Acknowledgments
This guide contains a number of photographs provided by Grundon, N.J., 1987, Hungry crops: a guide to nutrient deficiencies in field crops. Department of Primary Industries, Brisbane, Queensland
Noel Grundon, QDPI
Brendan Scott, NSW DPI
Hugh Wallwork, SARDI
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References
Hungry Crops: a guide to nutrient deficiencies in field crops by Dr N.J. Grundon, QDPI, Brisbane
Symptoms of nutrient deficiencies subterranean clover and wheat by K. Snowball and A.D. Robson, University of WA
Cereals - Frost Identification: The back pocket guide by C. White, Agriculture WA
WINTER CEREAL NUTRITION:
THE UTE GUIDE

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Purpose of this guide

This guide is designed to help farmers, advisers, researchers and students identify cereal nutrition disorders and other disorders that they are likely to encounter when monitoring cereal crops across Australia. It covers both nutrient deficiencies and toxicities and environmental, chemical and physiological disorders which can give similar symptoms to nutrient disorders. An emphasis has been put on ease of diagnosis with disorders giving similar symptoms being placed together. The guide focuses on wheat, barley and oats. Triticale and cereal rye are generally more efficient at extracting nutrients and only rarely are strong visual symptoms observed. In situations where symptoms are present in a triticale or cereal rye crop they are likely to be similar to those in wheat.

Soil testing, plant analysis and paddock test strips should all be part of a regular nutrition monitoring program for each paddock so that corrective action can be taken before significant yield loss occurs.

In most cases when visual symptoms of nutrient disorders appear large yield losses have already occurred. At the beginning of this guide there is a contents list with an identification key which will assist you to find the information on the particular disorder you are trying to identify. The contents listing divides the disorders into wheat, barley, oats, triticale and cereal rye and will lead you straight to the appropriate page if you believe you know the cause of the disorder. The identification key divides the symptoms of the disorders into: yellowing, striping, spotting, deformities and reddening/purpling.

Make use of this Ute Guide in your day to day operations out in the paddock.
Potassium deficiency

Description
- Reduced vigour and spindly growth of the whole plant.
- Specific symptoms: first appear on the oldest leaves; speckled along their whole length, quickly spreading to the tip and margins in severe cases.
- As leaves die back from the tip and margins a spear shaped pattern of green remains (best characteristic).
- Old leaves often die completely and plants appear to hay off prematurely.
- The photo shows the degree of deficiency from adequate, yellow mottling, death of leaf tips and the green spear effect.

Similar Symptoms
- Nitrogen deficiency – yellowing of oldest leaves, but leaf death occurs much more rapidly with potassium deficiency.
- Boron toxicity – although symptoms usually occur later in crop development than potassium deficiency.

Contributing Factors
- Sandy soils with leaching potential; history of high hay and/or grain removal.

Different colours for different crops and symptoms

Crop: Wheat
Major symptom: Yellow Old Leaves
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Disorders in italics are included because they can produce similar symptoms to the nutrient deficiencies/toxicities listed above.

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Nitrogen deficiency

Description
- Plants are pale green with reduced bulk and tiller formation.
- Symptoms first occur on oldest leaf, which becomes paler than the others with marked yellowing beginning at the tip and gradually merging into light green.
- Other leaves begin to yellow and oldest leaves change from yellow to almost white.
- Leaves may not die for some time.
- Reduced grain yield and protein levels.

Similar Symptoms
Potassium and phosphorus deficiency – yellowing of oldest leaves, but these die quickly.
Contributing Factors
Low soil nitrogen fertility and cold wet conditions reduce mineralisation and uptake of nitrogen.
Low incidence of legumes in rotation. High nitrogen loss by leaching in high rainfall areas and sandy soils.
Phosphorus deficiency

Description

- Reduced early growth and vigour with spindly plants under severe deficiency.
- All leaves are dull dark green.
- Slight mottling of oldest leaf and tip begins to yellow.
- Yellow area moves down the leaf, with the base remaining dark green (no "arrow" so not like potassium).
- Yellow areas die fairly quickly with the tip becoming orange to dark brown and shrivelling with the remainder of the leaf turning yellow.
Similar Symptoms
Nitrogen deficiency – yellowing of the oldest leaves, but death of the yellow tissue occurs more rapidly than with nitrogen.

Contributing Factors
Low available soil phosphorus and/or low vesicular arbuscular mycorrhizal fungi (VAM).
Cereal cyst nematode (CCN), produces similar symptoms to nitrogen and phosphorus deficiencies.

Description
- Yellow or pale green patches develop in crop during early winter.
- Plants are pale yellow and stunted, with fewer tillers.
- Root systems are shallow, with characteristic knotting and a proliferation of small lateral roots.
- Plants may partially recover in spring.

Contributing Factors
Insufficient CCN break crops in the rotation. Growing CCN intolerant varieties; sandy, less fertile soils.
Potassium deficiency

Description
- Reduced vigour and spindly growth of the whole plant.
- Specific symptoms; first appear on the oldest leaves; speckled along their whole length, quickly spreading to the tip and margins in severe cases.
- As leaves die back from the tip and margins a spear shaped pattern of green remains (best characteristic).
- Old leaves often die completely and plants appear to hay off prematurely.

The photo shows the degree of deficiency from adequate, yellow mottling, death of leaf tips and the green spear effect.

Similar Symptoms
Nitrogen deficiency – yellowing of oldest leaves, but leaf death occurs much more rapidly with potassium deficiency.
Boron toxicity – although symptoms usually occur later in crop development than potassium deficiency.

Contributing Factors
Sandy soils with leaching potential; history of high hay and/or grain removal.
Aluminium toxicity

Description
Aluminium is not an essential plant nutrient, but can still be taken up and accumulated in the plant.
- Poor lateral root development and main roots can become thickened and distorted.
- Early in season all leaves become pale, particularly the oldest, which turn yellow and die early.
- Leaf symptoms similar to phosphorus deficiency (central/northern NSW) and magnesium deficiency (southern NSW and north eastern Victoria).
- Late in season plants appear drought stressed, despite adequate soil moisture.
- Tolerant crops do not display clear symptoms.

Similar Symptoms
Early in season – nitrogen deficiency; late in season – drought stress/boron toxicity.

Contributing Factors
Low pH soils (<4.5 CaCl₂) make aluminium more available to plants.
Salt toxicity

Description
- Short stunted plants; short erect bluish-green leaves.
- Leaf tips of old leaves turn dull yellow then die and turn pale brown.
- Severe toxicity – yellowing and death moves down the old leaf, usually along the edges until whole leaf dies.
- Heads may turn reddish-purple (see page 36 in Reddening/purpling).

Similar Symptoms
Phosphorus deficiency – short erect bluish-green leaves.

Contributing Factors
Saline soils; rising water table; saline irrigation water.
Boron toxicity

Boron is essential for plants, but in some soils it accumulates to toxic levels.

Description
- Yellowing and death of leaf tips, starting on oldest leaves first.
- Symptoms often do not appear in early vegetative growth.

Similar Symptoms
Nitrogen and potassium deficiency but these are most obvious early in crop development (before boron toxicity symptoms normally appear).

Contributing Factors
High boron levels in sub soil; growing boron intolerant varieties.
Sulphur deficiency

Description
- Whole plant is pale green with a greater yellowing in the newest leaves which are a "butter" yellow.
- Whole leaves are light yellow with no stripes or green veins.
- Severe deficiency – leaf tips of old leaves can die.

Similar Symptoms
Nitrogen deficiency – yellowing, but nitrogen deficiency occurs in the oldest leaves first rather than the whole plant.

Contributing Factors
Low soil fertility (organic matter) and cold wet conditions reduce mineralisation and uptake of sulphur; acid sandy soils are subject to leaching. Low input of sulphur containing fertilisers eg DAP/MAP usage.
Molybdenum deficiency

Description
Symptoms are difficult to detect in the field, particularly early in the season.
- At low levels of nitrogen the crops are pale with some limpness.
- As nitrogen levels increase, symptoms become more specific with all but the oldest leaves pale green when adequate to high levels of nitrogen.
- Middle leaves have a speckled flecking/yellow stripes.
- Leaves appear limp and water stressed.
- Tip scorching of old leaves at high nitrogen levels.
- Severe deficiency – delayed maturity and empty heads.

Similar Symptoms
Copper deficiency can cause wilting, delayed maturity and empty heads. Crimping on flag leaf is often confused as a symptom of molybdenum deficiency, but is usually a physiological effect.

Contributing Factors
Acidic soils; moderate to high levels of available soil nitrogen; soils high in iron and aluminium oxides.
Iron deficiency

**Description**
- Stripping of new leaves with alternate yellow and green stripes down the length of the leaf.
- Under severe deficiency new growth may turn white.
- New growth remains yellow for some time before the leaf begins to die.

**Similar Symptoms**
Magnesium which usually has a "bead" appearance and manganese deficiency – yellow striping of new growth, but the striping is not as pronounced.

**Contributing Factors**
Highly calcareous soils; cold and wet conditions. Application of high rates of lime.
Barley yellow dwarf virus, produces similar symptoms to iron deficiency – yellow stripes.

**Description**
- Infected leaves turn yellow from the tips and often have yellow stripes down the length of the leaves with a purplish tinge (refer Reddening/purpling).

**Contributing Factors**
- Early opening rains which favour the build up of aphids which transmit the virus;
- Long-season crops in high rainfall districts and early sown crops in lower rainfall areas.
**Sulfonylurea herbicide damage,**
produces similar symptoms to iron deficiency.

**Description**
- New growth yellow at the early seedling stage.
- As plants develop, new growth becomes darker green while older leaves remain yellow.

**Similar Symptoms**
Iron deficiency for early symptoms;
nitrogen deficiency for later symptoms.

**Contributing Factors**
High pH soils (>7.5 CaCl₂); cold wet soil.
**Manganese deficiency**

**Description**

- It often appears as patches of pale, floppy wheat in an otherwise green healthy crop.
- New leaves are pale compared to old leaves and appear limp, with some withering of new shoots.
- Pale green/yellow striping appears at the base of the youngest fully opened leaf.
- As leaves develop the striping becomes more pronounced, particularly in the middle of the leaf where patches begin to die and the leaf collapses. By this stage the leaves are usually located on the middle of the plant.
- Maturity is delayed.
**Similar Symptoms**
Iron deficiency – striping, but iron is more even and more vivid with no flecking.

**Contributing Factors**
Highly calcareous sands; very infertile siliceous sands; alkaline peats; cold and wet conditions. High rates of lime. Application of some herbicides make the problem worse.
Zinc deficiency

Description

- Plants are stunted with short thin stems and usually pale green leaves.
- Young to middle leaves develop yellow patches between the mid vein and the edge of the leaf and extend lengthways towards the tip and base of the leaf.
- These areas eventually die turning pale grey or brown.
- Plants take on a water soaked or diesel soaked appearance.
- Affected areas may remain separate or join together with the death of the whole central leaf area; tip, base and margins remain green.
Adequate Deficient

WHEAT STRIPES

Severe deficiency – yellow areas and grey/brown lesions develop on the leaf sheath; reduced tillering with no or little grain produced.

- Maturity is delayed. Mature plants are a dull grey colour compared to a bright "yellow" appearance of a healthy crop.

Similar Symptoms
Yellow leaf spot.

Contributing Factors
Application of some herbicides make the problem worse. Occurs on many soil types but is most severe on highly alkaline clay soils and very infertile siliceous sands, yellow gravelly sands, yellow earths, highly alkaline peat soils and highly alkaline coastal sands.

MATTHEW WITNEY, DODGSHUN MEDLIN AG MANAGEMENT
Rugby stripe, may be confused with zinc deficiency.

Description
- Yellow to translucent horizontal stripes across the leaves of newly emerged wheat plants.

Contributing Factors
Seed sown too deep, followed by cold wet weather during emergence; severe frost.
Calcium deficiency

Description
- Spots in the middle of the newest leaf die, this area quickly expands and the leaf collapses in the middle before it even unrolls. Terminal growth is distorted.

Contributing Factors
- Rare in broad acre crops; acidic sandy soils, where calcium is removed by heavy rainfall;
- alkaline sodic soils; soils with high soluble aluminium.
Magnesium deficiency

Description
- Plants appear unthrifty and water stressed.
- New wheat leaves are pale and soon yellow, remaining unopened with a twisted appearance.
- Yellowing becomes mottled (spots/beads) and finally the leaves die, but remain upright.
- Oldest leaves also become a mottled yellow and in some cases reddish along the leaf margins.
- Severe deficiency – entire length of the leaf will remain folded or rolled.

Similar Symptoms
Potassium deficiency – plants unthrifty and water stressed, but yellowing and death only occur on the older leaves.

Contributing Factors
Applications of high rates of high quality lime. Rare in broad acre agricultural crops.
Manganese toxicity

Description
- Grey flecks or either yellow or brown spots develop on leaves.

Similar Symptoms
The flecking symptom could be confused with insect damage while the yellow spots could be confused with some leaf diseases or herbicide damage.

 Contributing Factors
Likely to occur in acid soils (pH < 4.5 CaCl₂) and in wet, poorly drained soils as these conditions make manganese more available for plant uptake. Manganese is low in many acid soils and is lost from the soil in free draining soils (e.g., sandy soils).
Grass and broadleaf herbicide damage, produces similar symptoms to manganese toxicity.

Description
- Yellow bleached spots on the surface of leaves.

Contributing Factors
- Application of a tank mix of grass and broadleaf herbicide.
**Phenoxy herbicide damage,**
produces similar symptoms to manganese toxicity.

*Description*
- Leaf mottling.
- Distortion of wheat heads (refer Heads deformed).
- Onion leaf type rolling of flag leaf.

**Paraquat herbicide damage,**
produces similar symptoms to manganese toxicity.

*Description*
- Spots of dead tissue on otherwise healthy leaves.
- Often worse on one side of the plant/stem.

*Contributing Factors*
- Herbicide drift from nearby application.
Calcium deficiency

Description
- Root growth is affected first; main roots shortened with a large number of stunted branches.
- Spots in the middle of the newest leaf die; area quickly expands and leaf collapses in the middle before it unrolls.
- Section above the collapsed leaf remains dark green.

Similar Symptoms
Severe copper deficiency – new growth similar, but section above the collapse withers and quickly dies; older leaves are also generally showing withered tips.

Contributing Factors
Rare in broad acre crops.
Copper deficiency

Description
- Whole plants are light green and begin to wilt at early tillering despite adequate soil moisture.
- First characteristic symptoms are sudden death and withering (curling) of the tip and up to half the length of young leaves. Tips of young leaves hang down and turn yellow.
- Base of leaf can remain green until the crop ripens.
- Old leaves remain green and apparently healthy.
- Severe deficiency – new growth withers before unfolding; reduced tillering, stems weak.
- Length of stems reduced and stem, nodes and spikelet glumes can purple; tillering from base of upper leaves.
- Mature plants are a dull grey-black colour with white heads compared to bright "yellow" appearance of healthy crop.

Similar Symptoms
Boron and calcium deficiency – shoots wither.

Contributing Factors
Intensive cropping rotations with grain legume crops; additional nitrogen fertiliser can exacerbate the severity of the deficiency (crop still appears nitrogen deficient).
Boron deficiency

Description
- Newer leaves split along the leaf close to the midrib.
- Saw tooth effect on edges of young leaves.
- Severe deficiency – increased tillering; new shoots water-soaked and paler; leaves distorted along edges; finally new growth dies and shoots wither.

Similar Symptoms
Copper and calcium deficiency – shoots wither.
Molybdenum deficiency

Description
- Tip scorching of old leaves at high nitrogen levels.

Leaf crinkling,
produces similar symptoms to molybdenum deficiency.

Description
- Crinkling of leaf along one edge.
- Leaf remains dark green and healthy with no other symptoms.

Contributing Factors
Cause is unclear, however it is thought to be a result of variable growing conditions with parts of the leaf growing quicker than others.
Salt toxicity
Description
- Heads may turn reddish-purple.

Phosphorus deficiency
(refer Yellow old leaves, p.10)

*Barley yellow dwarf virus,*
produces similar symptoms to phosphorus deficiency (refer BYDV – Stripes, p.20)

Description
- Small patches of stunted growth with reddening or purpling of leaves, particularly along the edges towards maturity.
- Heads may be sterile.

Similar Symptoms
Nitrogen (waterlogging) and phosphorus deficiency; copper deficiency; frost.

Contributing Factors
Early opening rains, which favour the build up of aphids; long-season crops in high rainfall districts and early sown crops in lower rainfall areas.
Copper deficiency

Description
- ‘Rat-tail’ appearance of heads with full grain in the base, shrivelled grains in the middle and a withered dead tip. Gaps in heads can also be present due to unfertilised embryos amongst fertilised grains.
- Marginal deficiency – shrivelled grain with the stem and head bending over.
- Reduced grain yield due to reduced pollen fertility.
- White heads in severe deficiencies.

Similar Symptoms
Drought stress; frost; Take-all; molybdenum deficiency.
Frost, produces similar symptoms to copper deficiency.

Description
- Florets (individual flowers of cereal plant) are bleached, shrivelled or dwarfed and grain does not form.
- Often only a portion of head is damaged and unaffected florets produce grains.
- With severe frosts, whole heads can be killed.
- Stem frosting just below the head can cause death of the whole head; the whole head wilts over 5-10 days after the frost event.
- Crop worst affected in low lying areas of paddock.

Similar Symptoms
Copper deficiency – rat-tail head; drought stress – head tipping.

Contributing Factors
Night air temperatures below 2°C between ear emergence and late grain filling; low lying areas; light textured soils.
Phenoxy herbicide damage, produces similar symptoms to copper deficiency.

Description
- Flag leaf rolls as in onion leaf.
- Heads distorted.

Drought stress, produces similar symptoms to copper deficiency.

Description
- Tips of wheat heads are shrivelled and bleached.
- All heads are affected.

Similar Symptoms
Frost – portion (not necessarily tip) or all heads affected; copper deficiency – rat-tail head.

Contributing Factors
Hot winds between head emergence and grain filling; worse on heavier soil types.
Nitrogen deficiency

Description
- Plants are stunted with thin, spindly stems and pale green stems and leaves; reduced tillering.
- Old leaves turn pale green and the tip becomes pale yellow.
- Yellowing moves down the leaf towards the base; yellow areas eventually die and turn pale brown.
- Youngest leaves remain green.
- Stems are usually pale green, but red stripes develop in cold conditions.
- Severe deficiency – tillers die before maturity.
- Reduced grain yield and protein.

Similar Symptoms
Potassium deficiency – yellow, dead old leaves.

Contributing Factors
Low soil fertility; high yield potential; consecutive non legume crops.
Waterlogging, produces similar symptoms to nitrogen deficiency.

**Description**
- As for severe nitrogen deficiency.

**Contributing Factors**
Prolonged periods of cold, wet conditions; poorly drained soils.
**Potassium deficiency**

**Description**
- Stunted plants with short, stout stems and pale yellow-green stems and leaves; appear limp or wilted.
- Symptoms develop first on old leaves, but eventually move to younger leaves.
- Tips of old leaves become dark yellow, moving down the edges of the leaves.
- Yellow areas die and turn grey.
- In some varieties, dark brown spots and streaks appear in the yellow areas or the green tissue close by; eventually the whole leaf becomes yellow, dies and turns pale to dark brown.

**Similar Symptoms**
Nitrogen deficiency – yellow; dead old leaves.

**Contributing Factors**
Light sandy soils in high rainfall areas.
Salt toxicity

Description
Barley is more tolerant than many other crops.
- High levels cause stunting with short, stout stems and dull, green-yellow stems and leaves.
- Old leaves turn dull yellow-green and the leaf tip becomes dark yellow; yellowing moves down the edges towards the base.
- Brown patches develop in the yellow areas until the whole leaf is affected and dies.
- Symptoms move to young leaves until whole plant is affected.
- Severe toxicity – plants appear droughted; all leaves limp or wilted with edges rolled upward into a tube.

Similar Symptoms
Nitrogen deficiency – yellowing of old leaves.

Contributing Factors
Saline soils; rising water table; saline irrigation water.
Aluminium toxicity

Description
- No specific plant symptoms.
- Mainly affects root growth, producing short stubby roots.
- Poor plant growth and reduced yield due to the reduced uptake of nutrients and water.
- Leaf symptoms similar to phosphorus deficiency (central/northern NSW) and magnesium deficiency (southern NSW and north eastern Victoria).
- Barley less tolerant than other cereals.

Similar Symptoms
Phosphorus deficiency; occasionally calcium, magnesium, potassium and iron deficiencies as a result of a poor root system.
Contributing Factors

Low pH soils (< 4.5 CaCl₂) make aluminium more available to plants.
Sulphur deficiency

Description
- Crops grow poorly, lack vigour and mature more slowly; reduced tillering, low grain yields and protein.
- Initially all leaves are pale green, but old leaves darker green.
- Youngest leaves turn pale yellow and eventually white; whole leaf is affected not just the area between the veins.
- Leaves generally do not die even when they have turned white.
- Old leaves remain green.
- In some varieties, margins and sheaths of old leaves become red or purple-red.

Similar Symptoms
Mild nitrogen deficiency.

Contributing Factors
Low soil fertility and cold wet conditions reduce mineralisation and uptake of sulphur; acid sandy soils subject to leaching.
Molybdenum deficiency

Description

Symptoms are difficult to detect in the field.

- All but the oldest leaves are pale green when adequate to high levels of nitrogen applied; all leaves normal colour at low nitrogen levels.
- Leaves appear limp and water stressed.
- Tip scorching of old leaves at high nitrogen levels.
- Severe deficiency – delayed maturity and empty heads.
Manganese deficiency

Description

Large variation in susceptibility between varieties.
- Uneven growth within crops; in poor areas plants are stunted with short, thin stems and pale green to yellow leaves; tillering is greatly reduced.
- Young leaves turn pale green to yellow, become limp and hang down as if wilted.
-Pale green stripes usually develop on young leaves (Less commonly these stripes can be grey or white, which join together to form small grey to pale brown spots. In these cases some varieties develop dark brown, elongated spots near the edges of the leaf amongst the grey/white stripes.).
- Leaves are weak and tear easily.
Contributing Factors
Highly calcareous soils; very infertile siliceous sands; alkaline peats; cold and wet conditions. High rates of lime. Some herbicides may make the problem worse.
Iron deficiency

Description
- Plants are stunted with thin, spindly stems and pale green to yellow leaves.
- Youngest leaves turn pale green.
- Leaves develop yellow (between the veins) and green (veins) stripes down the length of the leaf (interveinal chlorosis).
- Severe deficiency – yellow stripes may turn almost white, but do not die; veins become pale green to yellow; tillering reduced and young tillers die.
- Old leaves remain pale green.

Similar Symptoms
Nitrogen and sulphur deficiency – slightly pale plants with mild iron deficiency; barley yellow dwarf virus – yellow stripes.

Contributing Factors
Waterlogged, calcareous soils.
Barley yellow dwarf virus, produces similar symptoms to iron deficiency.

Description
- Often occurs in small patches of the crop.
- Pale yellow stripes between the leaf veins or a bright yellowing from the leaf tip.
- Some leaves may become red.
- Plants may be stunted and heads sterile.

Similar Symptoms
Iron deficiency – yellowing between leaf veins.

Contributing Factors
Cool summers and survival of volunteer cereals over summer build up aphid numbers which transmit the virus; early sowing.
### Sulfonylurea herbicide damage

**Description**
- New growth is yellow at the early seedling stage.
- As plants develop, new growth becomes darker green while older leaves remain yellow.

**Similar Symptoms**
Iron deficiency for early symptoms, nitrogen deficiency for later symptoms.

**Contributing Factors**
High pH soils (> 7.5 CaCl$_2$); cold wet soil.

### Rugby stripe

**Description**
- Yellow horizontal stripes across the leaves of newly emerged plants.

**Contributing Factors**
Crop sown too deep and cold wet weather during emergence.
Barley Spots

Magnesium deficiency

Description
- Young crops have poor growth with pale yellow leaves; mature crops plants are stunted with thin spindly stems and pale yellow-green leaves.
- Old leaves develop elongated grey to dark brown spots on or near the edges of the leaf, usually half way along the leaf quickly spreading towards the tip and base.
- Whole leaf becomes dark yellow with dark brown elongated spots.
- Youngest leaves remain green.
- Many young tillers die before maturity.
- Severe deficiency – old leaves die and turn brown.

Contributing Factors
Rarely seen in broad acre crops.

Adequate

Deficient

Adequate

Deficient

NOEL GRUNDON, QDPI

HUNGRY CROPS
Zinc deficiency

Description
Plants are stunted with short thin stems and usually pale green leaves.
- Young to middle leaves develop yellow patches between the mid vein and the edge of the leaf and extend lengthways towards the tip and base of the leaf.
- Grey/brown elongated spots can also be present on middle leaves, especially along leaf edges.
- These areas eventually die turning pale grey or brown.
- Affected areas may remain separate or join together with the death of the whole central leaf area; tip, base and margins remain green.
- Severe deficiency – yellow areas and grey/brown lesions develop on the leaf sheath; reduced tillering with no or little grain produced.
- Maturity is delayed. Mature plants are a dull grey colour compared to bright “yellow” appearance of healthy crop.
- Root growth is also affected reducing nutrient uptake and root disease resistance.
Contributing Factors
Application of some herbicides make the problem worse. Occurs on many soil types but most severe on highly alkaline clay soils and very infertile siliceous sands.
Barley scald, produces similar symptoms to zinc deficiency.

Description
- Water soaked areas first develop on leaves, turn grey green and then light brown (bleached).
- Bleached areas develop dark brown edges.
- All the above ground parts of the plant, except the upper stem, can be affected.

Contributing Factors
Early sowing into barley or barley grass residues; susceptible varieties; frequent rain.
Grass control herbicide damage, produces similar symptoms to early damage by zinc deficiency.

**Description**
Irregular tan coloured spots with dark brown edges from the mid section to the tip of all leaves.

**Contributing Factors**
Herbicides applied at incorrect growth stage of crop.
Boron deficiency

Description
- Stems are short and often fan-shaped; leaves are greyish-green.
- Dark brown, irregular spots on young leaves.
- Pale yellow areas in the middle of young leaves.
- Yellowing quickly moves towards the leaf tip and irregular, grey spots develop between the edge and mid-vein; spots often join leaving grey dead tissue with vein unaffected.
- Eventually whole leaf tip dies turning grey-brown, with base of leaf remaining pale green.
- Severe deficiency – youngest leaves fail to develop or expand fully and sometimes die; leaves tear and tips die and turn grey.

Contributing Factors
Sandy soils where boron has been leached, not confirmed in Australian cropping areas.
Boron toxicity

Description
- Small brown/black spots on leaves, firstly along the edges and near tip.
- Symptoms worse in old leaves.
- Leaves turn yellow and die from the tip as toxicity worsens.
- Spots can also appear on stems and heads in severe cases.

Similar Symptoms
Spot form of net blotch (a fungal disease).

Contributing Factors
High boron levels in sub soil.
Manganese toxicity

Description
- Grey flecks or either yellow or brown spots develop on leaves.

Similar Symptoms
The flecking symptom could be confused with insect damage while the yellow spots could be confused with some leaf diseases.

Contributing Factors
Likely to occur in acid soils (pH < 4.5 CaCl₂) and in wet poorly drained soils as these conditions make manganese more available for plant uptake. Manganese is low in many acid soils and is lost from the soil in free draining soils (eg sandy soils).
Calcium deficiency

Description
- Plants are stunted with short, stout fan-shaped stems and dark green leaves.
- Tips of youngest leaves die, turn grey or pale brown; become tightly rolled or twisted and usually hang down from the end of the leaf.
- Base of leaf remains green, but brittle and cracks or tears when bent.
- Dead leaf tip often breaks off leaving square ends to affected leaves.
- Severe deficiency – youngest leaves die before emerging fully; whole shoot then dies; previously healthy dark green older leaves, turn dark yellow at the leaf tips.

Similar Symptoms
Copper deficiency – tips of young leaves wither.

Contributing Factors
Highly acidic soils low in calcium.
Copper deficiency

Description
Barley is relatively susceptible.
- Crops have patchy growth and plants are pale green and stunted with a limp wilted appearance with moderate to severe deficiency.
- Tips of youngest leaves die, turn pale brown and become tightly rolled or twisted (wither-tip).
- Late tillers form at nodes or joints above ground level.
- Severe deficiency – young leaves die; old leaves remain dark green and apparently healthy.
- Delayed maturity with stem and leaves remaining green well after healthy plants have matured.
- Tips or all of head can be sterile, resulting in white heads (refer Heads deformed, p.67).
Similar Symptoms
Calcium deficiency – wither tip; frost damage, mouse or insect attack – white heads.

Contributing Factors
Very infertile sands; application of high rates of nitrogen fertilisers.
Phosphorus deficiency

Description

Often only reduced vigour, later maturity and lower grain yields.
- Other symptoms only occur with severe deficiency.
- Old leaves develop dark purple edges, usually towards the tip.
- Purpling moves down the leaf edges, the mid section of the leaf turns dark yellow or orange-red, with the mid vein often remaining dark green.
- Whole leaf turns dark yellow then dark brown.
- Youngest leaves remain green, but shorter and more erect.
- Stems are short and stout with base and leaf sheaths of lower leaves often purple-red.
Contributing Factors
Low available soil phosphorus.
Waterlogging, (refer page 41), produces similar symptoms to nitrogen and phosphorus deficiency.

Description
- Old leaves turn purple/red from the tip down.
- Leaves eventually turn yellow and die.

Contributing Factors
Prolonged period of cold wet conditions; poorly drained soils.
Copper deficiency

Description
- Tips, individual florets or all of head can be sterile, resulting in gaps in heads or white heads.

Similar Symptoms
Frost damage; mouse or insect attack – white heads; Barley yellow dwarf virus.

Barley yellow dwarf virus,
produces similar symptoms to copper deficiency.

Description
- Heads may be sterile.

Similar Symptoms
Frost.
**Frost**, produces similar symptoms to copper deficiency.

**Description**
- Barley can tolerate lower temperatures than wheat, because flowering occurs close to the boot providing more protection (about 1-2°C) against frost.
- Sterile florets (flower of cereals) results in missing grains in the head.
- Stem frosting just below the head can cause death of the whole head; the whole head wilts over 5-10 days after the frost event.

**Contributing Factors**
Early sowing in frost-prone areas.

Frosted barley heads, unaffected on left.
Nitrogen deficiency

Description
- Young crops – stems are short and thin; leaves and stems are pale green; dark green patches in a pale green crop.
- Mature crops – plants are stunted and multi-coloured; upper leaves are pale green, middle leaves are yellow to pale green with red tips and oldest leaves may have died, turned brown and lying on soil surface.
- Old leaves turn pale green.
- Tips of old leaves become pale yellow, moving down towards the base until the whole leaf is pale yellow.
- Severe deficiency – refer to Reddening/purpling, p.89.

Similar Symptoms
Waterlogging and cereal cyst nematode damage.

Contributing Factors
Sandy soils, leached or waterlogged soils, low incidence of legumes in rotation.
Cereal cyst nematode (CCN), produces similar symptoms to nitrogen deficiency.

Description
- Yellow or pale green patches develop in crop during early winter.
- Plants are pale yellow and stunted, with fewer tillers.
- Root systems are shallow, with thickened short roots.
- Plants may partially recover in spring.

Contributing Factors
Insufficient CCN break crops in the rotation. Growing CCN intolerant varieties; sandy, less fertile soils.
Potassium deficiency

Description
- Old leaves turn pale green and bronze-yellow areas develop in the mid-section of the leaf between the edge and mid-vein; these areas quickly extend towards the leaf tip until the top two-thirds of the leaf is bronze-yellow (orange-red in some varieties).
- Grey-brown spots develop within the bronze-yellow areas, usually beginning in the mid-section of the leaf between the mid-vein and leaf edge; spots join together, causing the leaf to bend down at that point.
- Leaves die and turn brown.
- Plants develop a three tone appearance; younger leaves green, middle leaves green with yellow to bronze colours and older leaves brown; many tillers die before maturity.

Contributing Factors
Light textured soils where potassium has leached below the root zone.
Salt toxicity

Description
- Plants become stunted, turning dull, bluish yellow-green; many tillers die.
- Old leaves become dull green, turning dull, bluish yellow-green and younger leaves become dull green.
- Tips of old leaves become dull yellow, die and turn yellow-grey.
- Yellowing moves down the edges until the whole leaf is dead.

Contributing Factors
Rising water table; irrigation/flooding with saline water.
Sulphur deficiency

Description
- Stunted plants with yellow to pale green leaves and stems.
- Young crops, whole plant pale green; mature crops, young leaves pale green to yellow; tiller production severely reduced.
- Youngest leaves turn pale green then pale yellow with whole leaf affected (no striping).
- Old leaves usually remain dark green.
- Severe deficiency – old leaves may become pale green.
- Very severe deficiency – refer reddening/purpling, p. 93.

Contributing Factors
Low soil fertility and cold wet conditions reduce mineralisation and uptake of sulphur; acid sandy soils subject to leaching.
Boron toxicity

Description
- Leaf tips and edges of upper leaves turn yellow and die.
- Leaf tips die completely and roll.
- Leaves continue to die back from the tip to the mid part of the leaf.

Similar Symptoms
Drought stress.

Contributing Factors
Boron intolerant varieties; high soil boron levels.
**Magnesium deficiency**

**Description**
- Stunted plants with pale green foliage which often develops orange-purple colours; tillering greatly reduced in young plants and tillers can die before producing heads.
- On young plants, old leaves turn pale green and yellow areas develop on the edge in the middle of the leaf.
- On more mature plants, yellow or white stripes develop between the veins in the mid-section of the leaf; this yellowing moves towards the tip and base of the leaf, developing into yellow or yellow-red, interveinal stripes.
- Youngest leaves usually remain green to pale green.
- Severe deficiency (refer Reddening/purpling, p.93).

**Similar Symptoms**
Barley yellow dwarf virus.

**Contributing Factors**
Rarely seen in broad-acre crops.
Iron deficiency

Description

- Stunted growth and pale green to yellow stems and leaves.
- Young leaves turn pale green.
- Areas between leaf veins become bright yellow while veins remain green.
- Interverinal areas may turn white and veins become pale green to yellow.
- Severe deficiency – tillering, forage and grain yields are greatly reduced.
Similar Symptoms
Barley yellow dwarf virus; sulfonylurea herbicide damage.

Contributing Factors
Calcareous soils or sands with low soluble iron; waterlogged soils.
Barley yellow dwarf virus, produces similar symptoms to iron deficiency.

**Description**
- Plants are often stunted (seedlings) with leaf tips and edges bright red (see Reddening/purpling, p.92).
- Yellow stripes often develop on leaves.
- Leaves become bronzed in some varieties.
- White sterile florets.
- Symptoms often occur in patches.

**Similar Symptoms**
Iron and zinc deficiency; severe phosphorus deficiency.

**Contributing Factors**
Cool summers and survival of volunteer cereals over summer build up aphid numbers which transmit the virus; early sowing.
**Sulfonylurea herbicide damage,**
produces similar symptoms to iron deficiency.

**Description**
- Yellow and green stripes down the length of the leaves.

**Similar Symptoms**
Iron deficiency – yellow stripes.

**Contributing Factors**
Cold, wet conditions; calcareous soils.
Manganese toxicity

Description
- Plants are stunted with stout stems and dull green leaves.
- Old leaves become dull green and bronze-orange areas develop between the edge and mid-vein at the base of the leaf.
- These move up the leaf producing bronze-orange stripes eventually affecting the whole leaf.
- Affected areas die and turn brown.
- Severe toxicity – mid-vein dies at base of leaf, causing leaf to bend down and lie on the soil.

Contributing Factors
Strongly acid soils with increased soluble manganese.
Boron deficiency

Description
- Plants are stunted with fan-shaped stems; many tillers die before maturity.
- Tips of young leaves become dull yellow; rest of leaf turns dull green-yellow.
- Leaf tips then turn dull orange-green and pale brown stripes appear between the mid-vein and edge in the top half of the leaf.
- Leaf tip dies and turns pale orange-brown.
- Old leaves remain dark green.
- Severe deficiency – whole plants can die before heading; old leaves may turn a dull orange-green.

Contributing Factors
Not confirmed in Australian cropping zones.
Manganese deficiency

Description

- Areas of poor growth: within poor areas plants are stunted with short, stout stems and pale green to brown stems and leaves.
- Small, grey flecks develop between veins (grey and green stripes) in the lower half of the older leaves.
- Grey flecks extend towards the tip and the flecks join to form large grey areas in the lower half of the leaf between the edge and the mid-vein.
- Affected areas eventually go across the whole leaf, causing the leaf to collapse.
- Areas die and turn pale brown.
Similar Symptoms
Red leather leaf disease.

Contributing Factors
Highly calcareous soils; poorly drained peaty soils; cold and wet conditions.
Red leather leaf 
(Spermospora avenae),
produces similar symptoms to 
manganese deficiency.

Description
- Spots with buff coloured centres and 
  red-brown edges.
- Severe – spots cover entire leaf.
- Leaves become stiff, slightly rolled with 
  a leathery appearance.

Contributing Factors
Periods of high humidity; most severe in 
high rainfall areas; growing susceptible 
varieties.
**Diflufenican herbicide damage**, produces similar symptoms to manganese deficiency.

**Description**
- Light green (bleached) spots on leaves.
- White-yellow spots/bands may develop soon after application.
- Effects disappear as new growth develops.
- No long term effects.

**Contributing Factors**
Herbicide applied to crops suffering stress and growing in cold, excessively moist conditions.

Tigrex® herbicide damage
**Septoria blotch,**
produces similar symptoms to manganese deficiency.

**Description**
- Small, dark brown to purple, oval or elongated spots develop on leaves.
- Spots enlarge up to 20 mm in diameter being either light or dark brown with the surrounding areas turning yellow.
- Entire leaf can turn yellow and greyish brown or shiny black spots develop on the stem.
- Dark brown blotches can also develop on the head and grain (very susceptible varieties).

**Contributing Factors**
Cool, rainy weather especially in coastal districts; early sowing; oats grown in close rotation.

NIGEL WILHELM, SARDI
Calcium deficiency

Description
- Plants are stunted with short, dark green stems and leaves; many tillers die before producing heads; if severe, whole plants can die.
- Young leaves become erect, short and pale green; leaf tips will and hang down, often with margins rolled inward into a tube; old leaves remain dark green.
- Leaf tips die and turn grey (wither-tipped), sometimes breaking off to produce squared ends to leaves.
- Severe deficiency – youngest leaves become brittle and easily torn and often have a ragged appearance; growing point of shoots die.

Similar Symptoms
Copper deficiency – wither tipped young leaves.

Contributing Factors
Acid sandy soils in high rainfall areas; high level of soluble aluminium and a low level of exchangeable calcium.
Copper deficiency

Description
- Crops have a patchy appearance, with plants in poor areas stunted, pale green and appear limp or wilted; late tillers may develop at nodes or joints above ground.
- Young leaves turn pale green and appear wilted, even with ample water.
- Tips of young leaves become pale yellow then die and turn dark brown (wither-tipped), rolling or twisting tightly into a tube.
- Old leaves remain green.
- Severe deficiency – many tillers die before maturity.

Similar Symptoms
Drought stress.

Contributing Factors
Very infertile sands; application of high rates of nitrogen fertilisers.
Nitrogen deficiency

Description
- Severe deficiency – leaf tips become orange-red; tissue dies and turns brown and leaf edges often roll upwards.
- Stems are usually pale green, but often develop red stripes in cold weather.

Similar Symptoms
Waterlogging and cereal cyst nematode damage.

Contributing Factors
- Sandy soils; leached or waterlogged soils; low incidence of legumes in rotation.
Waterlogging produces similar symptoms to severe nitrogen deficiency.

**Description**
- Leaf tips become orange-red; tissue dies and turns brown and leaf edges often roll upwards.

**Contributing Factors**
- Prolonged period of cold wet conditions; poorly drained soils.
Phosphorus deficiency

Description
- Tips of old leaves become dark orange-yellow; moving towards the base usually along the leaf edges.
- Severe deficiency – affected areas die and turn red or purple.
- Affected leaves often have green bases, orange-yellow mid sections and bright red or purple tips; edges of leaf are often rolled inwards.
- Whole leaf dies and turns dark brown.
- Stems often turn purple, especially in cold weather.

Similar Symptoms
Nitrogen deficiency – reddening of leaf tips and stems.

Contributing Factors
Low available soil phosphorus; cold temperatures.
Barley yellow dwarf virus, produces similar symptoms to phosphorus and severe nitrogen deficiency.

Description
- Leaf tips and edges turn bright red, with reddening progressing down the leaf until whole plant affected.
- Yellow stripes or mottling can also develop on the leaves (leaves become bronzed in some varieties).
- Plants are stunted with symptoms often occurring in patches.
- White sterile florets are common.

Contributing Factors
Cool summers and survival of volunteer cereals over summer build up aphid numbers which transmit the virus; early sowing.
Sulphur deficiency

Description
- Very severe deficiency – old leaves develop orange-red edges.
- Purple streaks develop on leaf sheaths.

Contributing Factors
- Low soil fertility and cold wet conditions reduces mineralisation and uptake of sulphur; acid sandy soils subject to leaching.

Magnesium deficiency

Description (refer Stripes, p.75)
- Severe deficiency – affected leaves turn a general orange-red, die and turn pale brown.
Zinc deficiency

Description
- Causes patchy growth with plants in poor areas stunted with pale green leaves and yellow or orange-red tips.
- Middle and older leaves turn pale green; pale yellow areas develop between the leaf edge and mid-vein at the tip.
- Affected areas spread and turn dark yellow, orange-red or purple.
- Brown spots appear in the affected areas, increasing in size until the leaf tip dies, often turning red-brown to black (main characteristic).
- Base of leaf remains green, mid-section yellow and tip dark brown or black.
- Youngest leaves usually remain green.
- Very severe deficiency – stems very short and youngest leaves have difficulty emerging fully.
Similar Symptoms
Barley yellow dwarf virus; severe phosphorus deficiency.

Contributing Factors
Application of some herbicides may make the problem worse. Occurs on many soil types but most severe on highly alkaline clay soils and very infertile siliceous sands.
**Copper deficiency**

**Description**
- Heads on apparently healthy plants may set few grains (sterile pollen).

**Similar Symptoms**
Drought stress; frost.

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**Frost, produces similar symptoms to copper deficiency.**

**Description**
- Some sterile florets.
- Oats are more tolerant as florets hang downwards allowing warm air to be trapped inside, protecting them from frost.

**Similar Symptoms**
Copper deficiency; heat stress.

**Contributing Factors**
Frost occurs as the panicle is emerging from the leaf sheath.
Heat stress, produces similar symptoms to copper deficiency.

**Description**
Caused by high temperatures before/during flowering.
- Tips of leaves turn brown to grey.
- Some or all grains fail to develop on a head.

**Contributing Factors**
Hot dry winds before or during flowering.

Head sterility due to temperature stress.  
Leaf burn due to hot winds.
Drought stress, produces similar symptoms to copper deficiency.

Description
- Grain in the top of heads fails to develop (sterile).

Contributing Factors
Extended period of dry conditions during spring.
Both of these crops are generally more efficient at taking up nutrients than wheat, barley or oats. Only rarely are strong symptoms shown in the crop. If symptoms are present in a triticale or cereal rye crop they are likely to be similar to those in wheat.

**Sulphur deficiency in Triticale**

**Description**
- Whole plant is pale green with a greater degree of yellowing in the newer leaves.
- Whole leaves are light yellow.
- Severe deficiency – leaf tips of old leaves can die.

**Similar Symptoms**
Nitrogen deficiency – yellowing, but nitrogen deficiency occurs in the oldest leaves rather than the whole plant.

**Contributing Factors**
Low soil fertility and cold wet conditions reduce mineralisation and uptake of sulphur; acid sandy soils subject to leaching.

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TRITICALE AND CEREAL RYE  YELLOW WHOLE PLANT
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