
Ko	2. 902	2.577	2. 277
K1	3. 050	2.679	2. 329
K2	2. 921	2.731*	2 306
Mg0	2. 973	2.700	2. 325
Mg1	3. 080*	2.616	2, 337
Mg2	2. 900	2.660	2. 199
SED	0. 068	0.051	0. 059

Leaf Phosphorus

In experiments 1 and 3, leaf P content was not affected by applied K and Mg. But in experiment 2, there was a significant decrease in leaf P with the application of Mg at both Mg 1 and Mg 2 levels (table 4).

Table 4. Effect of applied Mg on the leaf P content.

Level of Mg	Leaf P (%)
Mg0	0. 145
Mg1	0. 132**
Mg2	0. 133*
SED	0. 008

Leaf Potassium

At 6 months after planting, there was an interaction between applied

K and clones. (fig. 2) where RRIC 100 showed a quadratic effect while PB 86 showed a linear effect although both clones showed significant increases (Px0 . 001) due to application of K at both K 1 and K 2 levels.

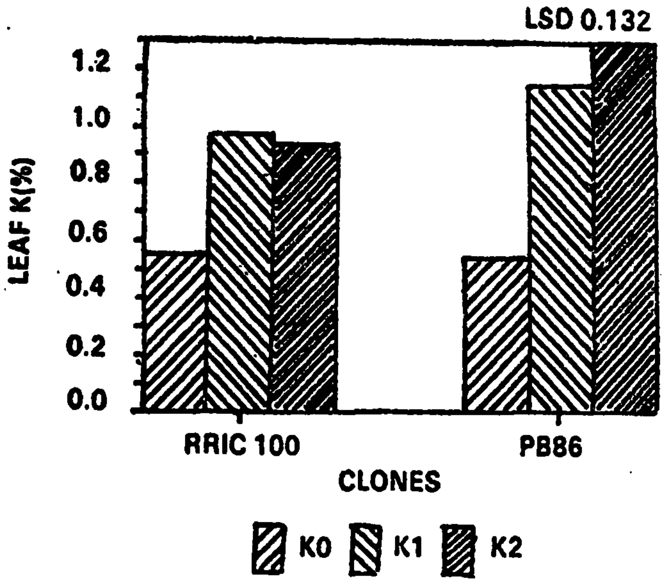

Fig. 2 Effects of levels of applied K on leaf K content of Clones RRIC 100 and PB86

In a similar interaction between applied K and applied sources of Mg both RRIC 100 and PB 86 recorded increases in leaf K content with application of potassium at K 1 and K 2 levels ($P < 0.01$) at 6 months. The differences in effect between K 1 and K 2 however were not significant. Application of Mg irrespective of the source, decreased the leaf K content.

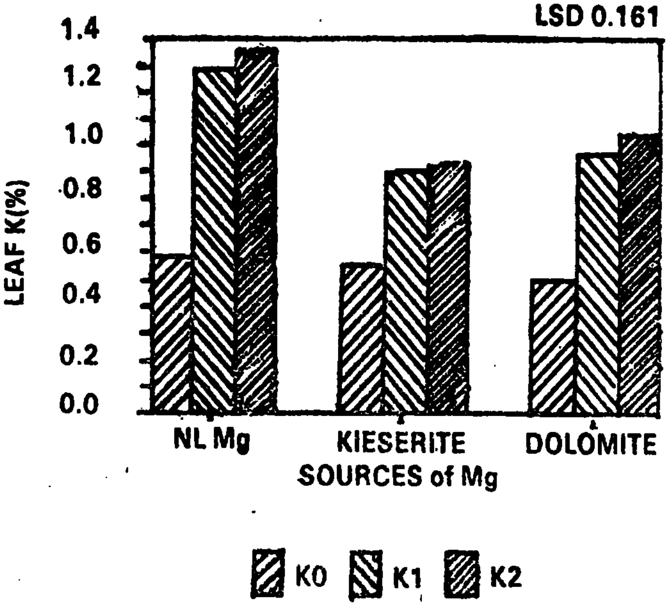

Fig. 3 Effect of levels of applied K and sources of Mg on leaf K content

A significant interaction was also observed between applied K and sources of N viz. urea and ammonium sulphate (fig. 4) on the K content of the leaf where a significant difference between urea and ammonium sulphate was observed at K 0 ($P<0.01$) and K 2 levels. In the absence of K, ammonium sulphate gave a higher leaf K content while at K 2 level urea gave a higher leaf K content. Application of K, irrespective of the source, increased the leaf K content significantly. ($P<0.001$).

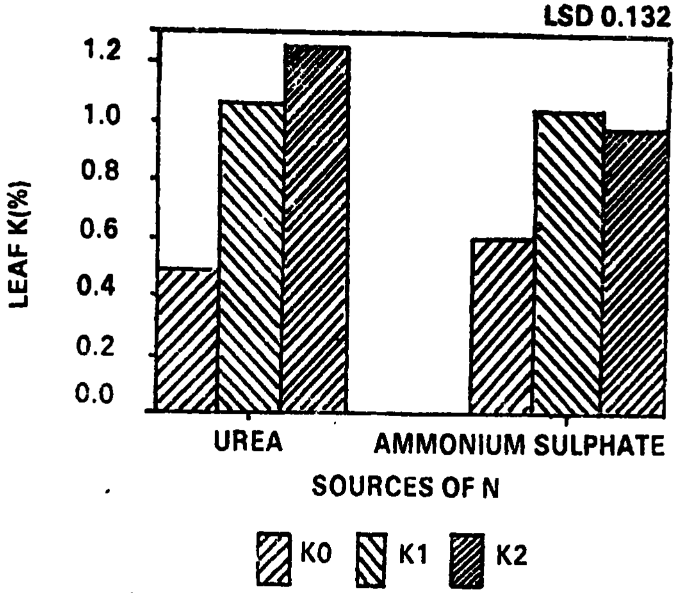

Fig. 4. Effect of levels of applied K and sources of N on leaf K content

At 12 months. an interaction between applied K and clones(fig 5) indicated that in both clones, leaf K content significantly increased with the application of K irrespective of the levels used, but the increase in leaf K was higher in PB 86 than in RRIC 100.

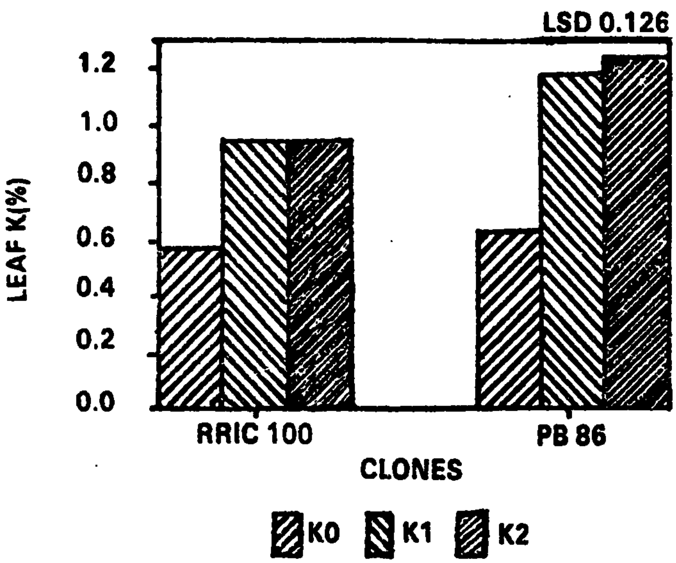

Fig. 5 Effect of levels of applied K on leaf K content of clones RRIC 100 and PB 86.

At 12 months, the interaction between applied sources of Mg and applied sources of N (fig 6) indicated that in the absence of Mg level, application of N in the form of urea significantly increased the leaf K content ($P < 0.01$), but this was decreased ($P < 0.05$) with the application of ammonium sulphate.

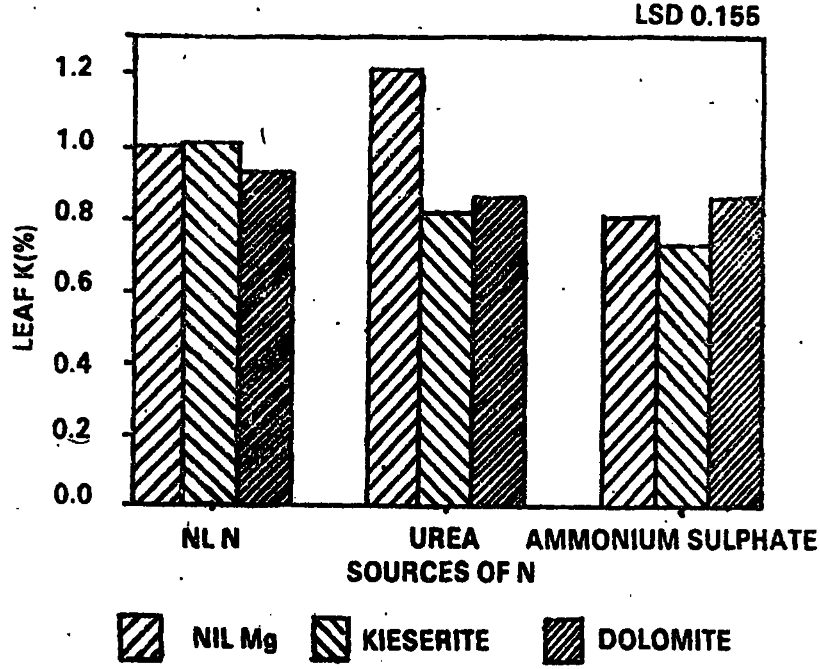

Fig. 6 Effect of applied sources of N and Mg on leaf content

Kieserite when applied with N, irrespective of the source of N, significantly decreased leaf K content ($P < 0.05$ with urea and $P < 0.01$ with ammonium sulphate). However, dolomite did not have any effect· Urea application in the presence of Mg in either forms reduced the leaf K content significantly ($P < 0.01$).

In Experiment 2, a significant interaction ($P < 0.05$) between applied K and clones was observed on leaf K content six months after commencement of the experiment (fig. 7) In all four clones, application of K increased the K content at both K 1 and K 2 levels, in PB 86 a significant difference in leap K content between applied K 1 and K 2 was also observed.

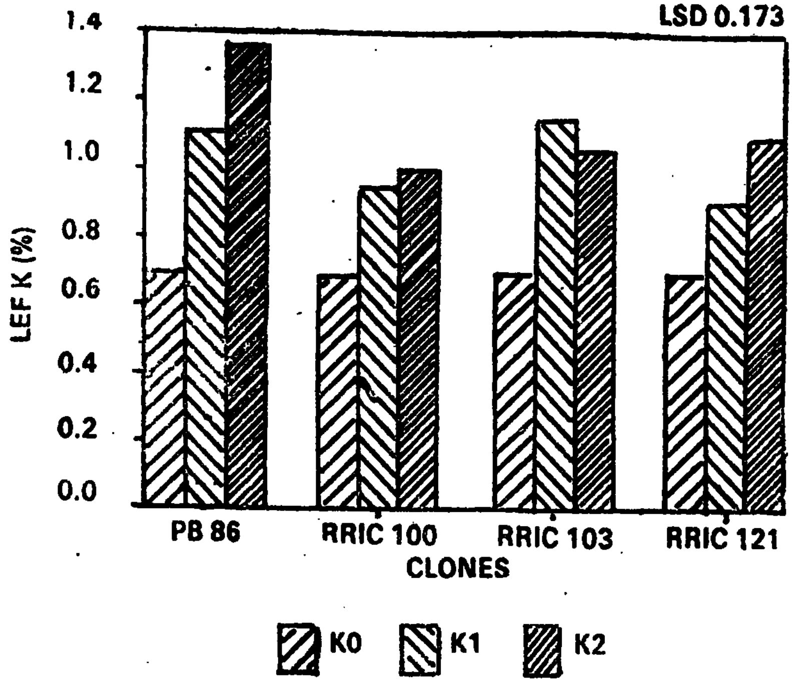

Fig: 7 Effect of levels of applied K on leaf K content of different clones.

At the end of 12 months, a significant interaction ($P < 0.05$) was observed between applied K and Mg on leaf K content. Leaf K content was significantly increased with application of K irrespective of the levels of applied Mg. But the difference in effect between applied levels of Mg, was only significant at K 2 level of applied K.

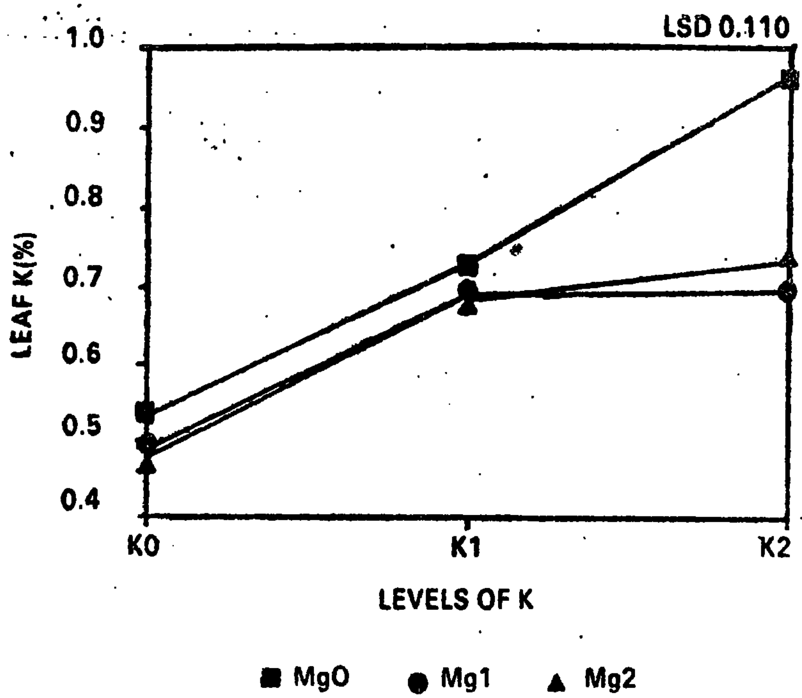

Fig. 8 Effect of levels of applied K and Mg on leaf K content

In the early stages of the experiment 3, leaf K content was influenced only by applied K. However in the latter stages (at the end of 22 months) both applied K and Mg showed significant effects ($P < 0.05$) on leaf K (fig. 9) in the latter stages irrespective of the level of applied Mg, application of potassium at K 1 level significantly increased leaf K. But in the absence of Mg (ie.at the zero level), increasing KI to K 2 level gave significantly higher leaf K value. Application of Mg significantly decreased leaf K content.

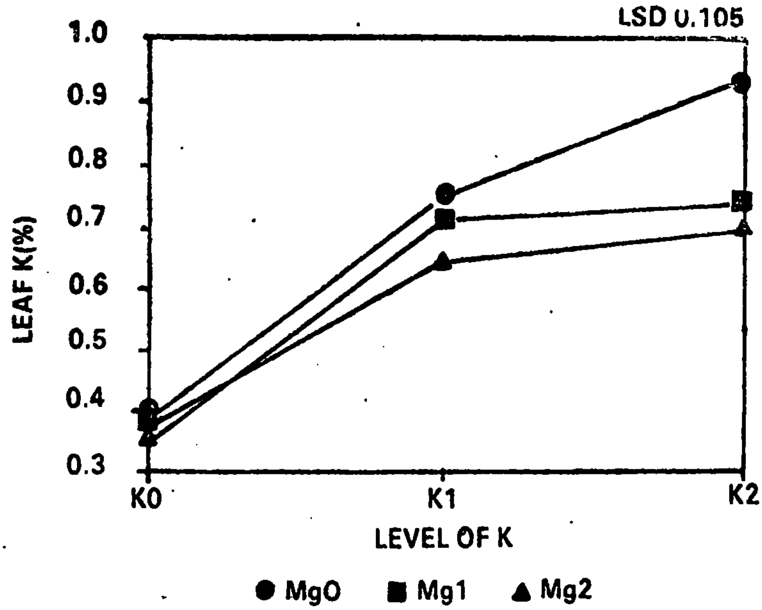

Fig. 9 Effect of levels of applied K and Mg on leaf K content

Leaf Calcium

Leaf Ca content was significantly increased by application of Mg in the form of dolomite ($P < 0.05$) at 6 months in experiment 1. Kieserite did not show any effect (table. 5). These effects were however not seen at the end of 12 months.

In experiment 2, leaf Ca showed a significant increase ($P < 0.01$) with application of Mg at Mg 2 level at 12 months, (table 6)

Table 5 Effect of sources of applied Mg on Leaf Ca content.

Source of Mg	Leaf Ca content (%)
Nil Mg	0. 808
Kieserite	0. 831
Dolomite	0. 991*
SED	0. 066

Table 6 Effect of applied Mg on leaf Mg, Ca and Mn contents·

Level of K	Leaf nutrient contents		
	Mg (%)	Ca (%)	Mn (ppm)
K0	0. 132	1. 460	217. 9
K1	0. 185***	1. 196***	168. 6**
K2	0. 216***	0. 177***	165. 8**
SED	0. 012	0. 101	33. 88

In experiment 3, there was a significant decrease in leaf Ca content (P <0 . 05) with the application of potassium at K 1 level and K 2 level at 16 months after planting although this tendency was seen at 10 and 22 months also but was not significant,

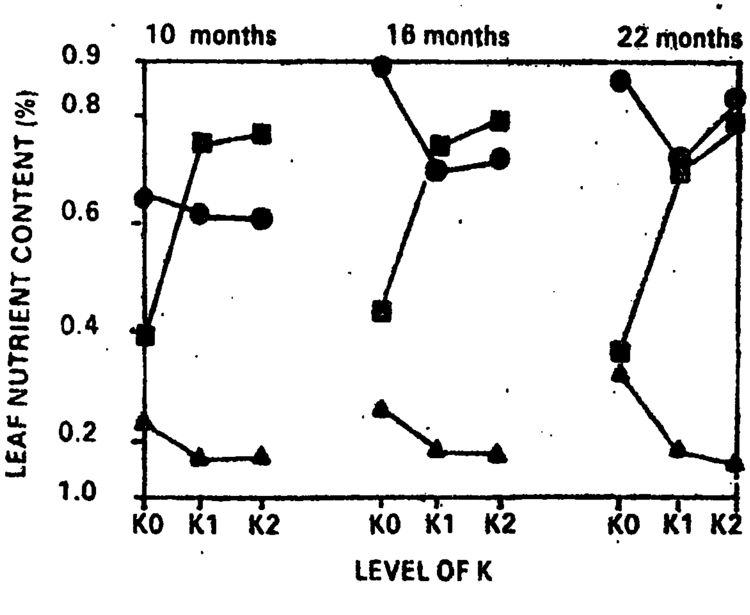

Fig. 10 Effect of levels of applied K and Mg on leaf K Mg and Co content

Leaf Magnesium

A significant (P <0 . 01) reduction in leaf Mg content was observed in experiment 1 due to application of K irrespective of the level, at the end of 6 months (table 7).

At the end of 12 months, significant interactions were observed between applied K and applied sources of Mg ($P < 0.05$) irrespective of the source of Mg applied. Application of K at level 2 significantly decreased leaf Mg content when Mg was not applied.

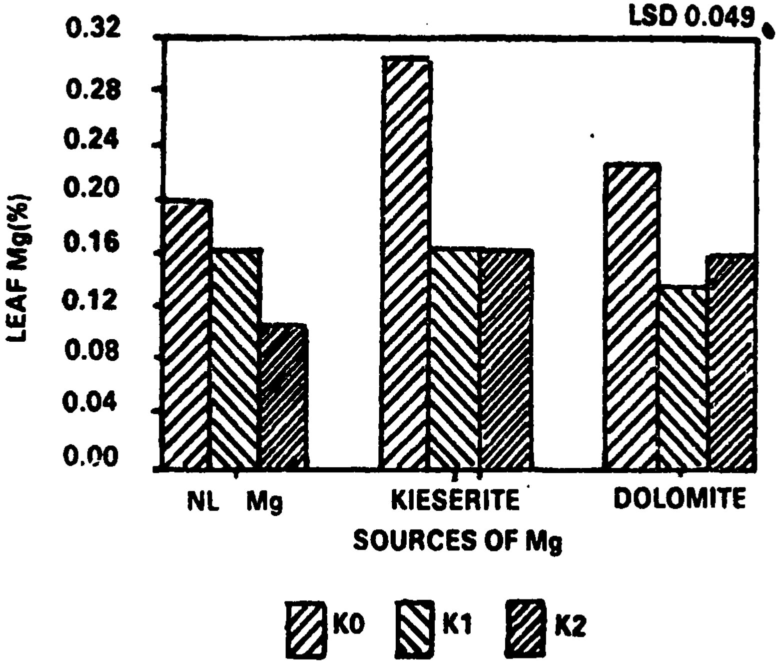

Fig. 11 Effect of levels of applied K and sources of Mg on leaf Mg content

When K was not applied, Mg in the form of kieserite increased the leaf Mg content significantly. But at K 2 level; application of Mg in both forms, kieserite and dolomite, increased the leaf Mg content significantly.

Table 7 Effect of levels of applied K on leaf Mg content.

Level of K	Leaf Mg content (%)
K0	0. 212
K1	0. 108**
K2	0. 101**
SED	0. 032

In another significant interaction ($P < 0.01$) between applied K and sources N of it was observed that when K was not applied, leaf Mg content significantly increased with the application of N in the form of ammonium sulphate ($P < 0.01$). The difference in Mg content between applications of ammonium sulphate and urea was also significant ($P < 0.15$). Irrespective of the source of nitrogen, application of K at both K1 and K2 levels decreased the leaf Mg content significantly ($P < 0.01$). At K2 level urea showed a significant decrease ($P < 0.01$) in leaf Mg content in comparision with ammonium sulphate.

At 12 months after planting, application of Mg increased the leaf Mg content both at Mg 1 and Mg 2 levels ($P < 0.001$). (table 6). Leaf Mg content was significantly decreased ($P < 0.001$) with the application of K at both levels (table 8).

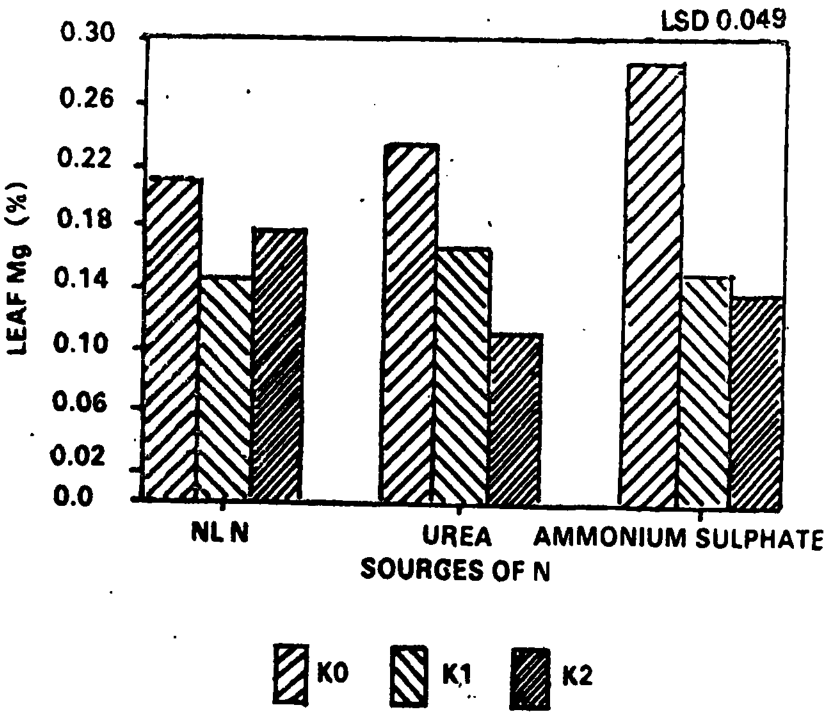

Fig. 12 Effect of levels of applied K and sources of N leaf Mg content

Table 8 Effect of applied K on leaf Mg content.

Level of K	Leaf Mg content (%)
K0	0 229
K1	0 151***
K2	0. 153***
SED	0. 012

At 10 and 16 months after planting in experiment 3, applied K and Mg both showed significant effects on leaf Mg content (table 9). Application of K at K 1 level significantly ($P<0.001$) decreased the leaf Mg level (fig. 10) and no further decrease was observed when K was increased to K 2 level. These effects were observed irrespective of the level and source of Mg.

On thc other hand, application of Mg at Mg 1 level increased leaf Mg content significantly ($P<0.001$)) and no further increase was observe at Mg 2 level of applied magnesium, irrespective the source of Mg used.

Table 9 Effect of applied K and Mg on leaf Mg content.

Level	Mg content (%)		
	Aug 1985	Feb 1986	Aug 1986
K0	0. 239	0. 268	0. 328
K1	0. 173***	0. 193***	0. 196***
K2	0. 177***	0. 183***	0. 163***
Mgo	0. 161	0. 164	0. 156
Mg1	0. 211**	0. 232***	0. 254***
Mg2	0. 217***	0. 246***	0 276***
SED	0. 014	0. 015	0. 018

However at 22 months, there was a significant interaction between K and Mg ($P<0.01$) on leaf Mg content and this effect was independent of the source of Mg applied. The increase in leaf Mg with applied Mg varied with the level of K, recording the highest leaf Mg content at the highest level of Mg (Mg 2) in the absence of K (fig. 13).

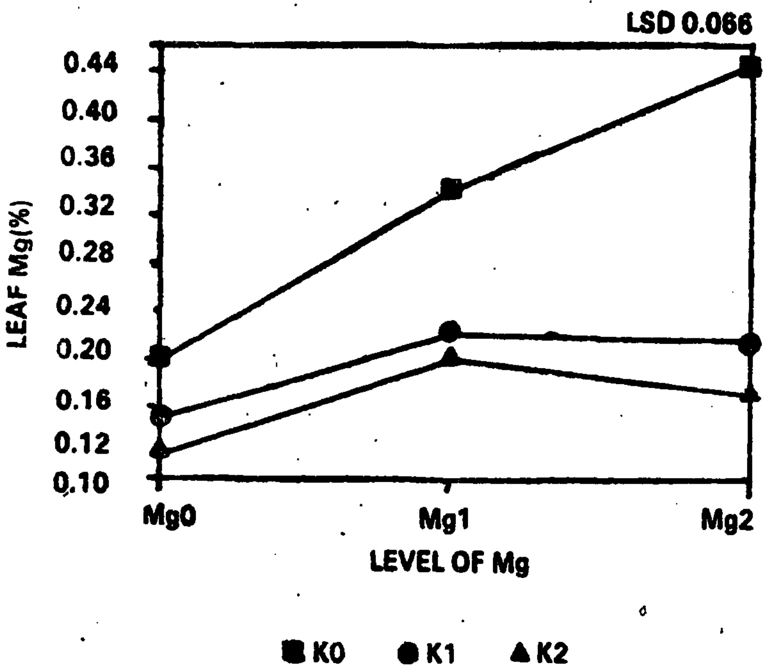

Fig. 13 Effect of levels of applied K and Mg on leaf Mg content

Bark Nitrogen

With the application of Mg in all forms, the bark N content was significantly decreased in experiment 1 ($P < 0.001$ with kieserite and $P < 0.05$ with dolomite) and also there was a significant difference ($P < 0.05$) in bark N between Dolomite and Kieserite where Kieserite showed a significantly greater reduction than Dolomite (table 10).

In experiment 2, bark N content was not affected by the application of K and Mg either K or Mg.

Bark Phosphorus

The bark phosphorus contents in experiments 1 and 2 were not affected by treatments.

Bark Potassium

In experiment 1. bark potassium showed a significant interaction ($P < 0.001$) between applied K and applied sources of N (fig 14).

With the application of K at both K 1 and K 2 bark K was increased significantly in the absence of N and with both sources of N ($P < 0.001$). At K 1 and K 2 levels of potassium, application of N in the form of urea increased the leaf K content significantly ($P < 0.001$ at K 1 level and $P < 0.01$ at K 2 level). When K was not applied application on urea decreased the leaf K content ($P < 0.05$), where as ammouium sulphate significantly increased it at K 1 and K 2 levels ($P < 0.001$ and $P < 0.01$ respectively).

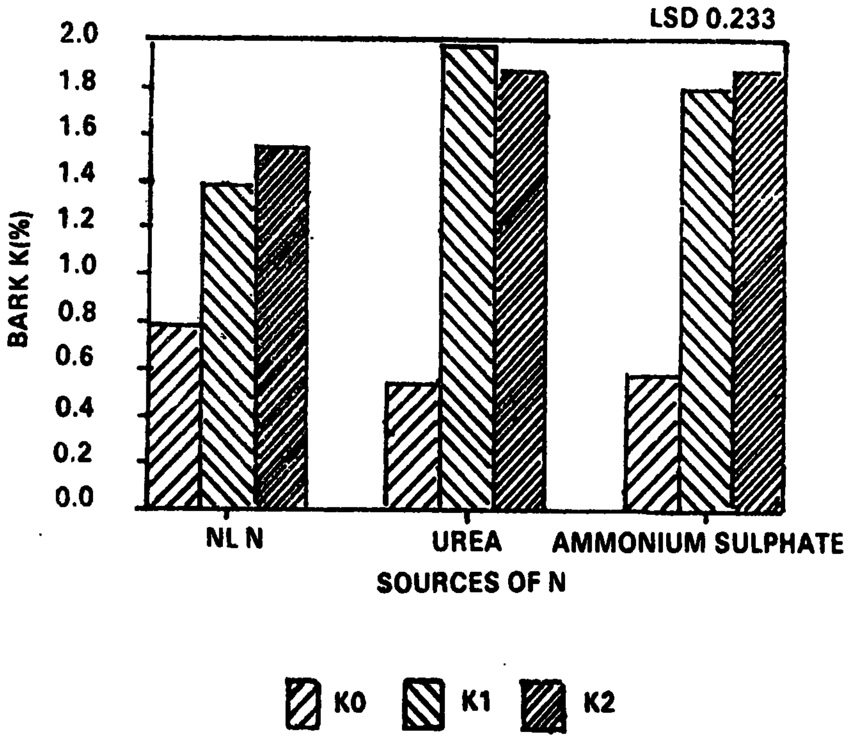

Fig. 14 Effect of levels of applied K and sources of N of bark K content

Table 10 Effect of sources of applied Mg on bark N content.

Source of Mg	Bark N content (%)
Nil Mg	0. 897
Kieserite	0. 807***
Dolomite	0. 852*
SED	0. 022

Bark K content was significantly increased with the application of K at both levels in experiment 2. (table 11) and reduced (P <0 . 001) by the application of Mg at both levels, Mg 1 and Mg 2 (table 12).

Bark Magnesium

Application of K and sources of Mg did not have any effect on bark magnesium content in experiment 1.

In experiment 2, application of K at both levels significantly decreased (P <0 . 001) bark Mg content (table. 11). Bark Mg content was increased significantly with application of magnesium at Mg 1 and Mg 2 levets (P <0 . 001) table. 12).

Table 11 Effect of applied K on black K, Mg and Ca contents.

Level of K.	Bark nutrient contents (%)		
	K	Mg	Ca
K0	0. 752	0. 328	2. 391
K1	1. 541***	0. 221***	1. 990**
K2	1. 718***	0. 223***	1. 946**
SED	0. 069	0. 018	0. 137

Table 12 Effect of applied Mg on bark K and Mg content.

Level of Mg	Bark nutrient content %	
	K	Mg
Mg0	1. 496	0. 165
Mg1	1. 263**	0. 280***
Mg2	1. 251***	0. 327***
SED	0. 069	0. 018

Bark Calcium

Bark Ca content was significantly decreased (P <0 . 01) with the application of K at both K 1 and K 2 levels in only experiment 2 (table.,11).

Disscussion

The leaf analyses provide abundant evidence of the uptake of potassium and magnesium fertilisers as reported by other workers (Yogaratnam and de Mel, 1986). Efficiency of K uptake by immature plants appears to have been influenced, as expected, by the level of applied potassium, the pre - treatment potassium content of the soils and the levels of magnesium applied. Similarly, magnesium uptake has also been influenced by the levels and sources of magnesium and levels of potassium applied. The well known antagonism between potassium and magnesium on leaf potassium and magnesium (Agboola and Corey, 1973, Terman et al. 1975) is clearly shown in this study also. In the field experiment, samples collected 22 months after planting showed that application of potassium at K1 level increased the leaf potassium content irrespective of the levels of applied magnesium, but at K2 level application of magnesium decreased the leaf potassium content suggesting that the antagonistic effects between potassium and magnesium on potassium uptake existed only at K2 level of applied potassium. But, with regard to the antagonism on leaf Mg content, the depressive effect on leaf Mg content due to application of K was seen even when Mg was applied at Mg2 level. It is also possible that whenever there had been increases in the Mg content in the leaf and the K content of the soil had been rather low as indicated by the pre - treatment soil K values, the antagonistic effect on leaf Mg level may not be seen. (Kumar et al., (1981) and Naiwal et al., (1985).) However such suggestions can only be substantiated under sand culture conditions. Moreover, it also suggested that soil K was very high doses of Mg may have to be applied to counteract the depressive effect of high levels of K in the soil on leaf Mg content. As the recognised visual symptoms of potassium and magnesium deficiency were seen at the very early stages of the experiment in the plots that did not receive either potassium or magnesium, it was not suprising that significant responses in terms of increase in the potassium and magnesium contents were observed within a very short period following the application of the respective fertilisers.

Both potassium and magnesium fertilisers were also found to decrease the Ca content in the leaves except when dolomite was used as the source of Mg. It is generally believed that the plants try to keep the sum of cations K, Ca, Mg and Na fairly constant (Ologunde and Sorensen, 1982). Therefore when potassium and magnesium contents increase, other cations may get decreased. Dolomite application on the other hand, increased the calcium content in the leaf, possibly due to the presence of approximately 35% CaO in it. Therefore where high levels of Ca in the tree are considered undesirable, as in the case of mature rubber due to the known pre-coagulating effect of Ca on latex, the desirability of using this fertiliser as a source of mg, will have to be further investigated.

It has also been possible to increase the bark K and Mg contents with the application of the respective fertilisers in a manner similar to that with leaf nutrient content. This aspect is of great significance to growing rubber as latex production depends on the rate of growth and thickness of the virgin bark during the early stages of the productive period and on the rate of bark renewal in the latter part of the cycle. It also appears possible to use bark analysis as a tool to assess the K and Mg status of young *Hevea* trees.

Acknowledgement

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