AGRICULTURE VICTORIA

Evaporative cooling in apple and pear orchards

Evaporative cooling in apple orchards is used to prevent sun damage of the fruit by applying overhead watering and lowering fruit surface temperature. Overhead watering during the daytime can lower fruit surface temperature by 15 – 20 °C. Scheduling of evaporative cooling systems is critical to keep fruit cool during the daytime, minimize the risk of waterlogging and avoid wasting water.

Losses from extreme heat damage to fruit have been significant in recent years and are likely to increase with global warming. Fruit can be sunburned, flesh can breakdown, colour formation can be suppressed and fruit colour can be fade from exposure to the sun during hot weather.

Damage thresholds

Considerable research has been undertaken on apples to determine damage thresholds. Three different types of sun damage have been identified:

1) *Photo-oxidative sunburn* can occur at fruit surface temperatures as low as 31 °C, where previously shaded fruit are exposed to direct sunlight. This causes bleaching of the skin followed by necrosis (cell death).

2) *Sunburn browning* occurs at fruit surface temperatures between 46 and 49 °C (depending on cultivar) for 60 min coupled with exposure to ultra-violet B (UV-B) radiation. This causes a browning of the skin but the flesh remains relatively unaffected.

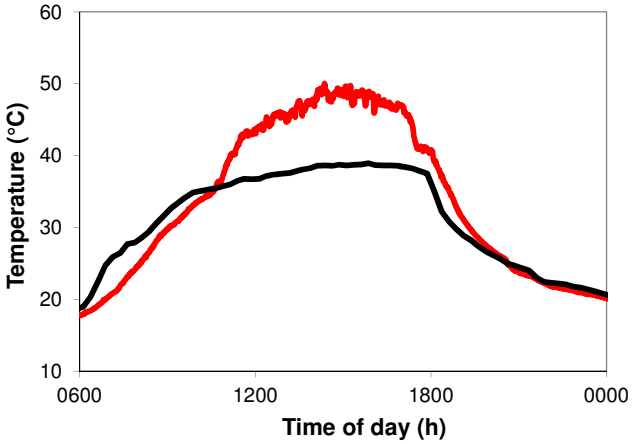
3) *Sunburn necrosis* occurs when the fruit surface temperature exceeds 52°C for 10 min and causes death of the skin and flesh cells.

Photo-oxidative (left), browning (centre) and necrosis (right) sunburn in apple.

Pears will also suffer from exposure to the sun during hot weather. Sunburn browning and necrosis in pears occurs at fruit surface temperatures greater than 47 and 50 °C, respectively. Unlike apples, red-skinned pears appear to loose colour when exposed to the sun. This is from the combination of suppression in colour formation and degradation of existing red colour.

Fruit surface temperature

Energy from direct exposure to the sun causes fruit to heat up. The surrounded air then cools fruit. For example, low air temperature and wind will dissipated the heat from the fruit surface and cool the fruit. Fruit exposed to direct sunlight can be 10 – 15 °C above air temperature on clear, calm days with low humidity. These weather conditions are common during summer and autumn in most fruit growing districts in southern Australia.



Fruit surface temperature of a sun exposed apple (red line) and air temperature (black line) in a Goulburn Valley orchard.

Overhead watering

Overhead watering aims to reduce fruit surface temperature below damage thresholds through evaporative cooling. Water must be on the fruit surface to evaporate and cool the fruit. This is not the same as hydrocooling where cool water removes heat from fruit by conduction. Evaporative cooling uses much less water than hydrocooling.

When to commence

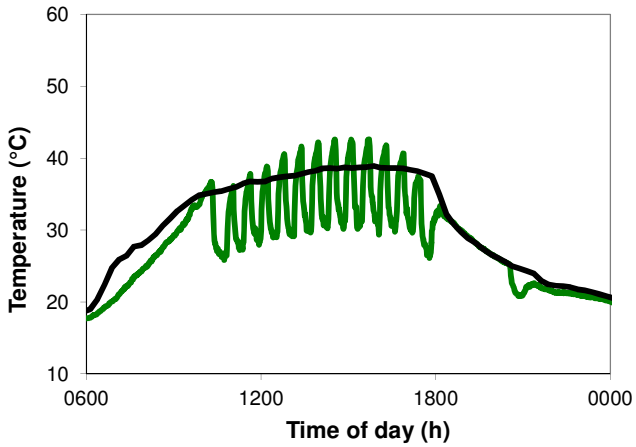
Overhead watering for evaporative cooling should be turned on when fruit surface temperature approaches the threshold for damage. Generally, this will occur at midday or in the early afternoon. Critical is to make sure fruit is cooled in the late afternoon. Fruit surface temperature can still be very high at 7 pm in the evening.

Pulsing

Pulsing the application of overhead watering is recommended to save water. Fruit is rapidly cooled when it becomes wet from overhead watering. When the overhead watering is turned off, the fruit surface will dry and then start to heat up but it does take some time reach damage thresholds. For this reason the overhead watering can be pulsed with typical on/off times of 15 minutes on then 15 minutes off.

Water requirement

Overhead watering for evaporative cooling not only cools the fruit but it also reduces leaf transpiration. Therefore, less root-zone irrigation is needed. Studies have shown that irrigation can be reduced by 5 mm for every 10 mm of overhead watering that is applied for evaporative cooling. Where application rates for evaporative cooling are high (e.g. 3 – 5 mm/h) then irrigation may not be needed. We strongly recommend that root-zone soil moisture is measured to help schedule irrigation after applying overhead watering for evaporative cooling.



The effects of pulsed overhead watering on fruit surface temperature of a sun exposed apple (green line) and air temperature (black line). This orchard in the Goulburn Valley received 13 watering events between 11 am and 6 pm.

Recommendations for evaporative cooling:

- Good quality water must be used to avoid leaf burn from salts in the water or discolouration of the fruit skin from clay particles in the water.
- Water must be distributed evenly so that all fruit exposed to the sun is wetted.
- Water should only be applied to the tree canopy to minimize the risk of waterlogging the root-zone and to avoid wasting water.
- A small droplet size is advised to get good fruit surface coverage but droplet size needs to be large enough to prevent wind drift.
- The watering system must be sufficiently automated to apply pulses (e.g. 15 min on then 15 min off).
- Application rates of 1 – 2 mm/h should not be exceeded as this is the maximum evaporation rate where apples and pears are grown in Australia.
- On clear, calm days with low humidity, overhead watering should commence when air temperature exceeds 32 °C.
- On cloudy, windy days with high humidity, overhead watering should commence when air temperature exceeds 35 °C.
- The pulse interval must be reduced during weather conditions where fruit surface temperature in likely to exceed 50 °C.
- The irrigation requirement to the root-zone can be reduced by approximately 50% of the water applied for evaporative cooling.

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