Calcium (Ca) deficiency (blossom end rot)

**Signs:** Emerging leaves appear scorched and distorted, and may cup downwards as leaf margins fail to expand fully. Blackening and sometimes death of growing points. Fruits develop a sunken, black or dark leathery patch that may enlarge to cover the entire blossom end of fruit. Small to large cracks on and around the blossom end are evident on some varieties.

**Cause/favoured by:** Deficiency of calcium or insufficient uptake and translocation of calcium to growth points. Can occur when plant is rapidly growing and calcium requirements cannot be met. Both very low and high soil moisture can inhibit calcium uptake and cause nutrient imbalances (e.g. excess nitrogen, high potassium or insufficient boron). More commonly found in acidic soils with a pH less than 5.5.

**When to look:** During vegetative growth, look for leaves that are scorched, distorted or cupped downwards. During fruiting stages, signs become evident on blossom end of fruit.

**Quick correction:** Increase the rate, frequency and timing of calcium nutrition using foliar sprays or fertigation with calcium nitrate or other calcium fertilisers. Consider boron nutrition in conjunction with calcium to provide a balanced remedy.

**Useful information:** Soil test results: optimal calcium levels of 65–80% of total cation exchange capacity and a calcium:magnesium ratio of 1:1–6:1. Excess calcium can inhibit boron, manganese, zinc and iron uptake.

**Prevention:**

- Check soil pH and calcium levels during land preparation and before planting. Correct acid soils by applying lime. Correct alkaline soils with acidifying or sulfate forms of fertilisers (e.g. sulfate of ammonia, sulfate of potash).
- Maintain adequate soil moisture levels and avoid high levels of nitrogen.
- Apply calcium nutrition regularly during crop growth from early flowering through fruiting to harvest.
- Check calcium levels, and check that nitrogen levels are in balance with other nutrients, using a petiole sap test of the youngest mature leaves during early stages of crop growth.
Disorders

Tomato—schorched appearance

Tomato—end rot in green fruit (C. Chen)

Tomato—end rot in red fruit (C. Chen)

Tomato—sunken black rot in blossom end of fruit

Capsicum—sunken black rot in blossom end of fruit

Chilli—sunken black rot in blossom end of fruit (C. Ma)

Eggplant—end rot
Iron (Fe) deficiency

**Signs:** The youngest leaves develop a light-green chlorosis of all tissue between the veins. This produces a distinctive pattern formed by the midrib and veins, which initially remain green. If the condition is severe and persistent, chlorosis becomes more yellow or even bleached white, and burnt patches develop within the chlorotic areas.

**Cause/favoured by:** Iron deficiency is also known as iron-induced or lime-induced chlorosis because it often occurs in crops grown in calcareous soils where the alkaline soils (high pH) makes iron unavailable. It may also occur in soils that have free lime or a limestone layer that the plant roots grow into. Soils with a high watertable and low soil temperatures may add to the problem.

**When to look:** Check soil pH and iron levels with a soil test during land preparation. Observe all growth stages up to and during harvest.

**Quick correction:** Increase the rate, frequency and timing of iron nutrition by using foliar sprays with iron chelate, iron sulfate or other iron nutrients.

**Useful information:** None

**Prevention:**
- Reduce alkaline (high pH) soils to below pH 7.5.
- Check iron levels, and check that nitrogen levels are in balance with other nutrients, using a petiole sap test of the youngest mature leaves during early stages of crop growth.
Tomato—light green chlorosis

Tomato—veins remain dark green (I. Walker)

Tomato—affects youngest leaves

Tomato—chlorosis becomes yellow or white in severe cases

Tomato—not all plants are affected (I. Walker)
Magnesium (Mg) deficiency

**Signs:** Bright yellowing of older leaves that spreads from the tips and margins towards the main veins, often leaving a green triangular area near the base of the leaf.

**Cause/favoured by:** More likely to occur in acidic and light-textured or sandy soils. May also occur when potassium or calcium levels become too high through the overuse of potassium fertiliser, or after heavy applications of agricultural lime.

**When to look:** Check magnesium levels with a soil test during land preparation. Observe all growth stages up to and during harvest.

**Quick correction:** Increase the rate, frequency and timing of magnesium nutrition using foliar sprays or fertigation with magnesium sulfate or other magnesium nutrients.

**Useful information:** Optimal soil test magnesium levels are 10–15% of cation exchange capacity.

**Prevention:**

- Check soil pH and magnesium levels before planting. Correct acid soils by applying dolomite (calcium magnesium carbonate) or magnesite (magnesium carbonate, MgCO$_3$).
- Check magnesium levels, and check that nitrogen levels are in balance with other nutrients, using a petiole sap test of the youngest mature leaves during early stages of crop growth.
Tomato—bright yellowing of older leaves

Tomato—veins remain green (C. Chen)

Tomato—veins remain green (C. Chen)

Tomato—veins remain green (C. Chen)

Capsicum—yellowing starts from tips

Capsicum—often leaving green base of leaf
Manganese (Mn) deficiency

**Signs:** Young tomato leaves develop a net-like pattern, where major and minor veins remain green and the tissue between the veins becomes progressively more yellow. Chlorosis due to manganese deficiency tends to be more of a progression from pale green to yellow, rather than to the whitish-cream colour found with severe iron deficiency. A strip of pale-green tissue surrounds the veins in the case of manganese deficiency.

**Cause/favoured by:** Rapid growth and alkaline soils.

**When to look:** Check manganese levels with a soil test during land preparation. Observe all growth stages up to and during harvest.

**Quick correction:** Increase the rate, frequency and timing of manganese nutrition using foliar sprays with manganese sulfate or other manganese nutrients.

**Useful information:** Manganese, like iron, is less available in high-pH calcareous soils. Heavy liming, especially of light sandy, poorly buffered soils, sometimes produces mild to moderate signs in tomato crops.

**Prevention:**
- Check manganese levels, and check nitrogen levels are in balance with other nutrients, using a petiole sap test of the youngest mature leaves during early stages of crop growth.
- Do not use excessive amounts of agricultural lime.
- Reduce alkaline (high pH) soils to below pH 7.5.
Molybdenum (Mo) deficiency

**Signs:** Older leaves become chlorotic and pale, then brown, and have necrotic margins. Tomato leaves are pale, thickened and tend to curl upwards because of the death of the margins. Leaves may be brittle, misshapen and, in severe cases, leaf margins will curl and leaves will die. Plants are stunted.

**Cause/favoured by:** More common in acidic soils with pH < 6.0.

**When to look:** Observe from seedling stage through to flowering.

**Quick correction:** Ammonium molybdate or sodium molybdate sprayed two or three times on early plant growth stages.

**Useful information:** In acid soils (soil pH < 6.0), molybdenum availability to plants is reduced and foliar applications of molybdenum are required.

**Prevention:**
- Check soil pH and nutrient levels with a soil test during land preparation and before planting.
- Correct acid soils by applying lime.
- Apply molybdenum nutrition in the early growth stages if a petiole sap test indicates a deficiency or pH < 6.0.
Nitrogen (N) deficiency

**Signs:** Growing tips are pale and weak. Older leaves are pale green to yellow, and eventually dry up. Leaves may develop a purplish colour. Plants are small, do not thrive, have fewer flowers, poor fruit set and small fruit with thin skin. Fruit are more slender and pinched at the blossom end.

**Cause/favoured by:** Too little nitrogen applied, or nitrogen leaching due to overwatering. Organic mulches (e.g. straw) around plants can lead to nitrogen deficiency because they use nitrogen to decay. Poor root system development, root diseases and root knot nematode will limit nitrogen uptake by plants.

**When to look:** Observe all stages, including up to the beginning of harvest.

**Quick correction:** Foliar spray, fertigate or sidedress with nitrogen fertilisers (e.g. potassium nitrate, calcium nitrate, urea, low biuret urea, sulfate of ammonia). If the nitrogen deficiency is caused by poor root development due to diseases, nematodes or other soil conditions, these need to be treated to help correct the nitrogen deficiency.

**Useful information:** Nitrogen levels in relation to other nutrients need to be monitored and kept in balance for optimum plant and fruit growth and quality. Plants will take excess nitrogen in preference to other nutrients, resulting in other nutritional deficiencies. Check potassium, boron, calcium and copper levels in relation to nitrogen levels from pre-flowering to fruiting.

**Prevention:**

- Apply recommended rate of nitrogen divided into small, frequent applications.
- Check nitrogen levels regularly with a petiole sap test of the youngest mature leaves.
- Improve irrigation management to reduce leaching losses and excessive soil moisture.
Phosphorus (P) deficiency

**Signs:** Poor germination and establishment of seedlings. Leaves are small, dark and appear dull, grey–green. Seedlings show reddening or yellowing of leaf margins and purple colouration of the undersides of leaves. Oldest leaves turn bright yellow, but leaves directly above remain dark green. Brown patches appear between the veins on mature leaves. At flowering stage, crops may have fewer flowers. Plants may have a weak root system and shortened internodes, and be stunted and slow growing.

**Cause/favoured by:** Insufficient pre-plant phosphorus fertiliser, and acidic or cold soil conditions.

**When to look:** Check phosphorus levels with a soil test during land preparation. Observe all stages, up to the beginning of harvest.

**Quick correction:** Application of phosphorus fertilisers (e.g. MAP tech grade, phosphoric acid [drip irrigation], DAP or other commercial phosphorus fertilisers) can increase flowering and crop health in phosphorus-deficient soils.

**Useful information:** Phosphorus can adhere to soil particles and move slowly in the plant system. Phosphorus fertilisers are usually applied at or before planting in sufficient quantities to meet all the crop's needs. Placement of fertiliser below the seed or seedling at depths of approximately 10 cm is optimal.

**Prevention:**

- If soil or leaf tissue tests indicate phosphorus deficiency, increase the rate, frequency and timing of phosphorus nutrition.
- Conduct a soil test to determine phosphorus levels and adjust as necessary.
- Check phosphorus levels regularly with a petiole sap test of the youngest mature leaves.
Potassium (K) deficiency

**Signs**: Leaf margins may be yellow or scorched, with signs spreading to the area between the veins, then the leaf centre. Scorching of the leaf margins may cause the leaves to curl downwards and cup upwards. In tomatoes, compressed growth characterised by shortened internodes can be observed. Fruit from potassium-deficient tomatoes are often poorly and unevenly coloured or distorted.

**Cause/favoured by**: Insufficient potassium nutrition or imbalance with other nutrients. Potassium is often required on lighter sandy soils. Overwatering or heavy rainfall can cause nutrient leaching. Signs can develop rapidly in hot weather.

**When to look**: Check potassium levels with a soil test during land preparation. Observe all stages up to and during harvest.

**Quick correction**: Foliar spray, fertigation or sidedress with potassium nitrate, potassium sulfate or other potassium fertilisers.

**Useful information**: Optimal soil test potassium levels are 1–5% of total cation exchange capacity (CEC) and a magnesium:potassium ratio of 2:1–4:1. Nutrient interrelationships, including excess nitrogen and calcium, can inhibit potassium uptake. Excess potassium can inhibit manganese and boron uptake. Use of potassium chloride in saline soils may make leaf signs worse. Potassium deficiencies are more likely to occur on light sandy soils.

**Prevention**:

- If soil or leaf tissue tests indicate potassium deficiency, increase the rate, frequency and timing of potassium nutrition.
- Apply potassium nutrition before planting and regularly during crop growth, particularly from early flowering through to harvest.
- Check potassium levels regularly with a petiole sap test of the youngest mature leaves.
Zinc (Zn) deficiency

**Signs:** Leaves are small and distorted. The shoot length becomes shortened, giving the leaves a clustered arrangement near the growing tip. The stunted crops look pale from a distance, but closer inspection reveals yellowing between veins, as well as an overall paleness of the whole plant. Flowers may drop off and fruit fail to set.

**Cause/favoured by:** More common on soils where the pH is above 7.5 (alkaline soils) or lower than 5.0 (acid soils).

**When to look:** Observe from seedling stage through to flowering.

**Quick correction:** Several foliar sprays of zinc sulfate or other zinc nutrients in the early growth stages are required to reduce signs.

**Useful information:** In acid soils (soil pH < 6.0), zinc availability to plants is reduced and foliar applications of zinc are required.

**Prevention:**

- Check soil pH and nutrient levels with a soil test before planting.
- It may help to apply zinc fertilisers before planting.
- Correct acid soils by applying lime.
- Correct alkaline soils by applying acidifying fertilisers.
- Check zinc levels regularly with a petiole sap test of the youngest mature leaves.
Chloride (Cl) toxicity

**Signs:** Dull, dark, leathery leaves. Yellow leaf margins, worsening to scorched appearance and premature leaf fall. Older leaves usually show signs first. Poor plant vigour and wilting plants, even when soil moisture seems adequate.

**Cause/favoured by:** Saline soil, watertable rising to root zone, irrigating with saline water with electrical conductivity greater than 800 deci-Siemens per metre, or sulfate fertilisers moving into root zone. Problems are worse where drainage is poor. Be cautious if using muriate of potash fertiliser, which has 50% chloride content.

**When to look:** If seeing signs then it is too late, so use preventive measures.

**Quick correction:** Correction of saline conditions usually takes time and planning. To correct saline soil, leach salts from root zone with leaching irrigation of fresh, good-quality water. To correct for saline water, avoid sprinkler irrigation of crop foliage with highly saline water; if this is unavoidable, irrigate at night. Higher salinity levels are tolerable for a short period if drip irrigation is used. If possible, follow with a leaching irrigation to flush salts from root zone.

**Useful information:** Excess salts (chloride, sodium, magnesium, sulfates, carbonates, bicarbonates, borates) can damage roots and result in stunting and reduced yields. Sufficient drip irrigation may help move salts from the root zone; inadequate drip irrigation will result in accumulation of salts in the root zone. Where furrow irrigation is used, placing plants on the sides of beds may allow them to escape excessive salts.

**Prevention:**
- Conduct a soil test before planting to determine salt levels. Test for chloride and sodium levels.
- Lower the watertable level with improved irrigation management and/or subsurface drainage.
- Check the function of installed subsurface drains. Leach salts from root zone with leaching irrigation.
- Test and monitor irrigation water quality.
- Do not use saline water for irrigation.
- Avoid potassium chloride fertilisers if salinity is an existing problem.
**Catface**

**Signs:** Extreme malformation and scarring at the fruit’s blossom end. Cavities that are lined with scar tissue lie between puckered or swollen areas. Locules (seed-containing compartments) of the fruit are sometimes exposed. Damage causes uneven ripening, and some signs make fruit unmarketable.

**Cause/favoured by:** Growth disturbances during flowering (pistillate formation) are thought to be the cause of catface. Various factors before and during flowering (including periods of prolonged, unseasonal cool to cold temperatures; thrips feeding on young fruit; and excessive nitrogen fertiliser) may aggravate the problem and affect fruit development.

**When to look:** Catface becomes evident during fruit development stages.

**Quick correction:** None

**Useful information:** Mainly affects large, fresh, market tomato varieties. Jointless varieties are more prone to catface than jointed varieties.

**Prevention:**

- Use tolerant cultivars or those that are not known to exhibit catface.
- Ensure optimal irrigation, and nutritional and temperature management in greenhouses to reduce losses.
- Prevent soils from becoming waterlogged.
Fruit splitting or skin cracking

**Signs:** Radial cracking and concentric cracking are two types of cracking that occur on fruit. Radial cracking is splitting from the stem end to the blossom end of the fruit. Concentric cracking occurs in a circular pattern or as rings around the stem end.

**Cause/favoured by:** Various conditions, including:
- periods of very fast fruit growth with high temperature and moisture levels
- initial fruit growth during a dry period followed by heavy rain or irrigation during ripening
- overpruning or lack of leaf cover for fruit
- wide fluctuations in day and night temperatures
- high nitrogen and low potassium levels.

**When to look:** During fruit development. As fruit mature, they become more susceptible to cracking, especially as colour develops.

**Quick correction:** None

**Useful information:** Cracking occurs more frequently in vine-ripe tomato production than in mature-green tomato production. The problem is usually more severe on the lower trusses. More susceptible varieties crack in the mature-green stage and more tolerant varieties at later stages.

**Prevention:**
- Monitor soil moisture monitoring and optimise irrigation management. Do not over-irrigate, and minimise fluctuations in soil moisture, particularly at fruit maturity.
- Maintain a balanced fertiliser program that prevents overly succulent plants.
- Maintain good foliage cover, as exposed fruit are more susceptible.
- Select tolerant varieties.
Disorders

1. Tomato—heat stress radial cracking
2. Tomato—concentric cracking of green fruit (C. Chen)
3. Tomato—radial cracking of green fruit (C. Chen)
4. Tomato—splitting of blossom end (I. Walker)
5. Tomato—concentric cracking (I. Walker)
6. Tomato—radial cracking of red fruit (C. Chen)
7. Capsicum—blossom end split (I. Walker)
Misshapen fruit

**Signs:** Misshapen fruit exhibit various signs, including malformation, irregular shape and lack of full shape development.

**Cause/favoured by:** Disruption to pollination and flowering processes by environmental conditions such as strong winds or extremes of temperatures. Occasionally fruit in early stages of development can be damaged by insects, disease or farm operations, which leads to misshapen fruit.

**When to look:** Signs only become evident during fruit development stages.

**Quick correction:** None

**Useful information:** On high-value crops, misshapen fruit may be removed by hand-picking at early stages.

**Prevention:**

- Grow windbreaks to provide crop protection from winds. This can be helpful to crops at flowering stages.
- Select low-toxicity pesticides (and foliar sprays) when spraying during flowering.
Disorders
Sunburn

**Signs:** Damage occurs as sunken, dark-brown-to-light-brown patches on the side or shoulder of fruit. On capsicum, a white, soft, sunken area develops that later dries out and becomes papery. On tomato, the damaged area is white, shiny and blistered, becoming sunken and wrinkled. Signs occur on fruit of any size, although maturing fruit tend to be more susceptible to damage.

**Cause/favoured by:** Inadequate foliage protection, particularly during extremely hot and/or humid conditions, that leaves developing fruit exposed to sun. Poor foliage protection may be due to trellising methods, inadequate fertiliser resulting in poor leaf development, or heavy pruning or leaf removal. Sunburn is a physiological problem and is not caused by insects, fungi, bacteria or other pathogens. Also known as sunscald.

**When to look:** During fruit development stages, and following extremely hot temperatures.

**Quick correction:** None

**Useful information:** None

**Prevention:**
- Ensure optimal nutrition and irrigation management that produces adequate vegetative growth and leaf cover for fruit.
Tomato—sunburn (QDAFF)

Eggplant—sunburn

Capsicum—sunburn (I. Walker)

Capsicum—sunburn (I. Walker)
Herbicide damage

**Signs:** Upward-curling, pale-green to yellow younger leaves and severe stunting of plants. Distortion of leaves and shoots and vein clearing may occur. Various chlorotic leaf patterns occur that are unrelated to leaf venation. The chlorosis is often an artificially bright hue of yellow, orange, cream or white.

**Cause/favoured by:** Spray drift in windy conditions or when a temperature inversion layer is formed, which can trap spray droplets in the lower air mass that moves sideways rather than mixing with the upper atmosphere. Herbicide residue left in a spray tank that is then used for a fungicide or insecticide application.

**When to look:** After spraying and from seedling through to harvest.

**Quick correction:** Plants damaged by herbicide may recover with optimal water and nutrient management. Plant tissue analysis may indicate nutrient applications that can improve plant growth and crop health.

**Useful information:** Check weather forecasts, temperature and wind speed before spraying, especially for herbicide sprays.

**Prevention:**

- Apply sprays under appropriate conditions to avoid spray drift.
- Follow instructions on chemical labels and record sprays.
- Triple-rinse spray tanks after use.
Tomato—stunting of roots caused by herbicide residue in soil and reduced nutrient uptake

Tomato—herbicide damage resulting in chlorosis near base of leaflets

Tomato—vein clearing caused by herbicide

Tomato—2,4-D herbicide injury

Tomato—2,4-D herbicide injury to roma fruit (I. Walker)

Tomato—dicamba, 2,4-D herbicide injury (I. Walker)

Tomato—glyphosate herbicide injury

Tomato—glyphosate herbicide injury (I. Walker)