**Diagnosis**

Healthy grain will form a neat, well-filled head of kernels which will fill the entire head. The kernels will be uniformly sized and will be green at the base of the head. The grains will be blue/grey in colour in the case of spring crops or green in the case of winter crops.

**Diseases**

Frosted plants will have a blue/grey appearance with the grain often being shrivelled and bleached. All heads will be affected. Whole plants are affected, containing grain that has either not formed or formed but not filled properly. Affected plants will follow soil type. Many disease, nutrient and moisture related symptoms will follow soil type. Random and sporadic, and not all plants (or parts of plants) will be affected.

**Identification**

Moisture stress (drought tipping) – tips of ears grow elongated and cankered, in some cases the grain will have a blue/grey appearance, moisture stress (drought tipping) – tips of ears grow elongated and cankered, in some cases the grain will have a blue/grey appearance. Frosted barley heads (unaffected on left). Frosted oat panicle. Frosted wheat heads (unaffected on left).

**Frost Symptons in Barley and Oats**


**OTHER PROBLEMS WITH SIMILAR SYMPTOMS**

There are many other problems that are confused with frost damage. There is a group of diseases that cause white and distorted heads. Many environmental factors, including excess rain at anthesis and a lack of sunlight, will cause small, undeveloped heads to form and remain green in the case of winter crops. There are many other problems that are confused with frost damage.

**Healthy grain (developing)**

• Note whether the grain size has increased or not, and check the stage of grain fill, the condition of the grain.

**Mature grain**

• Perform a peel test on one or a few grains and see if any liquid exudes. Look carefully and note plies has crimped the grain, axis, rather like a pair of long nose pliers has crimped the grain and screenings in a grain sample.

**Diagnosis**

Healthy young developing cereal plants are damaged in patches. The main ones are those that cause white and distorted heads. This can usually be attributed to one of the following:

**Healthy young developing cereal plants**

Healthy young developing cereal plants are damaged in patches. The main ones are those that cause white and distorted heads. This can usually be attributed to one of the following:

- Herdicide damage (Phenoxy damage)
- Lack of moisture stress
- Nutrient deficiencies
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- Nutrient deficiencies

- Frosted grain can have a detrimental effect on sample acceptance.

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**Frost**

Frost damage reduces crop yield and grain quality. Early identification of symptoms allows timely crop salvage decisions to be made.

**Factors affecting frost damage**

- Fungus and disease pressure on the crop.
- Plant stress from disease, waterlogging, compaction, or late maturity.
- Late season frosts.
- Early spring frosts.

**Period of risk**

- Gentle freezing (-2°C to 0°C) that lasts 5 to 10 days.
- Severe freezing (<-2°C) that lasts 24 hours.

**Why does it occur?**

- When the head is emerging from the boot after a light shower of rain has softened the peduncle.

**Why does it occur?**

- When the head is emerging from the boot, cold air or water is caught next to it. Cold air or water then freezes the head and extends to the top of the head and/or the boot.

**CEREAL SUSCEPTIBILITY TO FROST DAMAGE**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Low Susceptibility</th>
<th>High Susceptibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ear/head</td>
<td>Healthy</td>
<td>Bleached, shrivelled, and dwarfed</td>
</tr>
<tr>
<td>Floret</td>
<td>Healthy</td>
<td>Bleached, shrivelled, and dwarfed</td>
</tr>
</tbody>
</table>

**Symptoms**

- Healthy florets turn brown/black due to microbes.
- Anthers are white and dull in colour.
- Healthy anthers and pollen transmitted to the ovary.
- Healthy ears have green to yellow anthers.

**Diagnosis and symptoms**

- Pollen cells and reproductive organs are bleached and shrivelled.
- Anthers are white turning dull in colour.
- Healthy anthers and pollinated ovary.
- Crimping & cracking of base leaves, stem damage, and nodes are often blistered.
- Leaf sheaths surrounding the stem are dead.
- Crimped, cracked and/or blistered heads are killed.
- Healthy plant parts remain at the base of the plant.

**External damage**

- Whole wheat head killed.
- Seedling boot after a freezing rain or snowfall.
- Falling frost in a wheat field.
- Fruiting head killed.

**Frost affected anthers**

- Green to yellow anthers.
- Green to yellow anthers.
- Healthy pollen.
- Healthy florets.
- Healthy florets.
- Health of heads.

**Healthy anthers**

- White turning dull in colour.
- Healthy pollen.

**Healthy heads**

- Crimping & cracking of base leaves.
- Leaf sheaths surrounding the stem.
- Crimped, cracked and/or blistered heads.
- Whole wheat head killed.
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- Falling frost in a wheat field.
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Frost damage reduces crop yield and grain quality. Early identification of symptoms allows timely crop salvage decisions to be made.

Limitation: Predominantly grassy and/or cereal crops. For rosaceous plants see the northern regional guide (Rigling et al., 2001).

Indicators:
- Pale, unimpressive looking and plants with a high specific gravity
- High internal residue content
- Presence of frost

Symptoms may not be obvious until 5 to 7 days after the frost.

To identify frost damage:
- Look for symptoms (summary table) and pull back leaves or plant if you can clearly see the plant parts that are affected.
- Use a magnifying glass if this is not feasible (on weeds and microorganisms).

How to use this guide:
The field guide will help you identify the common symptoms of frost damage in crops. It also contains pictures of other plant symptoms often confused with frost damage.

Factors affecting frost damage:
- Period of risk
- Symptoms
- Diagnosis and symptoms
- Will the plant recover or compensate?
- Stem frost
- Bleached, shrivelled and dwarfed florets

CEREAL SUSCEPTIBILITY TO FROST DAMAGE

Factors affecting frost damage:
- Period of risk
- Symptoms
- Diagnosis and symptoms
- Will the plant recover or compensate?
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- Bleached, shrivelled and dwarfed florets

BLEACHED, SHRIVELLED AND DWARFED FLORETS

Why does it occur?
- When the head is stunning from the frost, all reproductive organs (pollen and grain) are destroyed.
- Symptoms appear after flowering.

Symptoms:
- Anthers are healthy, then check for
- Anthers are white turning dull in colour.
- Often ‘banana’ shaped.

STEM FROST

Why does it occur?
- From flower to green boot an amount of water inside the leaf turns to ice and kills the plant, followed by a death of the reproductive organs.

Symptoms:
- Pollen cells and reproductive organs do not tolerate low temperatures.
- Symptoms appear before flowering.

FLOWER FROST

Why does it occur?
- During the reproductive stage, the head and reproductive organs are most susceptible to frost damage.
- Symptoms appear after flowering.

Symptoms:
- Pollen cells and reproductive organs do not tolerate low temperatures.
- Symptoms appear after flowering.

Factors affecting frost damage:
- Period of risk
- Symptoms
- Diagnosis and symptoms
- Will the plant recover or compensate?
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CEREAL SUSCEPTIBILITY TO FROST DAMAGE

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- Symptoms appear after flowering.

Symptoms:
- Pollen cells and reproductive organs do not tolerate low temperatures.
- Symptoms appear after flowering.
Frost damage reduces crop yield and grain quality. Early identification of symptoms allows timely crop salvage decisions to be made.

### Factors affecting frost damage

Frost damage is possible under a variety of weather conditions, including:
- **Extremely low temperatures for a short duration**
- **Long duration with moderate temperatures**
- **Frost at flowering**
- **Frost at tillering**

### Why does it occur?

- **The head is emerging**
- **The stem begins to elongate**
- **The growing tip has grown away from the protection of the soil, when the stem begins to elongate, through the tillering stage, and finally through the boot stage**

### Period of risk

Cereal crops are most susceptible to frost damage during the period of greatest frost risk in the area. Factors affecting frost damage include:
- **Temperature**
- **Soil type**
- **Soil moisture**
- **Cloud cover**
- **Wind speed**
- **Humidity**

### How to use this guide

The guide will help you to identify frost damage symptoms and to also determine prognosis of other plant symptoms often confused with frost damage. Symptoms may not be obvious until 5 to 7 days after the frost.

### Diagnosis and symptoms

- **Head**
  - **Flattened or twisted**
  - **Florets bleached, shrivelled, or dwarfed**
  - **Spikelets shrivelled**
  - **Tillers distorted**
  - **Mature stems and nodes often blistered and/damaged**
  - **Water and nutrient supply to the crown may be disrupted**

- **Stem**
  - **Crimping & cracking of base**
  - **Florets bleached, shrivelled or dwarfed**
  - **Mature stems and nodes often blistered and/ or cut off water and nutrient supply to the crown**

### Bleached, shrivelled and dwarfed florets

- **Florets bleached, shrivelled or dwarfed**
- **Mature stems and nodes often blistered and/or cut off water and nutrient supply to the crown**

### Plant parts referred to in this guide:

- **Peduncle**
- **Ovary**
- **Anther**
- **Stigma**
- **Pollen cell**
- **Reproductive organ**
- **Ear/head**
- **Floret 1**
- **Floret 2**
- **Floret 3**
- **Lower glume**
- **Upper glume**
- **Lower lemma**
- **Upper lemma**
- **Rachilla**
- **Whisker**
- **Spikelet**

### CEREAL SUSCEPTIBILITY TO FROST DAMAGE

<table>
<thead>
<tr>
<th>Period of Risk</th>
<th>Plant Part</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-boot</td>
<td>Anthers</td>
<td>Healthy and active, elongated, turgid, sterile, and white to yellow in colour</td>
</tr>
<tr>
<td>Ear emergence</td>
<td>Anthers</td>
<td>Healthy, sterile, and white to yellow in colour</td>
</tr>
<tr>
<td>Post-boot</td>
<td>Anthers</td>
<td>Bleached, shrivelled, or dwarfed, sterile, and brownish in colour</td>
</tr>
</tbody>
</table>

### How to identify frost damage

- **Period of risk**
- **Symptoms**
- **Check other areas**

### How to salvage

- **Frost affected**
  - **Healthy**
  - **Dead**

### FLOWERING FROST

- **Frost at flowering**
- **Frost at tillering**
- **Frost at booting**
- **Frost at maturity**

### ANTHERS, STIGMA AND Ovary

- **Healthy and active**
- **Bleached, shrivelled or dwarfed**
- **Sterile**
- **Dead**

---

**Frost affected areas**

- **Healthy:** green, firm, and normal in appearance
- **Bleached, shrivelled or dwarfed:** bleached, shrivelled or dwarfed, and sterile
- **Sterile:** brownish, firm, and normal in appearance
- **Dead:** bleached, shrivelled, and dead

---

**Diagram not to scale**
Frost damage reduces crop yield and grain quality. Early identification of symptoms allows timely crop salvage decisions to be made.

### Symptoms

**Common Symptoms:**
- Anthers
- Peduncle
- Stems
- Nodes
- Leaves
- Ear (head)
- Pedicel

**Frost Symptoms:**
- Pale green to white ring on the peduncle
- Peduncle base often blistered
- Pedicel base (when pulled away from the stem) often blistered
- Pale green to white ring on the peduncle

**Healthy Symptoms:**
- Green to yellow in colour
- Anthers

### Diagnosis and Symptoms

**Anters Stigma and Ovaries**

**CEREAL SUSCEPTIBILITY TO FROST DAMAGE**

<table>
<thead>
<tr>
<th>Cereal</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oats</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Why does it occur?**

When the head is emerging from the boot, frost can affect the reproductive organs – grain will not form. The surviving ears will then normally provide the same yield as before frost.

**Why is it occurring?**

Frost affects the head at a small amount inside the head. More external damage of the boot is affected. The transition phase is followed by a frost. The transition phase is followed by a frost. Weather conditions can be critical by this stage.

**Exterior damage**

- When the head is emerging from the boot, frost can affect the reproductive organs – grain will not form. The surviving ears will then normally provide the same yield as before frost.

**Internal damage**

- When the head is emerging from the boot, frost can affect the reproductive organs – grain will not form. The surviving ears will then normally provide the same yield as before frost.

**Frost affected anthers**

- White turning dull in colour
- Often ‘banana’ shaped
- Dead tip of spikelet
- Sometimes a process of elimination

**Healthy anthers**

- Green to yellow in colour
- Anthers

**Flowerhead**

- Healthy
- Frost affected

**Anters, Stigma and Ovary**

**Bleached, shrivelled and drowned florets**

**Frost affected**

- Pedicel base (when pulled away from the stem) often blistered
- Peduncle base often blistered
- Peduncle base often blistered

**Healthy**

- Green to yellow in colour
- Anthers

**CEREAL SUSCEPTIBILITY TO FROST DAMAGE**

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<td></td>
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Frost

Frost damage reduces crop yield and grain quality. Early identification of symptoms allows timely crop salvage decisions to be made.

Important time to recognize symptoms and also good draping height if no temperature (several) below 0°C has been near late. Check for long, high colured tassels of CW until frost near late. Test look each other area.

Symptoms may be obvious within 5 to 7 days after the first frost.

To identify frost damage

• early symptoms are often confused with frost damage. It also contains pictures of those areas.

This field guide will help you identify the common symptoms of frost damage in cereal crops. It also contains pictures of other plant symptoms often confused with frost damage.

How to use this guide

• you MUST OPEN FLORETS and peel back leaves on plants to see clearly on the plant that has an affected. Using a magnifying glass to stain insect or smooch on soil.

To see how this guide

The field guide will help you identify the common symptoms of frost damage in cereal crops. It also contains pictures of other plant symptoms often confused with frost damage.

Factors affecting frost damage

Frost damage can be made to the plant by grass underlyng fairly south and on the same type. This is caused by many factors including: temperature, wind speed, movement, dew point, dust cloud, landscape, crop species, crop moisture and crop density.

Period of risk

General advice is to keep frost damage as far away from protection as possible, then to reduce the damage through one or more of these options.

Frost damage management depends on needing to grow crop and the damage can be controlled with the punch point in the area.

Which areas are susceptible?

Lauer, more Frost and glass can be affected. Frost in some areas can occur at any time through the growing season.

Will the plant recover or compensate?

Sometimes a "process of elimination" is required to decide whether crop damage has occurred for example, if the area is not affected and the glass has not been disrupted, it is unlikely that the crop has been affected. If the more widely affected winter crops, glass greatly improves the likelihood of being damaged. This can be done by looking at the area and other two to three areas.

ACHEELED, SHRIVELED AND DWARFED FLORETS

Why does it occur?

When the head is sitting from the frost, all of the activity that could occur in the head will not occur and the plant will not recover.

Symptoms

Anthers are bleached, shrivelled and dead. Heads will not recover from this stage of frost damage.

FLOWER FROST

Period of risk

Following blight and pod borer damage, only the temperature remains for a short time. There are exceptions from the crop in flowering.

When blight is causing in the center of the head and becomes to the top and outside of the plant.

Diagnose and symptoms

• the florets of the head open but do not develop.
• the florets open in the part of the head, but the florets do not develop in the part of the head.

In many cases frost will not reduce all of the frost damage and the crop will be affected.

External damage

The amount of frost damage may be minimal if the crop is not affected by frost. Water and nutrient supply is usually not cut off by this frost damage, however subsequent water and nutrient supply is usually limited due to frost damage. Separate the leaves, heads and ears affected from the non-affected heads and ears.

Frost affected

• when the head is affected (brownish) due to microbial invasion, the heads are bleached, shrivelled and dead. The surviving florets are bleached, shrivelled and dead. The surviving heads are bleached, shrivelled and dead. The surviving heads will not recover from this stage of frost damage.

Anthes, stigma and ovary

Common terms used in this guide:

- Anthe
- stigma
- ovary

Plant parts referred to in this guide

Frost affected

Healthy

Plant parts referred to in this guide

Frost affected

Healthy

Frost affected

Healthy

• the area of the head will develop and the florets will not develop in this stage of frost damage.

Many cases, frost will not reduce all of the frost damage and the crop will be affected.

ANTHERS, STIGMA AND OVARY

Common terms used in this guide::

- anthe
- stigma
- ovary

Plant parts referred to in this guide

Frost affected

Healthy

Plant parts referred to in this guide

Frost affected

Healthy

Frost affected

Healthy

These are exposed when the crop damage is being grown away. The ease at which the head and extends to the top is near or at flowering.

These are exposed when the crop damage is being grown away. The ease at which the head and extends to the top is near or at flowering.

Diagram not to scale

Note:

Susceptibility to frost damage

CEREAL SUSCEPTIBILITY TO FROST DAMAGE

LOW HIGH

Susceptibility to frost damage

Diagram not to scale

Note:
Frost

Frost damage reduces crop yield and grain quality. Early identification of symptoms allows timely crop salvage decisions to be made.

Identifying damage

Commonly confused with frost damage are other plant symptoms, such as disease or pest damage. Symptoms of frost damage in cereal crops can be detected on the peduncle (brownish) due to microbial attack.

To identify frost damage:

1. Inspect cereal crops between ear emergence and late grain filling. Before flowering, the peduncle is green in colour. Anthers are green to yellow in colour.

2. During flowering, examine the petals for pollen cells and reproductive organs:
   - Healthy anthers are white and dull colored.
   - Frost affected anthers turn green to yellow to brown/black due to microbes.

3. Examine the floret 1 (due to microbes). Anthers are white and dull colored. In many cases, stem frost will reduce the yield of affected tillers. Frost affected tillers and heads killed will not produce grain.

4. Fallow fields and pasture damage does not occur at low temperatures. There are no clear frost symptoms in fallowing.

5. Check for the following:
   - Crimping & cracking of base
   - Pale green to white ring on the peduncle
   - Cracked and/or blistered peduncle
   - Dead tip of spikelet
   - Bleached, shrivelled and dwarfed florets

CEREAL SUSCEPTIBILITY TO FROST DAMAGE

<table>
<thead>
<tr>
<th>Period of risk</th>
<th>Cereal susceptibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early to mid-June</td>
<td>Low for wheat, High for barley</td>
</tr>
<tr>
<td>Late June to mid-July</td>
<td>Low for wheat, Barley and oats, High for barley</td>
</tr>
<tr>
<td>Mid-July to mid-August</td>
<td>Low for wheat, High for barley</td>
</tr>
</tbody>
</table>

Frost damage management to date has focused on avoiding susceptible crop stages coinciding with the period of greatest frost risk in the area.

Factors affecting frost damage

- Light colored soil types and known frost prone areas first.
- Soil moisture and nutrients may reduce susceptibility. Nutrient deficiencies may make crops more susceptible to frost damage.
- The ease at which the head and external damage can be assessed.

HOW TO USE THIS GUIDE

1. Fill in your location.
2. Use the chart to identify symptoms.
3. Schedule timely crop salvage decisions to be made.
4. Monitor your paddocks and check for the following:
   - Pale green to white ring on the peduncle
   - Cracked and/or blistered peduncle
   - Dead tip of spikelet
   - Bleached, shrivelled and dwarfed florets

BLEACHED, SHRIVELLED AND DWARFED FLORETS

- Dead tip of spikelet
- Bleached, shrivelled and dwarfed florets
- Symptoms
   - Pale green to white ring on the peduncle
   - Cracked and/or blistered peduncle
- Will the plant recover or compensate?
   - Sometimes a "process of elimination" is required to decide whether crop damage has occurred. For example, if one area of a paddock is affected, that area can be examined for frost symptoms. If the area is not frozen, the paddock can be examined for other pest or disease damage.
   - In many cases, stem frost will reduce the yield of affected tillers.

WHY DOES IT OCCUR?

When the head is exposed from the boot, tillers are vulnerable to frost damage. The head is vulnerable from the protection of the soil, when the stem begins to elongate, through the period of risk until late grain filling.

WHICH PARTS ARE SUSCEPTIBLE?

The head and the peduncle (which contains the reproductive organs) are vulnerable to frost damage.

Symptoms

- Bleached, shrivelled or dead tillers, heads, seedpod and ears.
- The reproductive organs are damaged. Seed will not form.
- The survival of affected tillers depends on their stage of development at frost damage.

WHEN TO INSPECT?

- Once a heat wave has occurred and the heads have started to emerge.
- Early to mid-June
- Late June to mid-July
- Mid-July to mid-August
- Prior to flowering
- Examine stem and head symptoms.

FLOWER FROST

- Fallow fields and pasture damage does not occur at low temperatures. There are no clear frost symptoms in fallowing.

- Check for the following:
  - Pale green to white ring on the peduncle
  - Cracked and/or blistered peduncle
  - Dead tip of spikelet
  - Bleached, shrivelled and dwarfed florets

- Note: Always check for other symptoms of frost damage. Frost affects the reproductive organs. Healthy Anthers

ANTHERS, STIGMA AND OVARY

- Healthy anthers and reproductive organs:
  - Pollen cells and reproductive organs: green to yellow
  - Anthers: healthy, white and dull colored

- Frost affected anthers:
  - Pollen cells and reproductive organs: brownish
  - Anthers: dead, brown/black due to microbes

- Symptoms
  - Pollen cells and reproductive organs: brownish
  - Anthers: dead, brown/black due to microbes

- Dead tip of spikelet:
  - Bleached, shrivelled and dwarfed florets
  - Symptoms
  - Pale green to white ring on the peduncle
  - Cracked and/or blistered peduncle

- Will the plant recover or compensate?
  - Sometimes a "process of elimination" is required to decide whether crop damage has occurred. For example, if one area of a paddock is affected, that area can be examined for frost symptoms. If the area is not frozen, the paddock can be examined for other pest or disease damage.

- In many cases, stem frost will reduce the yield of affected tillers.
FROST SYMPTOMS IN BARLEY AND OATS

Barley

- Bending stems tending to the East
- Peduncle bends to point of frost
- Whole plant is affected
- Contains grain that has formed but not filled properly. Affected plants will follow (Crown rot and take-all) cause white heads.
- Frosted barley heads (unaffected on left).
- Frosted oat panicle.

Oats

- The florets hang downwards during freezing
- Tilted peduncle usually not a good indicator
- Pointy heads from frost exposure
- Frost exposed heads appear darker and thinner than normal

OTHER PROBLEMS WITH SIMILAR SYMPTOMS

- There are many other problems that are confused with frost damage.
- The main ones are those that cause white and distorted heads.
- Many environmental factors, including stress due to drought, and nutrient deficiencies will cause small and/or distorted heads due to a general or local reduction in plant vigor.
- The main ones are those that cause white and distorted heads.
- There are many other problems that are confused with frost damage.
- Many environmental factors, including stress due to drought, and nutrient deficiencies will cause small and/or distorted heads due to a general or local reduction in plant vigor.

MATURE GRAIN

- Healthy grains (developing)
  - Green and plump appearance,
  - Usually “spongy” when squeezed,
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  - Usually “spongy” when squeezed,
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  - Usually “spongy” when squeezed,
Diagnosis
• Frosted grain will form at or near field critical temperature and will exude liquid white milk/dough. Affected grain will be light to dark green, and the peduncle/axis will show signs of frost damage. Affected grain can be peeled open. The flesh is often blue/grey and the peduncle/axis is often the pale green of a healthy plant. Affected grain can have a detrimental effect on sample acceptance.
• Frosted grain is creased along the long axis, rather like a pair of long nose pliers has crimped the grain, or the grain can have a blue/grey appearance. Frosted grain will usually “sponge” when squeezed, has a light to dark green colour, and can be dimpled and crimped. Frosted grain can have a detrimental effect on sample acceptance.

Mature Grain
• Affected grain can have a blue/grey appearance, and the peduncle/axis will show signs of frost damage. The peduncle/axis will have crimped along the long axis, rather like a pair of long nose pliers has crimped the grain, or the grain can have a blue/grey appearance. Frosted grain will usually “sponge” when squeezed, has a light to dark green colour, and can be dimpled and crimped. Frosted grain can have a detrimental effect on sample acceptance.

Other Problems with Similar Symptoms
• There are many other problems that are confused with frost damage. The main ones are those that cause white and distorted heads. There are many other problems that are confused with frost damage. The main ones are those that cause white and distorted heads. Many environmental factors, including pests, can affect the structure of plant parts and the way that the plant develops. There are many other problems that are confused with frost damage. The main ones are those that cause white and distorted heads. Many environmental factors, including pests, can affect the structure of plant parts and the way that the plant develops.
• FROST SYMPTOMS IN BARLEY AND OATS

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• Barley: Barley may be frost damaged prior to heading. Affected barley will have crimped along the long axis, rather like a pair of long nose pliers has crimped the grain, or the grain can have a blue/grey appearance. Frosted grain will usually “sponge” when squeezed, has a light to dark green colour, and can be dimpled and crimped. Frosted grain can have a detrimental effect on sample acceptance.
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Healthy developing grain barley. Frosted grain barley. Frosted grain barley. Frosted grains. Frosted barley heads (unaffected on left).


Healthy grain (developing)
• Light or dark green colour - normal late flowering stage and maturity
• Barley: Normal heading/flowering stage and maturity
• Sheared stubble - typical appearance, usually “spry” when squared, does not yield satisfactory samples or confirm the presence of the grain because of the grain is certainly collected.

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**DEVELOPING GRAIN**

**Diagnosis**
- In severe frost grain will form but not properly sealed or filled in the seedcoat.
- Lightly tap the sack or straddle check for frost damage. If a score of cold heads is evident, new straw will often appear in the lower part of the grain.

**Healthy grain (developing)**
- Light or dark grey colour to the grain and seed without a prominent blue-grey or greenish sheen.

**Affected grain**
- White, sometimes browning from the top downwards. Glazed and glossy appearance, usually “spongy” when squeezed.
- Often small and usually less than half normal size, with less than half the normal volume of endosperm.

**OTHER PROBLEMS WITH SIMILAR SYMPTOMS**

**MATURE GRAIN**

**Healthy developing endosperm (crop stage: dough)**
- Exudes liquid (white milk/dough) when squeezed.
- Green and plump appearance.
- Usually “spongy” when squeezed.
- Dimpled and crimped appearance.
- White, eventually turning brown when stressed and nutrient deficient grain.

**Frosted endosperm (crop stage: dough)**
- Creases are regular, not random as in frost damage. Usually the case, with moisture deficit and nutrition deficient grain.
- Takes on the plastic look of frost damage.
- Blue/grey appearance.
- In some cases the grain will have a blue/grey appearance.

**FROST SYMPTOMS IN BARLEY AND OATS**

Barley
- Browning symptoms, forming a layer of frost against first-formed rowing.
- Whole plants may be affected, leading to a decrease of grain.

Oats
- The finger hangs downwards drooping, usually with the flag leaf very visible at the base and only the lowermost two rows of florets from lowermost leaf visible.
- A bright white frost coating occurs on the pericarp in varying thickness.

**FURTHER INFORMATION**

Further information can be obtained from
Department of Agriculture Western Australia
Development Board
Merredin
Western Australia 6415
Website: http://www.agric.wa.gov.au

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**CEREALS Frost Identification: THE BACK POCKET GUIDE**

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**CEREALS Frost Identification: THE BACK POCKET GUIDE**
**DEVELOPING GRAIN**

- Diagnose in the early growth stage of the plant when affected heads are identifiable by:
  - the presence of white dough-like material or blisters in the ear;
  - a blue/grey sheen on the affected tissue;
  - the presence of a mechanical stress injury (i.e., a mechanical tear or hole in the ear).

**Healthy grain development**

- Light or dark green colour;
- Quality seed;
- Smooth and uniform appearance.

**Affected grain**

- White, yellow, or brown heads;
- Poorly filled seeds;
- Bulky and plump appearance;
- Presence of mechanical stress injuries.

**MATURE GRAIN**

- Whole plant is affected, containing grain that has formed but not filled properly. Affected plants will follow soil type.

**FROST SYMPTOMS IN BARLEY AND OATS**

- Barley
  - Frost damage occurs to the leaf, stem, and head regions. The presence of affected heads in barley indicates frost damage.

- Oats
  - Frost damage occurs to the leaf, stem, and head regions. The presence of affected heads in oats indicates frost damage.

**Diagnosis of frost damage**

- Healthy developing heads (unaffected on left).
- Frosted heads (affected on right).

**OTHER PROBLEMS WITH SIMILAR SYMPTOMS**

- There are many other problems that are confused with frost damage. Some of the main ones are those that cause white heads.

- Barley
  - Moisture stress (drought tipping) – tips of ears can be affected in patches.

- Oats
  - Diseases (Crown rot and take-all) cause white heads.

**FURTHER INFORMATION**

- Further information is available from:
  - Department of Agriculture Western Australia
  - Oats, Barley and Oats Bulletin 4375
  - Healthy developing endosperm (dough).
  - Frosted endosperm (dough).

- Healthy developing oat grains.
- Frosted oat grains.

- Diagnosis of frost damage (unaffected on left).

- Frosted oat panicle.
- Frosted oat heads (unaffected on left).

- Frosted barley heads (unaffected on left).
- Healthy developing barley heads.

- Healthy endosperm (dough).
- Frosted endosperm (dough).

- Frosted barley heads (unaffected on left).
- Healthy developing barley heads.

- Healthy developing grain.
- Frosted grain sample.

- Frosted grains (creased along the long axis, rather like a pair of long-nose pliers that has squeezed the grain).

- Frosted grains (dimpled and crimped appearance, usually "spongy" when squeezed, often the case with moisture stress or with nutrient deficiencies).

- Frosted grain (in some cases the grain will have a blue/grey appearance, which is usually the case, with moisture stress and nutrient-related stress).
Diagnosis

- Frosted grains will turn a soft, pale green as frost-induced tissues become bleached and form a papery feel to the affected part of the grain.
- Affected heads
  
  - Many environmental factors, such as moisture deficit during anthesis, and nutrient deficiencies, will come small barley heads or lodging in a-general, frost is a less
  
  - Other problems with similar symptoms

  - Effects on sample acceptance.
  - Moisture stress symptoms, and all plants will be affected.
  - White, eventually turning brown.
  - Blue/grey appearance.
  - Dimpled and crimped appearance.
  - Creases are regular, not random as is the case, with moisture stress and nutrient deficiency.
  - Burred grain occurs as a detrimental effect on sample acceptance.

Frost affected barley heads (unaffected on left).

Mature grain

- Frosted grain is creased along the long axis, rather like a pair of long nose pliers has crimped the grain, axis, rather like a pair of long nose pliers has crimped the grain.
- Losses are usually 5-10% of the grain crop, but can be much higher under severe frost conditions.
- Frosted grain can have a detrimental effect on sample acceptance.
- Green and plump appearance.
- Light to dark green colour.
- Exudes liquid (white milk/dough) when squeezed.
- Dimpled and crimped appearance.
- Usually "spongy" when squeezed.
- Dished and sunken appearance may develop in some cases (due to microbes).
- Dished and sunken appearance, usually the case, with moisture stress and nutrient deficiency.
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