Plate 126: Close-up of older leaves of a potassium-deficient plant showing the characteristic green area at the base of the leaflet.

Plate 127: Close-up of leaves from the same plant showing the progression of symptoms from youngest to older leaves. Even when the deficiency becomes quite severe, young leaves are little affected (a). However, youngest mature leaflets are now showing much more severe chlorosis but the base of the leaflet remains green (b). By this stage mature leaves have become severely chlorotic as well as developing necrosis of leaf tips. Again note the green base of leaflets (c). Old leaves are now severely chlorotic (d).

Plate 128: Close-up of leaves from the same plant suffering from severe potassium deficiency. The young leaves are starting to develop a slight chlorosis (a). The youngest mature leaf becomes more chlorotic but the base of the leaflets remains green (b). The middle-aged leaves become severely chlorotic (c). Other middle-aged leaves show a different pattern of tip necrosis (d). Old leaves show severe chlorosis (e).

Plate 129: Old leaves from a severely potassium-deficient plant. Note the development of distinct localised necrosis.

Calcium (Ca) Deficiency

Symptoms

Calcium-deficient seedlings stop growing and develop short, stout stems. The roots become short and thickened, and growth of the lateral roots ceases, giving the root system an overall stumpy appearance.

On the stem, calcium deficiency appears firstly in the emerging leaves which become either twisted or cupped. In older leaves, a pale yellow chlorosis develops at the leaf tip, but the chlorotic area quickly dies and turns a pale brown, so that the region of chlorosis is usually quite narrow (compare with potassium deficiency). In some leaves, the terminal leaflet withers and dies, often quite rapidly so that at times the leaves appear flaccid.

Occurrence likely

- Acid coarse-textured soils (eg sandy soils from granites) in the humid tropics where the original calcium has been removed by heavy rainfall.
- Strongly acid peat soils where total calcium is low.
- Alkaline sodic soils where high pH and high exchangeable sodium depresses the uptake of calcium.
- Many humid tropical soils where the pH is less than 4.5 and soluble aluminium is high and exchangeable calcium is low.

Occurrence highly unlikely

- Calcareous soils (eg those derived from coral or limestone).
- Soils in arid regions.

Plate 130: Close-up of young developing leaves showing the first signs of calcium deficiency. Note the twisting (a) or cupping (b) of the leaves.

Plate 131: Older leaves of calcium-deficient plants develop chlorosis of the leaf tips that is followed by necrosis of tips as the chlorosis extends along the leaf.

Plate 132: As calcium deficiency becomes more severe, the young leaflets become strongly curved and the terminal leaflets and that portion of the rachis die.

Plate 133: Middle-aged leaves from a calcium-deficient plant. The tips of the leaflets become necrotic with a distinct, sharp boundary between necrotic and healthy tissue and a small (if any) region of chlorosis (a, b). In some leaves (c), the terminal leaflets die and fall off.

Plate 134: Older leaves from a calcium-deficient plant where the necrosis is much more developed.

Plate 135: On some middle-aged leaves, calcium deficiency causes the leaves to appear flaccid as well as necrotic.

Magnesium (Mg) Deficiency

Symptoms

The growth of magnesium-deficient seedlings slows down and the stems become spindly.

The first symptom to appear on the shoots is a pale yellow chlorosis which begins as a mild interveinal chlorosis on young leaves, becoming more severe as the leaves age. On older leaves, small brown spots appear which become larger and more diffuse and eventually turn necrotic. These brown necrotic patches then turn white and coalesce to form large areas of white necrosis within the interveinal areas of the leaf.

Occurrence likely

- Coarse-textured acid soils (eg sandy soils derived from granites) in the humid tropics where the original magnesium has been removed by leaching.
- Strongly acid peat soils where total magnesium is low.
- Soils that have been over-fertilised with calcium (eg over-limed), potassium or ammonium, thus inhibiting the uptake of magnesium.

Occurrence highly unlikely

- Soils derived from parent material high in magnesium, (eg serpentine).

Plate 136: Leaves from magnesium-deficient plants. Magnesium deficiency starts as a mild interveinal chlorosis (a), becoming more severe as these young leaves age (b, c).

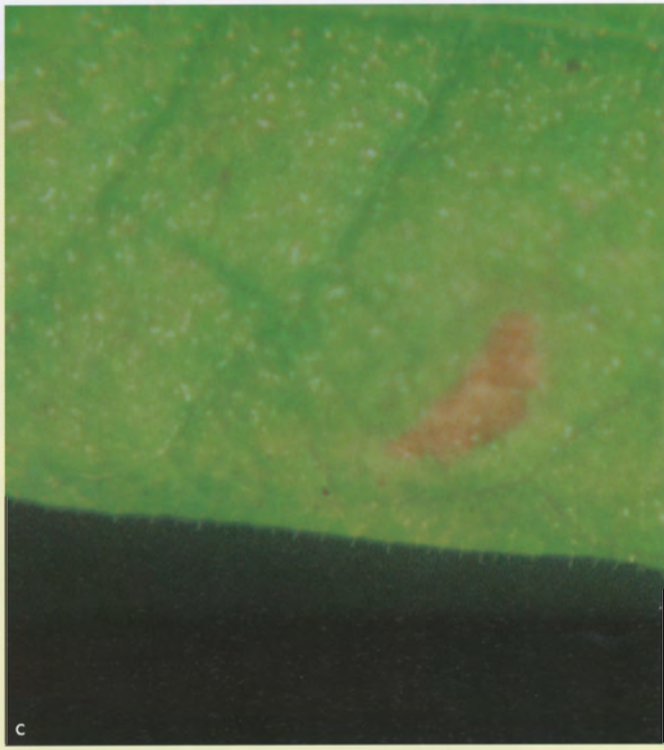

Plate 137: Older leaves from magnesium-deficient plants. Note the development of brown spots on the leaves (a). These spots become larger and more diffuse (b) and eventually turn into a necrotic patch (c).

Plate 138: Close-up of leaves showing how the necrosis turns to white patches of various sizes as the deficiency becomes more severe. These patches are still mainly within the interveinal areas of the leaflets.

Plate 139: Older leaves from a magnesium-deficient plant showing how the patches are similar to those in younger leaves but may begin to join up (b). In both younger leaves and old leaves these white patches have a sharp boundary with very little brown and no yellow surrounding the patch except where the entire leaf is chlorotic (see upper left leaflet in b).

Plate 140: Close-up of the oldest leaves which developed before the deficiency was severe. Note the development of a general chlorosis with only a small number of necrotic patches.

Plate 141: A young seedling suffering from magnesium deficiency. Note that the entire plant appears spindly and weak with many of the leaves lost.

Sulphur (S) Deficiency

Symptoms

Symptoms develop rapidly when sulphur is omitted from the nutrient supply. Within two weeks seedlings stop growing, become very spindly, and develop an overall pale green to pale yellow appearance. The younger leaves become pale green to yellow and the older leaves initially remain dark green. The yellow chlorosis is uniform across the leaf blade and veins but may vary along the length of the leaf or even the leaflet. This pattern of symptom development is similar to that found in other species. At this early stage it is difficult to discriminate between nitrogen and sulphur deficiency, as the patterns of development are similar. This is unusual in that, in other species, nitrogen deficiency generally affects older leaves first (see nitrogen deficiency). As the deficiency becomes more severe, the older leaves also become chlorotic and develop necrotic areas on the tips of each leaflet.

Occurrence likely

- Acid sandy soils in the humid tropics where the original sulphur has been leached by heavy rainfall.
- Coarse-textured soils (eg sandy soils) low in organic matter.
- Soils formed from parent material low in sulphur (eg from volcanic rocks and ash).

Occurrence highly unlikely

- Soils high in decomposing organic matter.
- Soils where atmospheric inputs could be high (such as soils adjacent to coal-burning industries, major cities, oceans, or marshes), especially calcareous soils or soils high in aluminium and iron hydrous oxides (eg highly weathered basalts).