Plate 102: Young and healthy plant showing light green leaves that have a soft texture.

Plate 103: Slightly older plant with similar light green leaves that have a soft texture.

Plate 104: Close-up of leaflets showing the soft 'matt' appearance

Plate 105: Close-up of a healthy growing point with a newly emerging leaf.

Nitrogen (N) Deficiency

Symptoms

Symptom development is quite rapid when nitrogen supply becomes limiting. Growth slows down quickly and the stems become thin and spindly.

In striking contrast to most other species where the symptoms appear firstly on older leaves, in *Cedrela odorata* the symptoms always appear first on the youngest leaves. Generally, the leaves turn pale green then yellow with younger leaves more severely affected than older leaves. At this early stage of deficiency it is difficult to discriminate between nitrogen and sulphur deficiency (compare also with iron deficiency). With mild deficiency, the older leaves remain quite dark green and only the newly developing leaves show signs of chlorosis. As the deficiency becomes more severe, the chlorosis is more pronounced and the older leaves also lose colour. Newly developing leaves may have less chlorosis than older leaves at this stage; however, chlorosis within a leaflet may not be uniform—typically the terminal leaflets are more chlorotic than those closer to the leaf stalk.

Occurrence likely

- Mineral soils low in organic matter, with a neutral to alkaline pH, and where organic matter has been depleted and is not being replaced.
- Where large amounts of organic matter with a high C:N ratio have been incorporated; this may cause only a transient deficiency.
- Light-textured soils (eg sands, sandy loams) where rainfall is high and soils can be easily leached.

Occurrence highly unlikely

- Peat soils recently limed for the first time.
- Soils where large amounts of organic matter with low C:N ratio have been recently incorporated.
- Clay soils (with smectite minerals) with a recent history of ammonium fertilisation or ammonification of organic matter.

Plate 106: Nitrogen-deficient plants on left; nitrogen supply increases to the right. The nitrogen-deficient plants are slightly smaller and noticeably more chlorotic. Interestingly this chlorosis first appears in the younger leaves with the older leaves remaining green. This is in contrast to the pattern described for many agricultural crops.

Plate 107: Close-up of deficient and healthy plants. Notice that the colour of the old leaves is similar, irrespective of nitrogen status but the young leaves are chlorotic in the nitrogen-deficient plant on the left.

Plate 108: Nitrogen-deficient plant showing how the deficiency develops. As the chlorosis becomes more intense, it spreads to more leaves.

Plate 109: Severe nitrogen deficiency in the seedling on the left compared with a healthy plant on the right. Note the development of a strong chlorosis affecting most of the leaves on the severely deficient plant.

Plate 110: Nitrogen-deficient seedling where the chlorosis appears to be more severe in the older leaves with some of the newly emerging leaves being quite green.

Plate 111: As deficiency progresses and leaf senescence occurs, some of the younger leaves may appear green.

Plate 112: A close inspection of the leaves of plants in Plate 111 shows that, although some parts of these new leaves are green, other parts are chlorotic.

Plate 113: Severely nitrogen-deficient seedling where most of the leaves have died and fallen off. The few new leaves that are able to develop can be quite green.

Phosphorus (P) Deficiency

Symptoms

Apart from affecting the size of plants, phosphorus deficiency has few other visual effects that can be used reliably to diagnose the deficiency, except under extremely severe conditions. This is in marked contrast to most other species in which symptoms such as darkening of leaves or reddening/purpling of petioles are commonly reported.

Seedlings lacking phosphorus grow slower than healthy seedlings, but there is no difference in appearance between phosphorus-deficient and healthy seedlings.

When phosphorus is withheld for some time, the whole shoot loses some of its green colour but not in a way that might be a useful indicator without a healthy plant as a reference.

Only in the case of extreme P deficiency is there some development of symptoms in mature leaves that could be a useful guide (see Plate 119 onwards). These symptoms include some necrosis, leaf loss and leaf curling. However, if there is *a priori* knowledge of growth rates and history of the plants, phosphorus deficiency might be considered as one possibility when there are no symptoms but plants are not growing at the expected rate.

Occurrence likely

Phosphorus is one of the most widespread deficiencies in tropical soils. It is more likely to occur in:

- Mineral soils low in organic matter.
- Highly weathered, aluminium- and iron-rich acid soils (eg old soils from basalt) where phosphate is fixed in less available forms.
- Acidic soils that contain allophane (eg volcanic ash soils) or kaolinite clays.
- Alkaline soils high in calcium and magnesium where the phosphate may be tied up in insoluble phosphates.
- Leached quartz sand, and peat soils.
- Soils where the topsoil has been lost through erosion.

Occurrence highly unlikely

- Soils recently converted from agriculture (where P fertilisers were used).

Plate 114: Note the substantial reduction in growth in the phosphorus-deficient plant on the left in both photographs. Plants are approximately two months old.

Plate 115: Close-up of phosphorus-deficient plant from Plate 114. In spite of the growth reduction, there are no diagnostic symptoms.

Plate 116: Even in older plants there is little to distinguish a phosphorus-deficient plant (above) from a healthy plant (below).

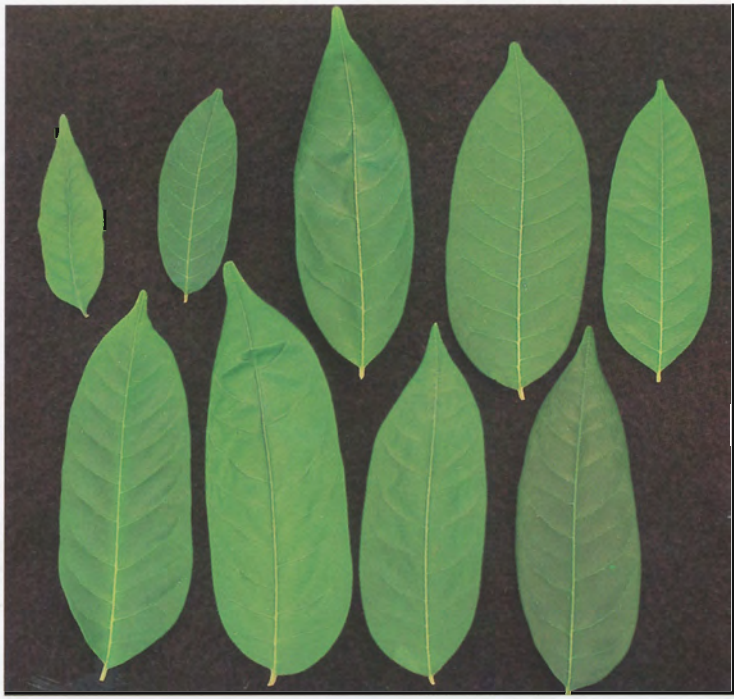

Plate 117: Young leaves from plants similar to those shown in Plate 116. Apart from an obvious difference in size there is no other symptom of phosphorus deficiency. Top left to bottom right: 0, 25, 50, 100, 150, 200, 250, 500, 1000 mg P added / kg soil.

Plate 118: Youngest mature leaves from plants similar to those shown in Plate 117. Apart from an obvious difference in size there is no other symptom of phosphorus deficiency. Top left to bottom right: 0, 25, 50, 100, 150, 200, 250, 500, 1000 mg P added / kg soil.

Plate 119: Old leaves from plants similar to those shown in Plate 116. Only in these old leaves is there any visual symptom, apart from a reduction in size, that might be an indication of a nutritional disorder. Top left to bottom right: 0, 25, 50, 100, 150, 200, 250, 500, 1000 mg P added / kg soil.

Plate 120: When the deficiency is severe or prolonged some symptoms develop on the old leaves with the remainder of the plant appearing quite healthy.

Plate 121: Close-up of leaves from plant in Plate 120. Note the development of necrotic patches with little or no associated chlorosis.

Plate 122: As the deficiency becomes severe, the older leaves die and fall off while the leaflets on the remaining young leaves become stiff and curl downwards.

Potassium (K) Deficiency

Symptoms

As potassium becomes deficient, young seedlings grow more slowly and stems become thin and spindly.

Potassium deficiency affects older leaves more severely than younger leaves. The first sign of potassium deficiency is a slight chlorosis in the middle of the blade of older leaves. This is followed by a marginal chlorosis in the youngest mature leaves which eventually develops into a strong interveinal chlorosis. Although the leaflets develop a severe chlorosis, the bases of the leaflets remain green. When the deficiency becomes more severe, the tips of the leaflets become necrotic, but their bases remain green. By this stage the young leaves are starting to show some chlorosis. Some older leaves develop small and distinct necrotic patches in the mid-region of the leaflets.

Occurrence likely

- Highly weathered mineral soils low in organic matter.
- Light-textured soils (eg sands and sandy loams) formed from parent material low in potassium (eg sandstone, limestone and some granites).
- Mineral soils where the original potassium has been leached by heavy rainfall.

Occurrence highly unlikely

- Potassium deficiency is unlikely in **young** soils formed from parent material that is rich in potassium, eg soils from igneous rocks.

Plate 123: A young seedling in the early stages of potassium deficiency. There is little effect on the youngest mature leaf (a). However, a slight pale yellow chlorosis develops in the middle of the leaf between the secondary (b) and tertiary (c) veins of older leaves.

Plate 124: Close-up of the youngest mature leaf showing the chlorosis that appears on the leaf margins as the deficiency becomes more severe.

Plate 125: Close-up of the leaves showing another feature of potassium deficiency. The base of the leaflet remains green while the rest loses colour.