Sprinkler Frost Protection: Early Results from a Hawkes Bay Trial

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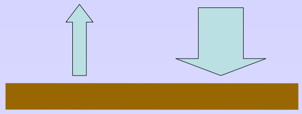
Objective: To evaluate and compare the performance of several sprinkler frost protection configurations under typical frost conditions in the Hawkes Bay region of New Zealand.

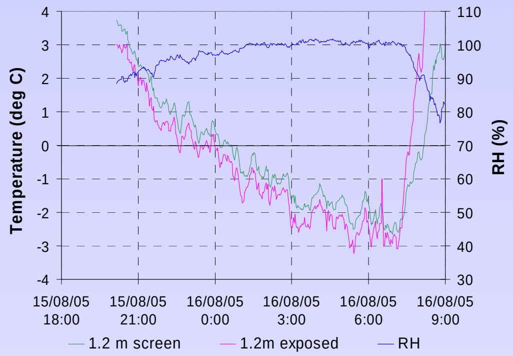
Background

Most frosts in New Zealand are radiation frosts



- The earth's surface loses 50-70 W/m² on clear nights
- On still clear nights, the ground and vines cool rapidly

A typical radiation frost



Sprinkler Frost Protection

- Heat is released when water freezes
- The temperature of wet ice remains near zero

Implementation issues:

- Application rate (~1mm/hr/°C)
- Air movement increases cooling and distorts pattern
- Shading and alignment of targeted sprinklers
- Starting temperature

The Trial

- Hawkes Bay Grape Growers Association (HBGGA) trial to determine effectiveness of various sprinkler configurations
- Extensive support from MAF - SFF, ISHB, NaanDan, and Sileni, and also HBGGA, Deeco, Delegats and Villa Maria

Method

- For radiation frosts, bud temperatures are 1 or 2 degrees lower than screen (air) temperature (Trought et. al. 1999)
- An exposed temperature sensor replicates bud or floret temperature (Hamer 1980)
- Our trial block used exposed temperature sensors (Fig 1)

Figure 1: Exposed sensor in trial block.

Results

Sprinkler	Pressure (kPa)	Spacing (m)	Est. rate (mm/hr)	Protection (°C/mm/hr)	Efficiency (°C/l/hr/m²)	Protection (°C)	
S Mamkad 445	300	13.2 x 9	4.1	1	1.0	4.0	
S Mamkad 445	350	13.2 x 9	4.5	1.1	1.1	5.0	ref Fig 2
Turbohammer	300	4.4 x 9	6.1	0.8	0.7	4.5	
Turbohammer	300, 50%	4.4 x 9	3.0	0.7	0.7	2.0	
Flipper, black	300	2.2 x 9	2.2	0.5	0.9	2.0	
Flipper, black	250	2.2 x 9	2.0	0.7	1.3	2.5	
Flipper, black	300	2.2 x 7.2	2.7	0.4	0.7	2.0	
Flipper, black	250	2.2 x 7.2	2.5	0.6	1.0	2.5	
Flipper, violet	250	2.2 x 7.2	1.8	0.8	1.4	2.5	ref Fig 3

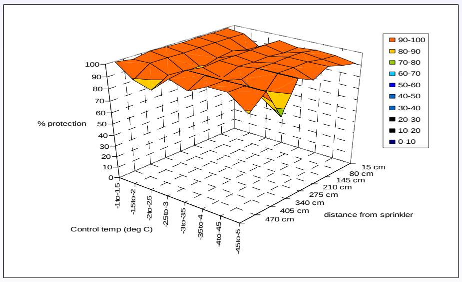


Figure 2: Best protection, Super Mamkad at 350 kPa, 13.2 by 9 m spacing.

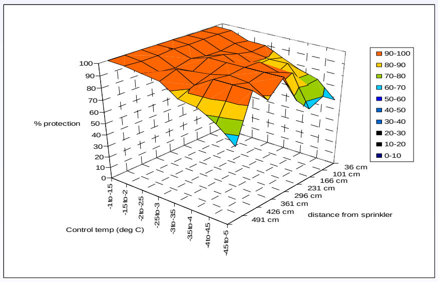


Figure 3: Best efficiency, Flipper at 250 kPa and 7.2 m spacing.

We define mean protection (P) as:

$$P(\%) = \frac{\sum_{n} 100(t_c - t_p - 1)}{n.t_c}$$

t_c is the corrected control temperature

n is the number of events

t_p is the protected temperature

Hence, P is 100% when at or above -1 °C, and 0% when at the exposed control (unprotected) temperature.

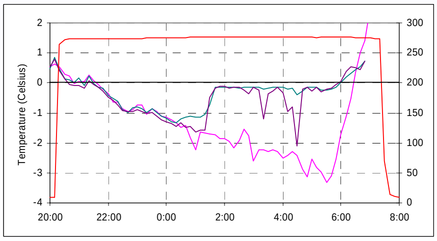


Figure 4: Ice formation. When sprinklers (red trace) are started too early, ice formation can be delayed (until 1:40 as here).

Conclusions

- Of the range of sprinklers characterised to date, the full cover Super Mamkad provided the best protection (5°C)
- Of the sprinklers characterised to date, the targeted Flipper provided the highest efficiency (1.4°C/l/hr/m²)
- The vineyard manager should know the level of protection provided (from the system designer)
- Map vineyard temperatures and record the temperature difference between coolest site and startup sensor location
- Turn sprinklers on when the bud temperature at coolest location is -0.5 deg. (~ +0.5 deg. screen) at canopy height (unless further information such as dew point is also available)
- Reasons for insufficient water include: misaligned sprinklers, shading, and wind effects
- Further sprinkler configurations will be tested in 2006
- Data from the trial including detailed time-at-temperature tables are available

References:

Hamer, P. J. C. (1980). An automatic spinkler system giving variable irrigation rates matched to measured frost protection needs. Agric. Meteorol. 21(281-293).

Trought, M. C. T., G. S. Howell, et al. (1999). Practical Considerations for Reducing Frost Damage in Vineyards, New Zealand Winegrowers.

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