University of Queensland, Centre for Horticultural Science – macadamia integrated disease management (IDM)

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In macadamia, diseases caused by *Phytophthora*, fungi and bacteria pose the most threat to farm productivity. The potential spread and economic impact of these diseases to macadamia are rated as high. In the past decade, we have seen increased reports of detection and devastation caused by several pathogens in macadamia worldwide. It is therefore necessary to continue to improve surveillance strategies and preparedness, including evaluation of varietal susceptibility.

The IDM project operates through strong partnerships with macadamia growers, industry consultants, other national and international macadamia research programs and the industry peak body, the Australian Macadamia Society.

The overall objective of the IDM project is to safeguard the industry from pathogen threats, increase orchard productivity, improve nut quality and for continued access to international markets.

By improving our understanding of the pathogen biology and the environmental factors that contribute to disease emergence and severity, the IDM project provides diagnostic capability, resources and disease management options to support the industry.

Strategic and applied research, training and extension activities are ongoing for endemic priority diseases including Phytophthora diseases, flower blight complex, Botryosphaeria branch dieback, husk spot and Phomopsis husk rot.

Phytophthora diseases

Phytophthora diseases in macadamia cause significant economic losses. The potential economic risk to the global macadamia industry has stimulated extensive collaborations to identify the major causal *Phytophthora* species and deploy resistant germplasm.

A recent survey of Phytophthora diseases in Australian macadamia orchards has revealed a new major pathogen, *Phytophthora multivora*, as one of the causal agents of stem canker in macadamia (Figure 26 and Figure 27). Although several other species were obtained from the soil around macadamia roots and irrigation channels, the aggressiveness of these *Phytophthora* species is considered to be low in macadamia (Jeff-Ego et al. 2020). The exotic *Phytophthora ramorum* and *Phytophthora tropicalis* (the causal agent of macadamia quick decline in Hawaii and China) were not isolated in Australia.

Figure 26. Stem canker symptoms on macadamia caused by *Phytophthora multivora*.

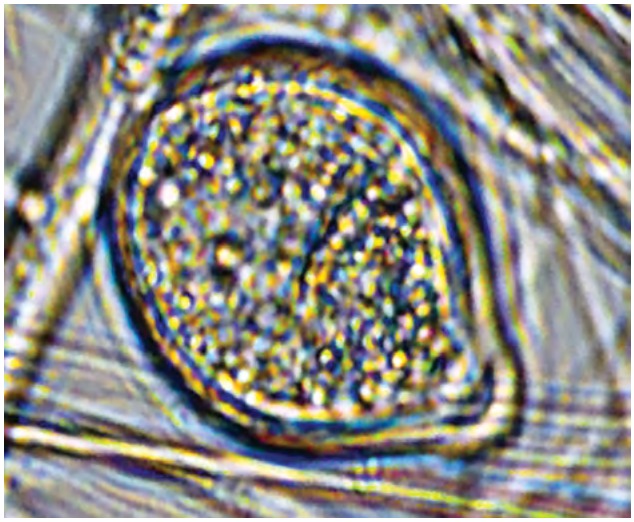

Figure 27. Sporangia of *Phytophthora multivora*.

A new *in vivo* macadamia whole-leaf-dip assay has been developed, with high-throughput potential to screen several *Phytophthora* species and determine varietal susceptibility.

Botryosphaeria branch dieback

A major concern to the macadamia industry is the increasing death of trees (Figure 28) associated with Botryosphaeria branch dieback. Several fungal species within *Botryosphaeriaceae* have been obtained from different tissues of macadamia (Jeff-Ego and Akinsanmi, 2018; Liddle et al. 2018). However, there is limited information on the pathogen biology and disease cycle, including the interrelated environmental stressors required for disease expression in macadamia. Understanding the biology and epidemiology of Botryosphaeria branch dieback in macadamia is the focus of current PhD research.

Monitoring of the fungal spores has so far revealed the influence of certain weather factors on the pattern of spore dispersal in macadamia orchards. The outcomes of this study will provide valuable tools and information to support disease management.

The current spray applications of phosphonates and soil health management strategies are still adequate to control *Phytophthora* infections and improve tree heath. The risk of residue above the minimum residue limit (MRL) in macadamia kernel is low when phosphorus acid products are applied at the recommended rates.

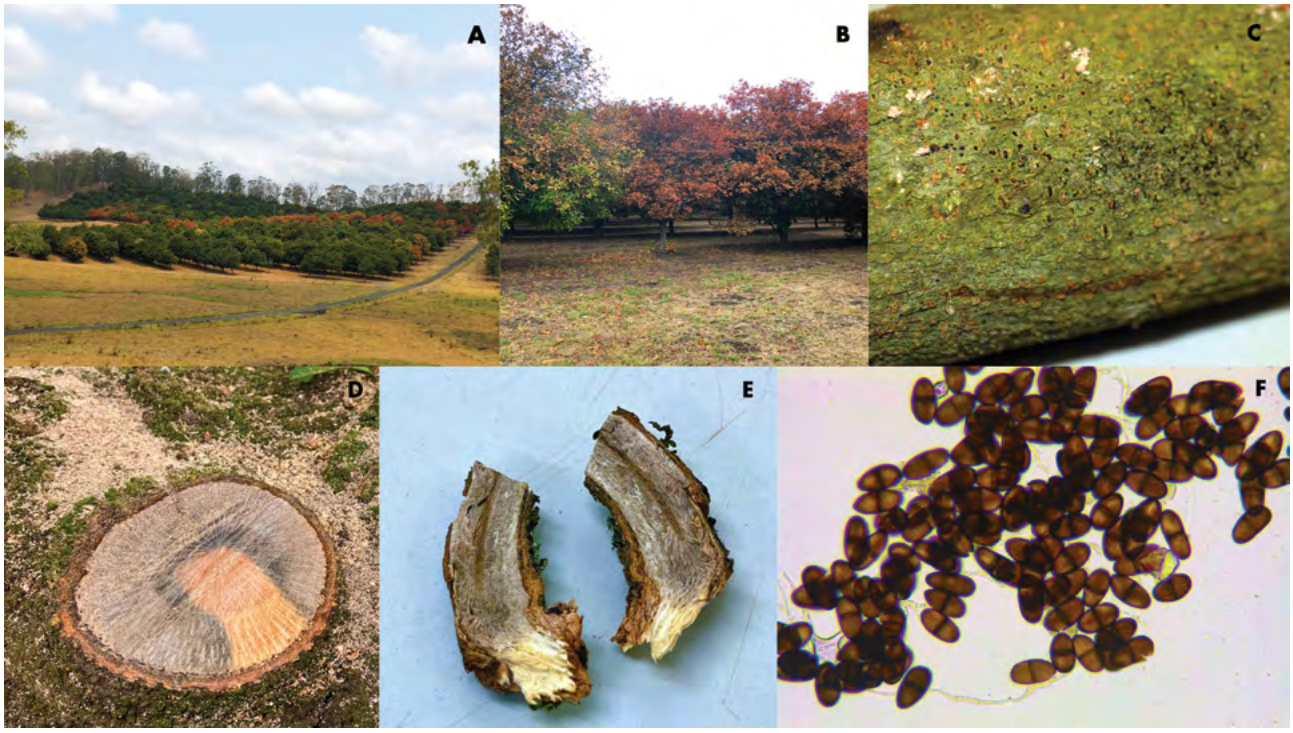

Figure 28. Botryosphaeria branch dieback symptoms on macadamia and fungal structures.
A-B: affected macadamia trees with characteristic brown, burnt-looking leaves that remain attached on the tree
C: fungal structure of Botryosphaeriaceae on macadamia branch
D-E: cross-sections of diseased trees with discoloured wood
F: conidia of one of the causal pathogens (*Lasiodiplodia* species).

Flower blight complex

The flower blight complex in macadamia in Australia includes dry flower (Pestalotiopsis blight), grey mould (Botrytis blight) and green mould (Cladosporium blight). Preliminary information from a PhD study has shown key differences in the biology and favourable climatic conditions for growth and development in the flower blight pathogens.

Temperatures between 18 and 22 °C are optimum for Botrytis blight, whereas the peak spore production and infection of the other pathogens occurred at about 25 °C (Figure 29). The dry flower causal agents (*Pestalotiopsis macadamiae* and *Neopestalotiopsis macadamiae*) function well within a wider temperature range of 22–30 °C and *Cladosporium* blight pathogen (*Cladosporium cladosporioides*) performs best at a narrow temperature range of 22–25 °C. Another key difference in the biology of the pathogens is the difference in the favourable flower stages for infection and disease development.

This information may be critical for field diagnostics and management options, including disease risk assessment protocol.

Phomopsis husk rot

Severe cases of Phomopsis husk rot (PHR) are often intermittent and the resulting economic impact may be significant. Recent reports have shown the diversity of the causal pathogens and four new species that cause PHR in macadamia have been described including *Diaporthe australiana*, *Diaporthe drenthii*, *Diaporthe macadamiae* and *Diaporthe searlei* (Wrona et al. 2020). It is estimated that effective control of PHR resulted in over $8,000 increase in NIS/ha (at $4/kg NIS, 10% MC) compared with the untreated control. Consistent effective control is hindered by limited knowledge about PHR aetiology and epidemiology. Further research is currently underway to address this gap in knowledge.

Leaf spots in macadamia

Spots are often observed on macadamia leaves. In most cases, these are caused by damage to the leaf tissue through chemical burns or injury. Extensive spots on all the leaves of young macadamia trees is a concern, due to the potential loss in the photosynthetic ability of the leaves, resulting in death and poor establishment of the affected trees.

Two new types of fungal leaf spots (Figure 30) were commonly detected in commercial macadamia orchards (Prasannath et al. 2020):

- **Pestalotiopsis leaf spot** – symptoms are circular dark brown spots with yellow halos caused by *Neopestalotiopsis clavispora*.
- **Colletotrichum leaf spot** – symptoms are irregular dark brown spots caused by *Colletotrichum siamense*.

These spots may coalesce to form a 'patch' blight. Further studies are underway to determine the importance of these pathogens and as sources of inoculum for other diseases in macadamia.

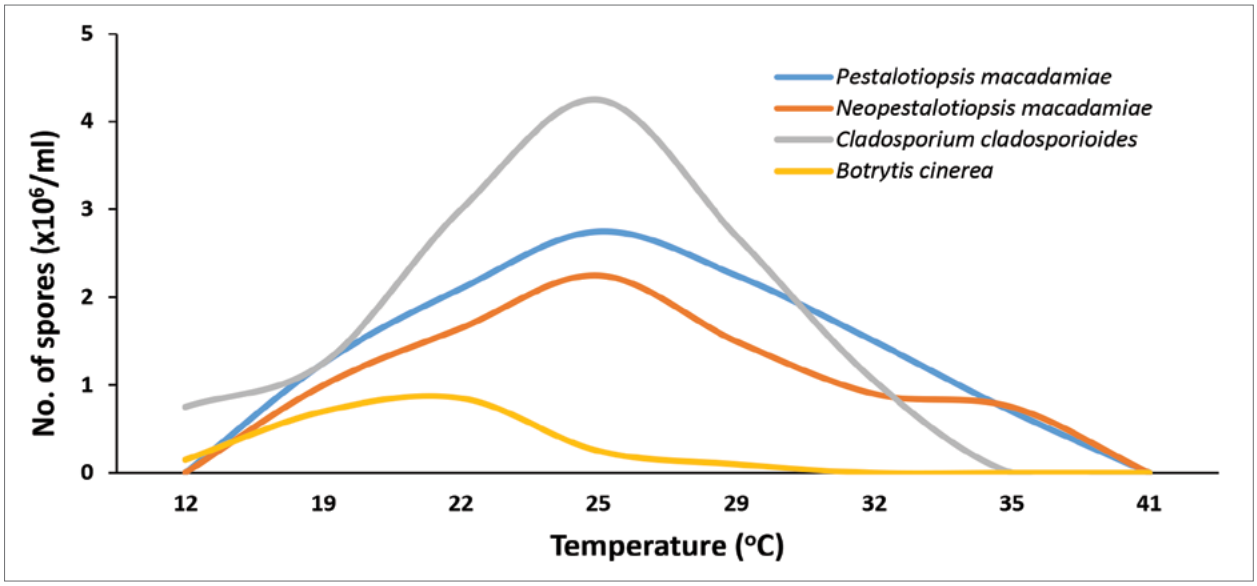

Figure 29. The average number of spores produced by flower blight pathogens at different temperatures.

Figure 30. Symptoms of leaf spots in macadamia. Top row: Pestalotiopsis leaf spot, symptoms are circular dark brown spots with yellow halos caused by *Neopestalotiopsis clavispora*. Bottom row: Colletotrichum leaf spot, symptoms are irregular dark brown spots caused by *Colletotrichum siamense*.

Acknowledgements

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References

Jeff-Ego OS and Akinsanmi OA. 2018. *Botryosphaeriaceae* causing branch dieback and tree death of macadamia in Australia. *Australasian Plant Pathology*, 48: 59–64, https://doi.org/10.1007/s13313-018-0604-6

Jeff-Ego SO, Drenth A, Topp BL, Henderson J and Akinsanmi OA. 2020. Prevalence of *Phytophthora* species in macadamia orchards in Australia and their ability to cause stem canker. *Plant Pathology* (in press), https://doi.org/10.1111/ppa.13208

Liddle RL, Akinsanmi OA and Galea VJ. 2018. Non-host specificity of *Botryosphaeriaceae* on macadamia and blueberry. *Australasian Plant Pathology*, 48: 65–73, https://doi.org/10.1007/s13313-018-0600-x

Prasannath K, Galea VJ and Akinsanmi OA. 2020. Characterisation of leaf spots caused by *Neopestalotiopsis clavispora* and *Colletotrichum siamense* in macadamia in Australia. *European Journal of Plant Pathology*, 156: 1219–1225, https://doi.org/10.1007/s10658-020-01962-6

Wrona CJ, Mohankumar V, Schoeman MH, Tan YP, Shivas RG, Jeff-Ego OS and Akinsanmi OA. 2020. Phomopsis husk rot of macadamia in Australia and South Africa caused by novel *Diaporthe* species. *Plant Pathology*, 69: 911–921, https://doi.org/10.1111/ppa.13170