Olives New Zealand – BMP Shelter and Temperature

Shelter and Temperature by Sandy Lang and Murray Judd

It can sometimes be difficult to bring an olive crop to harvest maturity before the risk of an early frost becomes extreme. This is especially the case in the South Island. Plant growth is well known to be faster at warmer temperatures so anything that can be done to raise the temperature of the block, and thus advance its maturity, would seem to be well worthwhile. Radiation frosts are 5-times more common in New Zealand than air frosts and are associated with still-air conditions. Likewise, therefore, anything that can be done to lower the risk of radiation frost would also seem to be well worthwhile. How does a shelterbelt affect temperature?

SHELTER AND MEAN TEMPERATURE

Temperature is slightly increased away from the edge of a sheltered block due to lower windspeeds and less turbulent heat transfer out of the block but it is slightly reduced at the margins due to shading by shelter trees. Temperature is also slightly reduced at night in a sheltered block due to less air movement and less cold air drainage. These negative and positive-going effects of shelter on air temperature have a tendency to cancel one another out as far as the plants are concerned as their daily growth increment is related to the *average* temperature they experience over the period - see[TEMPERATURE AND PLANTS] and [TEMPERATURE AND OLIVES]

Certainly, with shelter, the spatial *variability* of temperature within the block is slightly greater (warmer towards the centre), and hence the temporal (diurnal) *range* of temperature is slightly increased but the *average* temperature (for the whole block and over a reasonable period of time) works out about the same. So, no *net*temperature gains are to be had with shelter and so no special gains in terms of an early harvest. Instead, the factors having the greatest effect on grove temperature are latitude, proximity to the sea, elevation and aspect. These are critical considerations at the time of site selection [SITE SELECTION] but are not amenable to change once you own the land.

SHELTER AND TEMPERATURE RANGE

We have already alluded to the idea that shelter tends to increase the *range* of air temperatures experienced by your olive trees – temperature increases and depressions. Let us look at these effects more closely.

NOTE: To avoid confusion where we must refer both to low temperatures (temperatures just a little above or below freezing) and also to small differences in temperature (where the temperature at one point may be just a little warmer or cooler than that at another) we adopt the slightly unconventional use of the symbol C° (the little superscripted 'o' follows the big 'c') to refer to a difference in temperature of so many 'Celsius degrees' and °C to refer (conventionally) to an actual temperature of so many 'degrees Celsius'.

Temperature increases: *Strong sunlight causes plant and soil surfaces to heat up. If there is some wind, forced convection ensures that leaves remain very close to air temperature – by contrast, if the air is still, leaves will be warmed several degrees above air temperature. These warm surfaces then transfer their heat to the air, which increases the orchard temperature. Thermal convection (heated air rises) prevents too severe overheating of the plants, even under low airflow conditions (shelter or low wind). The same tendency for temperatures to equalise does not apply at night*

Temperature depressions: Under clear, still nighttime conditions the effect is opposite to that during the day. Exposed surfaces (leaves) radiate heat and so they cool down to *below* air temperature by 1-2C°. These cooled leaves then cool the surrounding air which, being denser, subsides to the ground causing a build-up of the coldest air near the ground. This cold air may be several degrees cooler than the air 1 or 2 m higher up. If it is on a slope this cold air will pond in depressions and flow downhill over the terrain like a slow river. Meanwhile, the temperature of the general volume of air just 3-4 m higher up is relatively unaffected and remains significantly warmer.

Inversions - In sunny daytime conditions air temperatures decrease with height. The highest temperature is found near the ground and the air is cooler the higher you rise - you may have noticed the extremely cold air temperatures outside aircraft in flight. As the air adjacent to the ground is heated it becomes less dense and rises. This warm air develops into turbulent plumes which mix the orchard air with cooler air overhead. At night time these processes are reversed. The build-up of cold, heavy air near the ground (described above) means that air temperature increases with height in the lower few meters (see Fig 1). This inverted temperature profile tends to suppress mixing. Inversions are commonly from a few to several metres deep and become visible if there is ground mist.

Radiation frost - In the winter months it is common for air temperature to fall to 4°C or less due to the general synoptic conditions e.g. a southerly airflow. Under these conditions, and on a still, clear night, surfaces facing the sky, radiate heat and their temperature can easily fall below 0°C. If this happens, any dew present freezes over and further condensation of atmospheric water is deposited as crystals of ice (a hoar frost).

Any exposed parts of an olive tree whose temperature drops low enough for its cells to freeze (much below –1°C) are killed (see Figs.1 and 2).

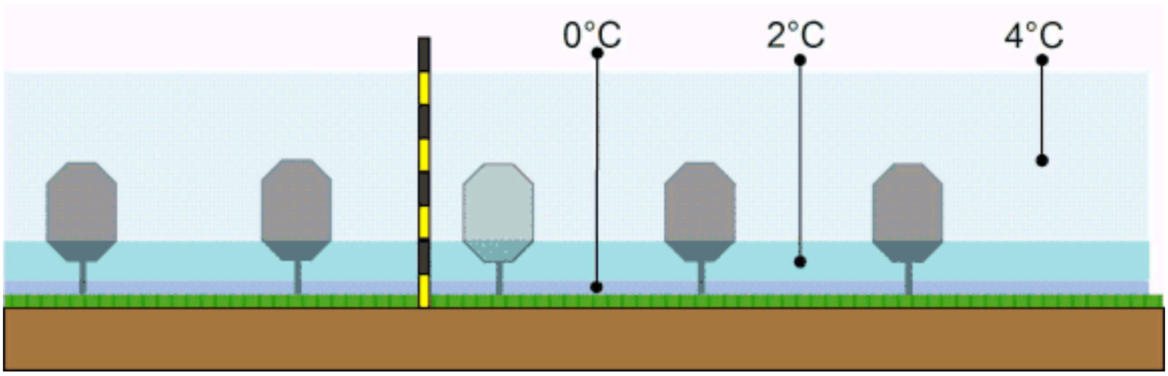

Figure 1. Diagramatic representation of air temperatures near the ground in an olive grove under a clear night sky and still-air conditions (no wind).

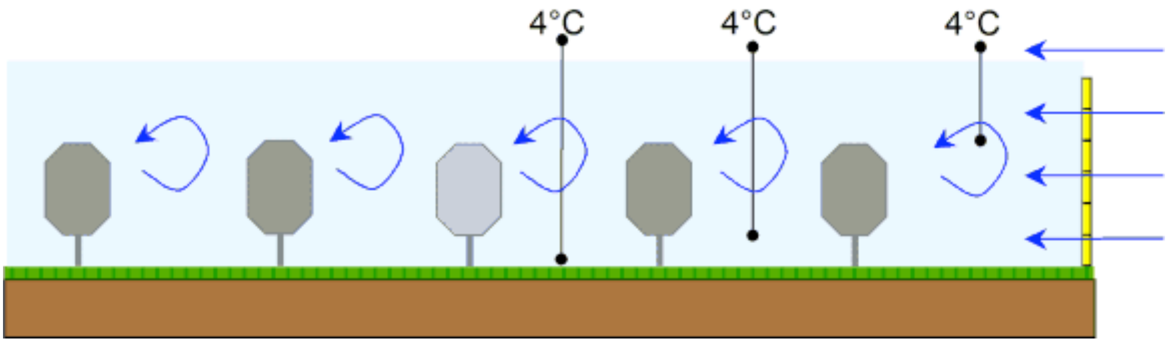

Figure 2. Air temperatures under a clear night sky but with very light air movement. There is just sufficient turbulence to prevent the formation of an inversion.

Shelter and frost

One of the conditions essential for a radiation frost is still air. Clearly if shelter reduces wind speed, shelter will also increase the risk of a radiation frost by reducing the turbulent mixing of the air (see Fig. 3). It is of course true that *immediately* adjacent to shelter, some frost protection occurs as the olive tree leaves 'see' less of the clear sky and hence do not cool to the same extent. Similarly, you will have noticed that garden plants close to the house do not suffer from frosts as badly as those in the middle of the garden.

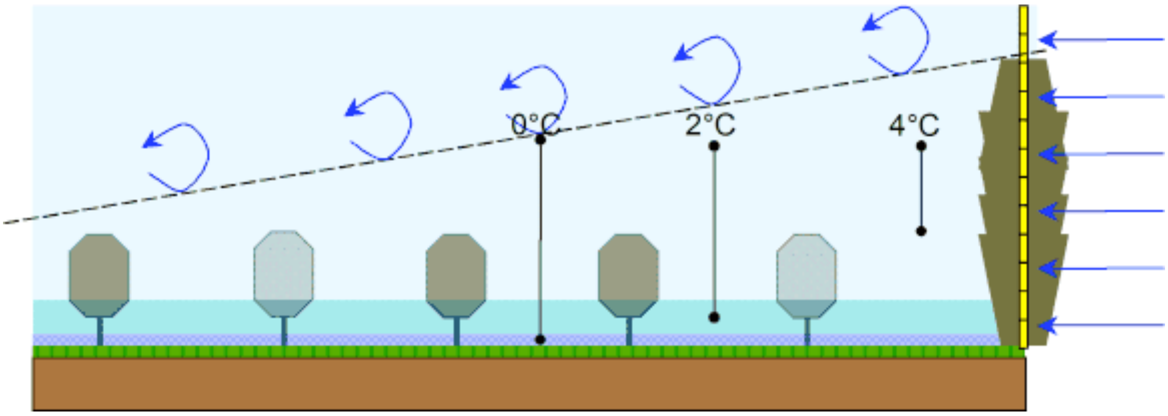

Figure 3. As previous figure but an upwind shelter has sufficiently slowed air movement close to the ground to allow an inversion to develop.

Sadly, it is very common to see signs of frost damage in New Zealand olive groves that are over-sheltered. This over-sheltered effect can arise either from an adjacent shelterbelt on the same (or a neighbouring) property, or from some natural feature of the local topography.

Shelter and damming

If under the same atmospheric conditions as Fig.1 (above) the land has a sloping aspect, this allows the dense, cold air close to the ground to drain away (see Fig. 4). The layer of draining cold air is continuously replaced by warmer air from above. A sloping aspect is well known to reduce the incidence of radiation frosts.

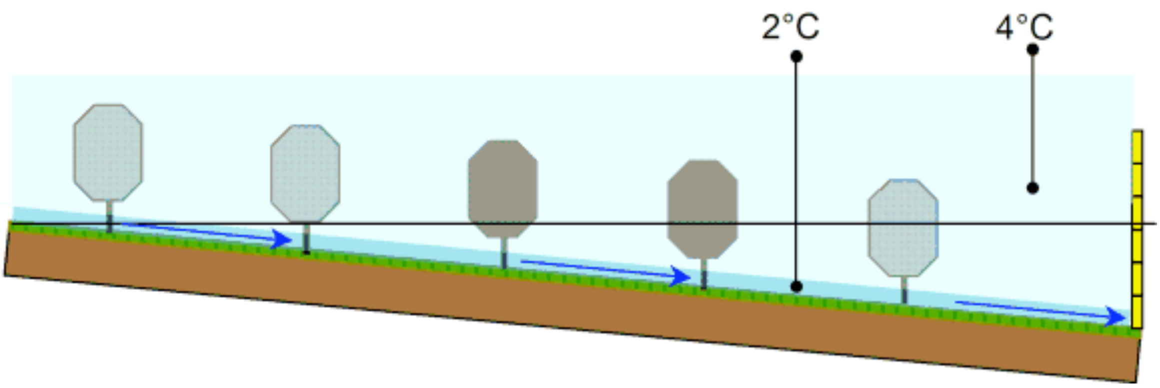

Figure 4. As in Fig. 1 but the grove floor falls away (in this example with a slope of 1:10). The layer of cold, dense air near the ground is able to drain away to the right, helping to keep the temperature of the ground surface closer to that of the general volume of air above.

However, if a dense shelterbelt is at the foot of the slope (Fig. 5), it will prevent the drainage of cold air – cold air damming. The positive effect of the slope is undone and, worse still; the shelter creates the potential for severe frosting as the downhill trees are now engulfed with the cold air draining down from further up the slope. An olive grove having a north, to north-westerly aspect and a shelterbelt at the foot of the slope to 'protect' it from the prevailing north-westerly wind is set up for disaster! *The grove will be quite unnecessarily cool and damp at all times of the year and it will be particularly frost prone in the winter.* This situation may be mitigated by severely pruning (bare poling) the shelter up to a couple of meters and keeping the undergrowth well controlled. This will allow the cool air to pass through the shelter without ponding.

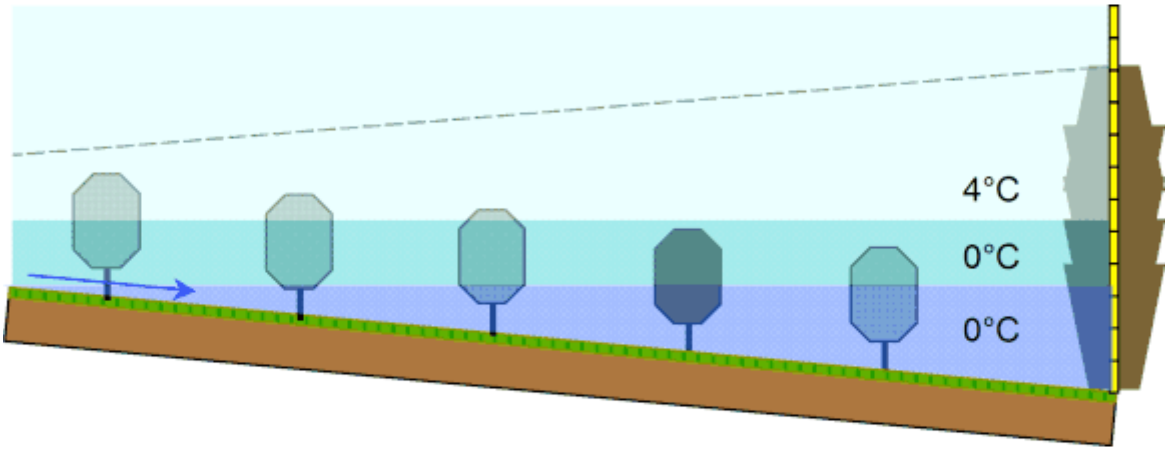

Figure 5. As in Fig. 4 but a poorly sited shelterbelt (or other feature) hinders cold-air drainage such that a pool of very cold air accumulates so as to engulf the downhill trees.