Department of Primary Industries
primefact

Frost damage in citrus

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Frosts with temperatures low enough to damage fruit occasionally occur in the southern growing regions of Australia. Action can be taken to reduce the risk of frost and identify-frost affected fruit.

Freezing of fruit

Ripe citrus pulp freezes at about −1.9 to −3.9 °C. Whether frost damage will occur is determined by both time and temperature: the fruit needs time to decrease in temperature and reach freezing point.

Factors affecting frost damage to fruit

Mature fruit is less susceptible than immature fruit to frost damage, as the sugar in the juice acts as an antifreeze (i.e. late-maturing navels are more susceptible than early-maturing navels). There might also be varietal differences in fruit susceptibility to frost damage (e.g. lemons are more susceptible to frost than oranges).

Smaller fruit will freeze quicker than larger fruit because they contain less stored heat energy.

The tree canopy can provide some protection. Exposed fruit on smaller trees is at greater risk of damage than fruit inside the canopy of mature trees. Fruit on trees that are sick or have low vigour and sparse canopies is also at high risk.

The vast majority of frosts in inland regions are radiation frosts (still nights, clear skies). Temperatures are lower closer to the ground, and damage might be more prevalent in the lower parts of the canopy.

Factors affecting frost in the orchard

Moist soils can store heat and affect temperatures within the orchard; dry soils store less heat. Bare soil can adsorb heat from sunlight and dissipate heat better than sod- or mulch-covered soil can. Wetting the soil can increase temperatures by 1 °C, and mowing the inter-row sod can increase temperatures by a further 1 °C. Moist, bare soil in the inter-row can increase orchard temperatures by 2 °C above a dry mulch- or sod-covered soil.

Frost can be worse if temperatures stay low on consecutive days: fruit temperatures remain low and the fruit freezes quickly, as it has little stored heat to resist freezing.

The lower parts of a block are at greater risk of frost than the higher parts, as dense cold air moves to the lowest parts of an orchard. Cold air movement can be restricted by windbreaks and the topography, causing frosts in unusual places.

Blocks next to native dryland vegetation or open paddocks are also at higher risk.

Frost risk guidelines

Fruit susceptibility to frost varies. The following points are general guidelines to the risk of frost damage:

- −2 °C for 4 hours. There is a risk of damage. Check the fruit immediately.
- −4 °C for 2 hours. There is a risk of damage. Check the fruit immediately.
- −4 °C for 5 hours. There is a significant risk of damage. Suspend harvest for 10–14 days.

Monitoring and assessment

Reviewing data from an infield temperature logger is very important to identify susceptible blocks. Temperature loggers should be installed at 1.2 m height in the outer tree canopy. Temperature loggers are often installed in low areas of the orchard or in frost-sensitive varieties. Cutting fruit on the morning of the frost event can

provide valuable information. The presence of ice crystals in the fruit will indicate internal damage. However, external damage can occur without internal damage and vica versa.

In low-risk situations, harvest can continue pending the results of frost-morning fruit cutting assessments and review of the temperature data.

In a significant risk situation, it is best to wait 14 days for internal and external damage symptoms to appear.

Assess fruit throughout the whole block and on both sides of the row, as frost can affect a portion of the block. Focus on sampling the exposed and lower-positioned fruit.

Fruit damage

External damage

External frost damage symptoms differ with variety and frost severity. Water-soaked rind damage can appear within a day (Figure 1). Oleocellosis-type damage (skin injury from rupture of the oil glands) can take between 3 and 14 days for symptoms to fully develop on the rind (Figures 2 and 3). Fruit abscission can result from frost damage, particularly in lemons, Valencia oranges and mandarins.

Figure 1. Water-soaked rind damage within a day of a frost event

Figure 2. Oleocellosis-type damage can take 3 to 14 days to be fully expressed on the rind of the fruit.

Figure 3. Frost damage symptoms on the rind can take 3 to 14 days to develop fully.

Internal damage

As ice forms in the juice vesicles they expand and break open. Frozen juice then escapes from the fruit segment. When the fruit thaws, water in the juice is transpired through the rind, leaving small hollows in the fruit.

The broken juice sacs can be detected by an experienced assessor from five to seven days after the frost event. A very sharp knife must be used to slice the fruit. Broken vesicles give the cut fruit a ragged appearance (Figure 4).

Internally damaged fruit will eventually develop off flavours and be unmarketable. Externally damaged fruit is at risk of in-transit breakdown.

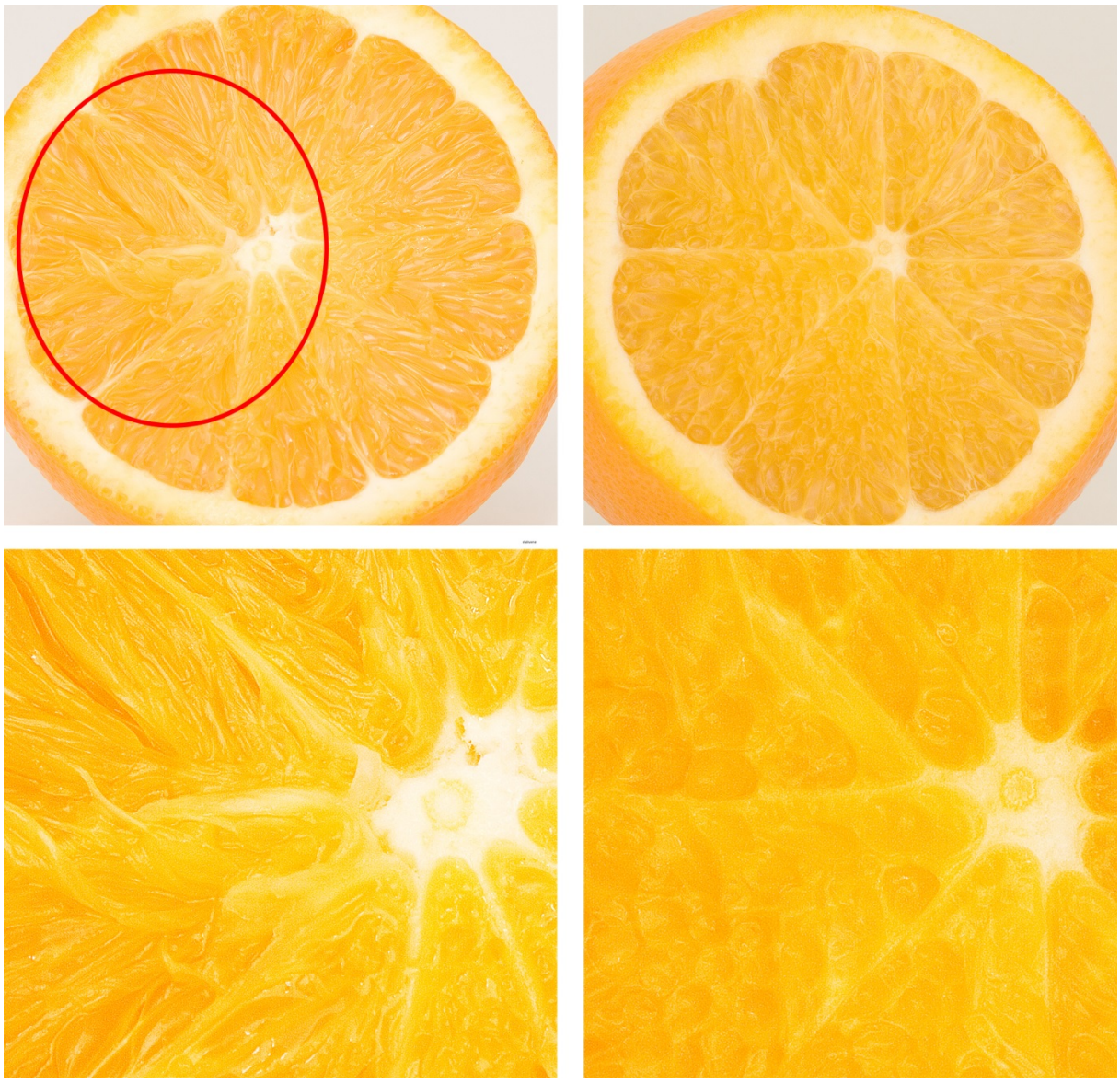

Figure 4. Left upper and lower: Fruit with early internal symptoms (five to seven days) after frost damage. Because the vesicle walls have ruptured they have a ragged appearance on the cut surface. Right upper and lower: Fruit not affected by frost. There is a clean cut on the fruit surface and the rounded shape of the juice vesicles remains intact.

Early visible cut-fruit signs can be made more obvious by allowing the cut fruit to dry for 24 hours or accelerating the drying process with a fan heater (Figure 5).

Figure 5. Cut fruit that has been allowed to partially dry shows symptoms of juice vesicle damage.

Symptoms of internal fruit dryness can show up after seven days of a frost event and are clearly visible after two weeks (Figures 6 and 7). Damage should not be confused with fruit sunburn or granulation, which can have similar symptoms.

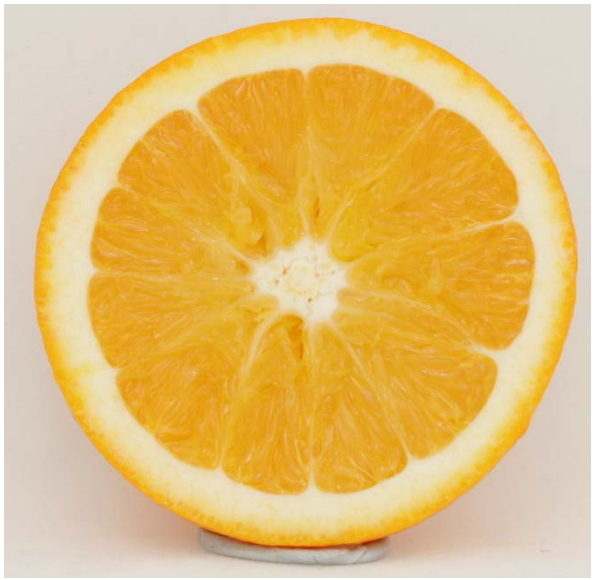

Figure 6. Frost-damaged fruit two weeks after a frost event.

Figure 7. Close-up of frost-damaged fruit two weeks after a frost event

Cutting method

Cutting the fruit in four slices increases the chance of detecting damage (Figure 8). A sharp knife must be used; specialised long-bladed fruit-cutting knives are sometimes sold by agricultural supply stores. Take care not to cut your hands; cut-resistant gloves are sold at outdoor supply stores.

Figure 8. Cutting the fruit in four slices increases the chance of detecting damage.

On-tree symptoms

A light frost that will not affect the fruit can burn young shoots (Figure 9). A significant frost will affect mature foliage and possibly the whole tree (Figure 10). Severely affected trees show signs of leaf wilt, and the leaves can eventually drop off.

Figure 9. A light frost can damage young shoots.

Figure 10. A severe frost can affect the whole tree.

Communication

It is critical that you actively work with your packing house in assessing fruit damage and harvesting frost-affected blocks. If frost-damaged fruit is sent to market it might need to be repackaged at export markets. Unsatisfied customers and repackaging greatly reduce financial returns.

Minimising frost damage

- Moist soil radiates heat at night, increasing localised temperatures. Install on-farm irrigation storage dams if winter water access is limited. Maintaining adequate soil moisture in dry-winter years prevents water stress of trees; such trees are more likely to be damaged by frost.
- Overhead irrigation can be used effectively to mitigate frost damage on suitable soil types. However, if there are consecutive frost events this can cause temporary waterlogging issues. Water application output rates need to be matched to the canopy size and the expected temperature of the frost.
- Using unsuitable windbreak trees can prevent cold air drainage across an orchard. Opening a gap in a windbreak can improve air movement.
- Frost fans are effective when there is a warm inversion layer of air to pull down and force cold air out of the block. Frost fans can cover 3 to 8 ha, depending upon model and design.
- Fruit inside the canopy is less affected than external fruit by frosts. Selective annual pruning will encourage more fruit production inside the canopy.
- Keep inter-row vegetation mowed low.
- Some growers burn hay bales or windbreak prunings to try to raise orchard temperatures during frost events. Fuel burner pots have been used in the USA to mitigate frost damage.

More information

Detailed information on frost prevention in citrus is in the 2011 September/October issue of Citrograph. (http://citrusresearch.org/frost_issue)

Acknowledgments

Some of the information presented this Primefact was based on a presentation developed by Tony Filippi (formerly Murray Valley Citrus Board development officer) and Steven Falivene during the 2006 Sunraysia frost event.

For updates go to
http://www.dpi.nsw.gov.au/citrus

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