Climate Change Influence on Scale Insects and Sooty Mould Occurrence

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Introduction

Insect scale numbers have become more noticeable on grapevines in the South Australian wine regions in recent years. Although the scales are abundant, the real problem with the presence of scale insects is the loss of productivity in grapes due to reduced vigour in severe cases, as well as the higher incidence of sooty mould that occurs when scale insects are present. In order to understand the relationship of sooty mould to scale insects and the effect that changes in climate may be having, a graphical model has been developed that explains what may be occurring in vineyards. One aspect of the modeling is the differences in sooty mould that are observed among cultivars and how these differences may be determined by differences in scale infestation among cultivars.

Methods

Various graphical models were generated using principles of the effects of temperature and humidity on insect biology similar to Deutsch et al. (2018). Empirical evidence from previous studies was incorporated where available. Some assumptions were made regarding how temperature and humidity influences sooty mould growth.

Deutsch, C.A., Tewksbury, J.J., Tigchelaar, M., Battisti, D.S., Merrill, S.C., Huey, R.B., Naylor, R.L., 2018. Increase in crop losses to insect pests in a warming climate. Science 361, 916-919.

Results

Figure 1. Conceptual figure of how abiotic and biotic processes interact to cause the development of sooty mould on grapevines. Cultivars differ in their evapotranspiration and that may result in some cultivars more likely to develop sooty mould (e.g.Shiraz).

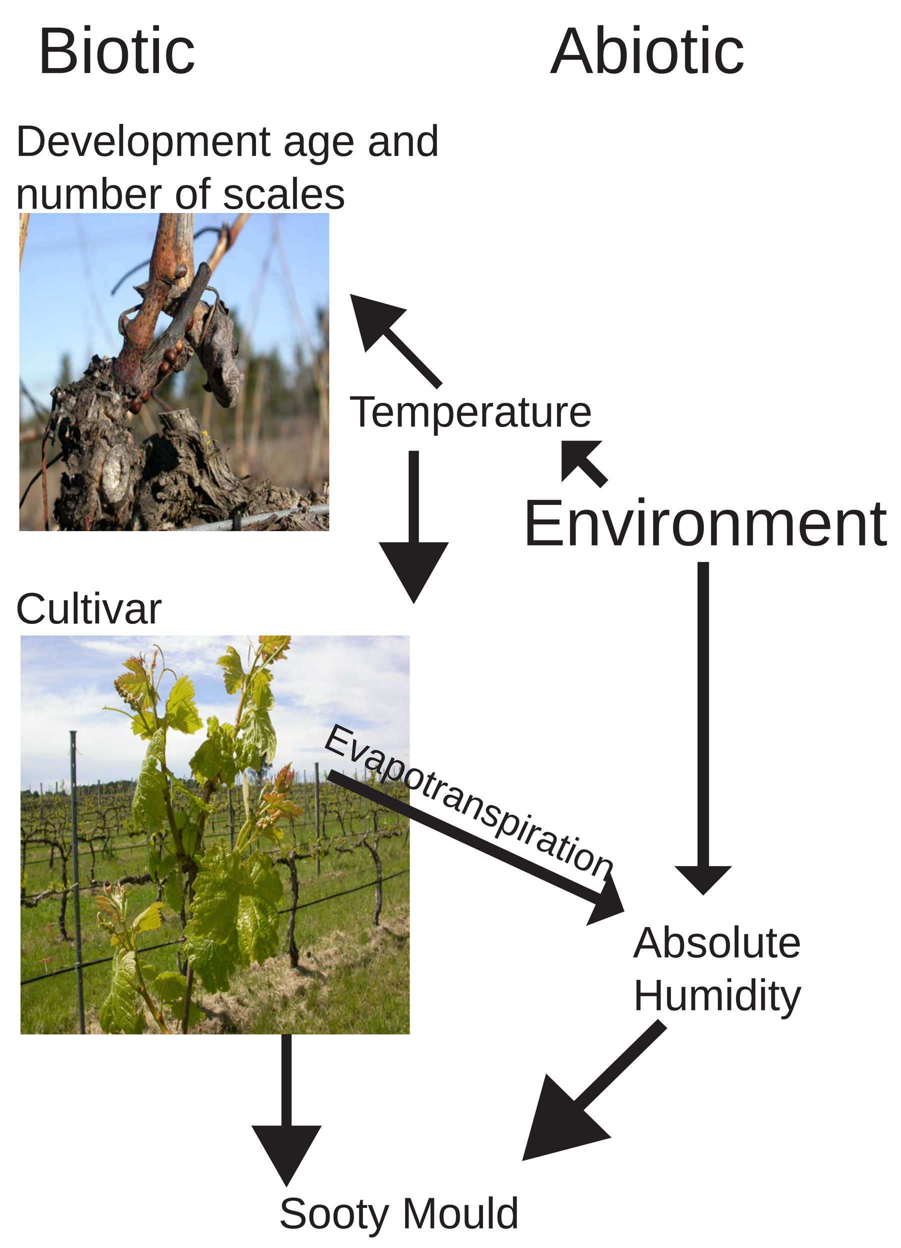


Figure 2. Scale insects (*Parthenolcanium persicae*) are normally located on the underside of grape leaves. When scales are abundant, both leaf sides will be occupied. Scales are flattened dorsoventrally, meaning that they can be within the boundary layer of air movement adjacent to the leaf. As a result, the absolute humidity to which the scale insect is exposed may depend more on the evapotranspiration from the leaf than the abiotic absolute humidity.

Figure 3. Effect of temperature on increasing population of scales, and as a result of more insects, the production of honeydew increases. The warmer the temperature, the faster the insects develop, as a result of increased metabolism and feeding rate. The increased feeding leads to the increase in the scale insect excreta (i.e. honeydew production). Decrease shown above 40˚C is estimated heat death temperature or maximal critical temperature (CTmax).

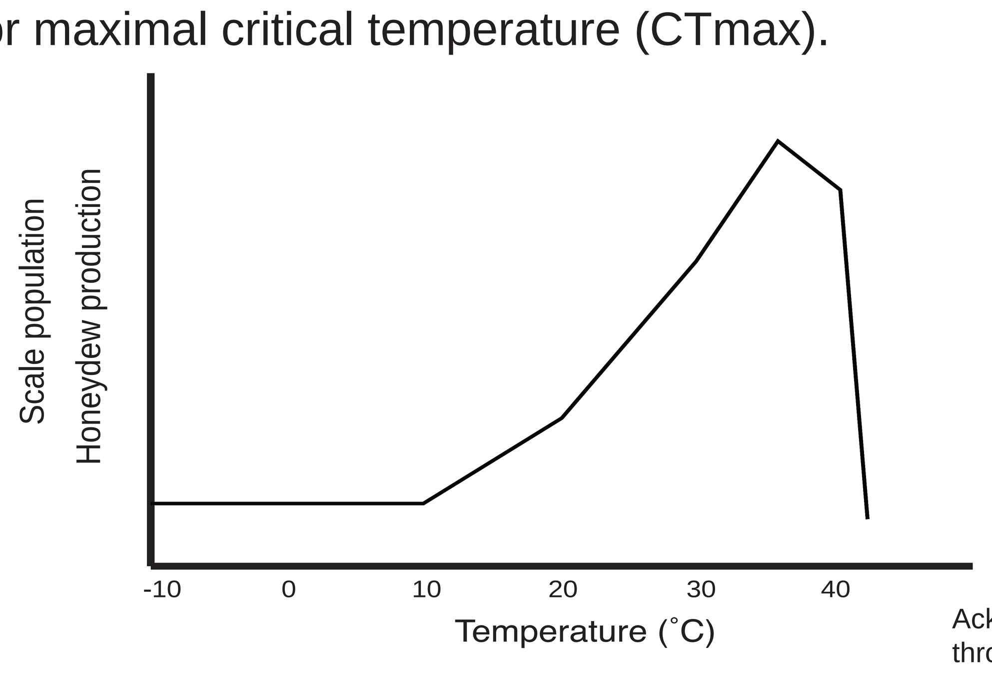


Figure 4. Because the development of scales increases with temperature, the total time for development from egg to adult decreases. This developmental decrease implies that increased temperature will lead to more generations of scale insects than the single annual generation that is currently present within Australian vineyards. As shown below, total time for development potentially could only be 25 days, although it is likely that above 40˚C, mortality increases as well.

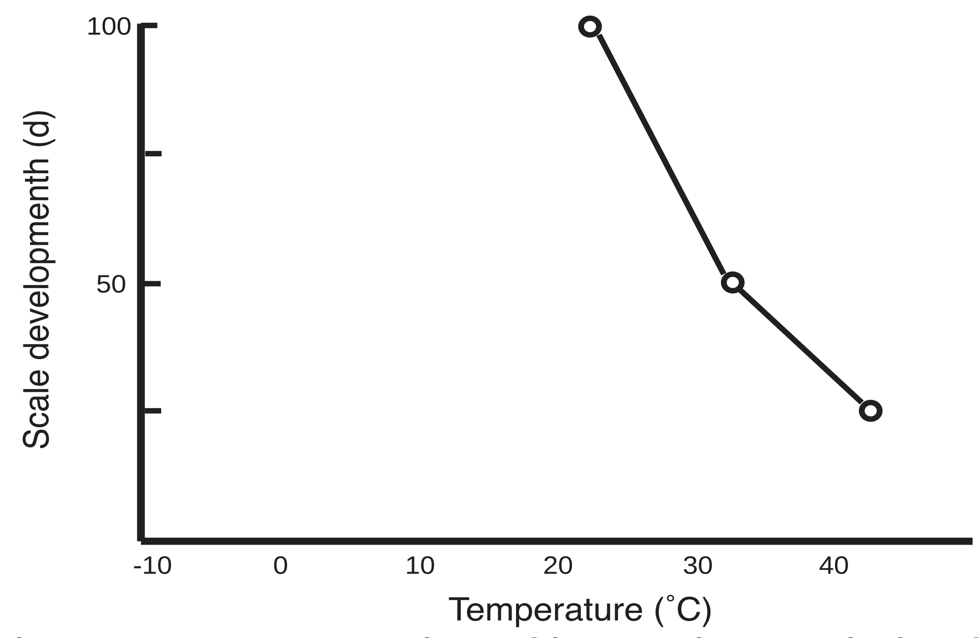


Figure 5. Change in dry mass concentration of honeydew and absolute humidity as temperature increases. As honeydew dry mass increases, it becomes more hygroscopic and will reach a point where water can be drawn into the honeydew from the air. As plant evapotranspiration increases with temperature, this may be contributing to the moisture content of the honeydew, as the absolute humidity increases within the boundary layer of the leaf where the scale insects are located. Arrow indicates where honeydew may absorb water from the surrounding absolute humidity.

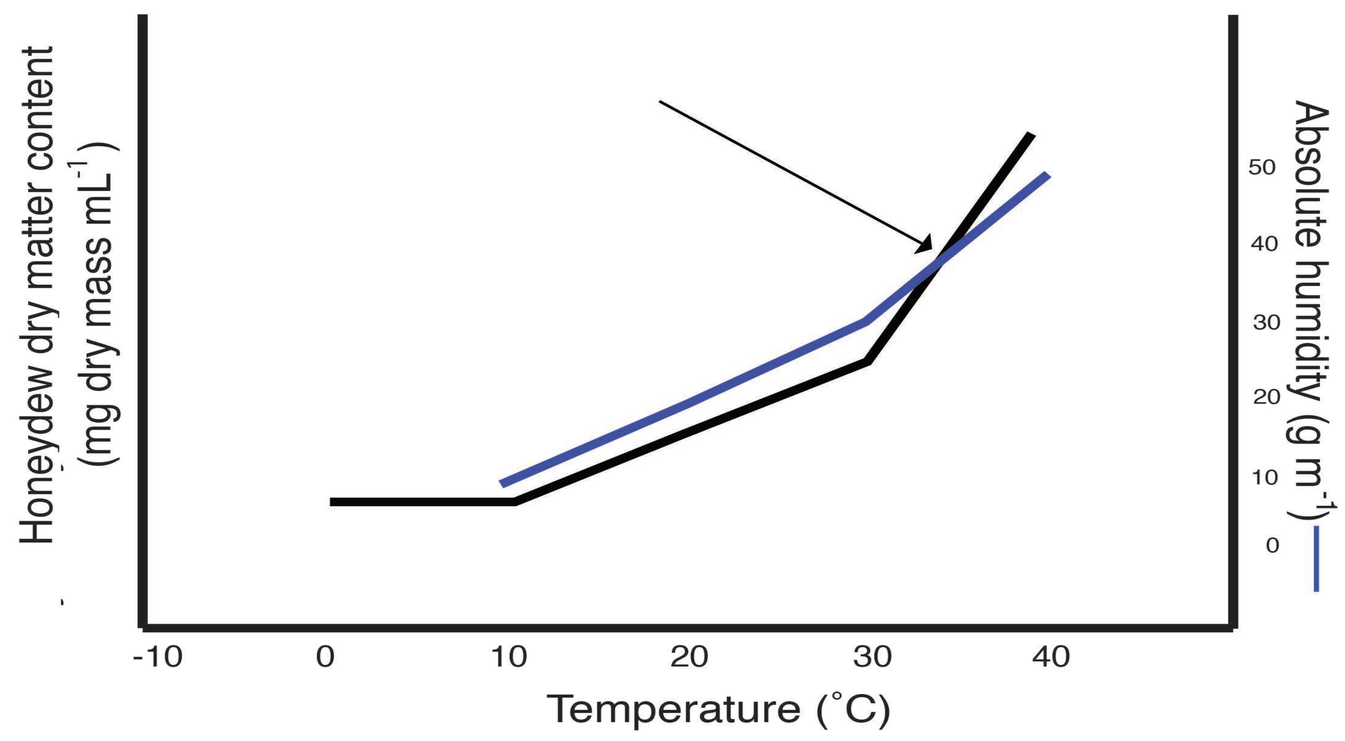
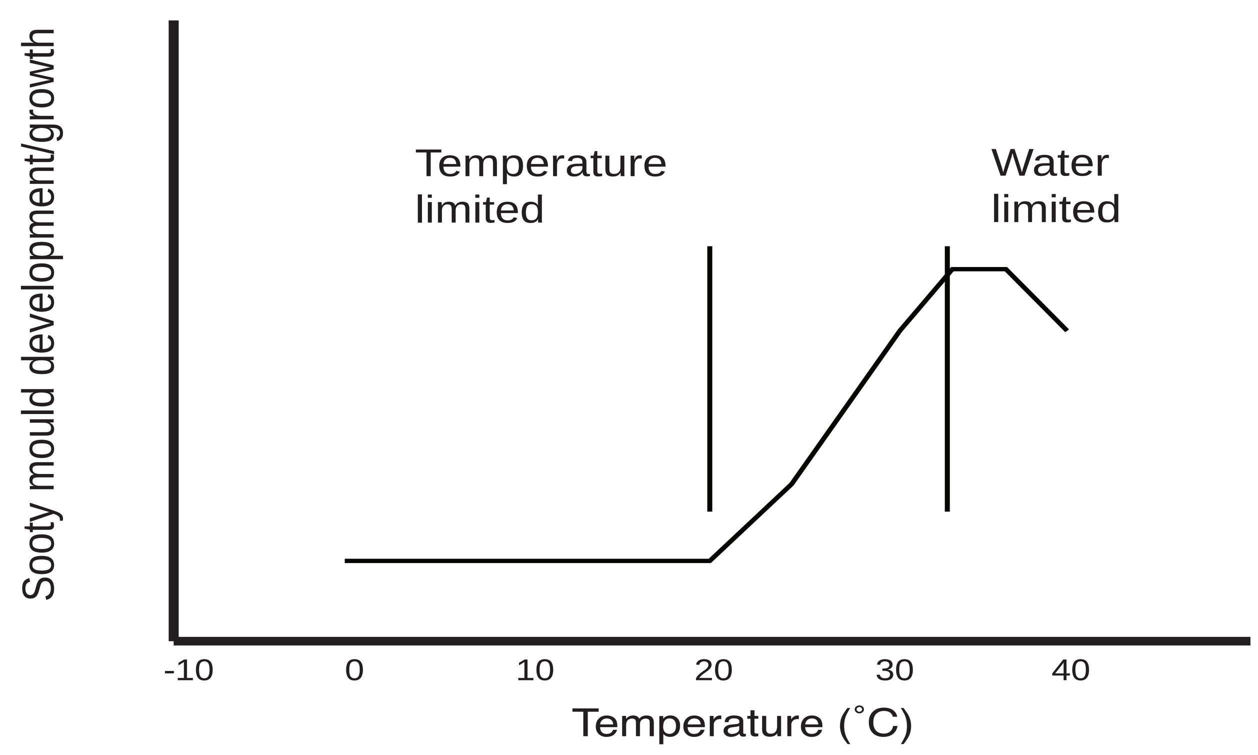


Figure 6. Temperature over which sooty mould can grow. No sooty mould grows below 20˚C, then grows to around 40˚C, but is then dependent upon the presence of moisture on the leaves and honeydew to permit growth. If conditions are dry, then sooty mould does not grow, but as absolute humidity increases or honeydew is able to stay on the leaf as result of plant evapotranspiration, then sooty mould will continue to grow.



Conclusions

1. Temperature increases may lead to more scales being present.
2. Sooty mould may not always occur at higher temperatures, as it also requires water, either as a result of humidity or in association with honeydew.
3. If temperature and humidity increase, then a reduction in grapes that are suitable for wineries may be more common.

Acknowledgements: Lian Jaensch has helped with all aspects of this work. Funding was provided by the Research School of Biology, ANU and Wine Australia through the R&D Regional Program for SA Central (incorporating the wine regions of Langhorne Creek, Adelaide Hills, McLaren Vale, Kangaroo Island, Currency Creek and Southern Fleurieu). Several local vineyards in both ACT/NSW and SA Central region cooperated by permitting access to their properties for undertaking field assessments of scale insect infestation.