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Research article

Partial Cold Treatment of Citrus Fruit for Export Risk Mitigation for *Thaumatotibia leucotreta* (Lepidoptera: Tortricidae) as Part of a Systems Approach

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Abstract

Some of South Africa's citrus export markets require mandatory postharvest cold treatment of citrus fruit as a phytosanitary risk mitigation treatment for *Thaumatotibia leucotreta* (Meyrick) (Lepidoptera: Tortricidae). An alternative to this may be partial cold treatment as one of the final steps in a systems approach to mitigate phytosanitary risk. Consequently, the efficacy of such partial cold treatments was evaluated. It was first determined that a 2°C cold treatment was significantly more effective against fourth and fifth instars (the most cold-tolerant instars) than treatments at 3°C and 4°C for a duration of 18 d. Secondly, it was determined that 2°C for 18 d and 1°C for 16 d were similarly effective, but both treatments were significantly more effective than 1°C for 14 d. Mean mortality of fourth and fifth instars treated with 2°C for 18 d in seven replicates from four trials was 99.94%. Finally, it was determined that the inability of the majority of surviving larvae to develop to adulthood would further increase the efficacy of a 2°C for 18 d treatment to 99.96%. Inclusion of reproductive nonviability of survivors increased mortality to 99.99%.

Key words: false codling moth, South Africa, artificial diet, mortality, viability

Export markets often require postharvest treatment of fresh commodities for the control of phytosanitary organisms (Follett and McQuate 2001, Follett and Neven 2006). A stand-alone postharvest quarantine treatment, such as cold treatment, is the most commonly used phytosanitary risk mitigation measure (Paull and Armstrong 1994). This is also the case for *Thaumatotibia leucotreta* (Meyrick) (Lepidoptera: Tortricidae), known in Africa as the false codling moth, which is an important pest of citrus in southern Africa (Newton 1998, Grout and Moore 2015). As a result of its endemism to sub-Saharan Africa (Moore 2002), certain export markets of importance for the South African citrus industry, such as United States, People's Republic of China, and South Korea, regulate it as a quarantine pest (South African Department of Agriculture Forestry and Fisheries [SA DAFF] 2015). The South African citrus industry is dependent on export of fresh fruit to these and other markets around the world, with ~70% of South Africa's citrus crop being exported (Citrus Growers' Association [CGA] 2013).

The cold treatment developed for *T. leucotreta* by Myburgh (1965) entails maintenance of temperatures below 0°C for 22 d, a treatment that is expensive, requires extensive preshipping cooling infrastructure, and can be detrimental to fruit quality (Lafuente et al. 2003, Cronjé 2007). Consequently, alternatives such as a systems approach (Follett and Neven 2006) should be investigated. Systems approaches are being increasingly considered (Riherd et al. 1994, Jang 1996, Centre for Agriculture and Biosciences International–European and Mediterranean Plant Protection Organization [CABI–EPPO] 1997) and implemented (U.S. Department of Agriculture, Animal and Plant Health Inspection Service and Bureau of Animal and Plant Health Inspection and Quarantine [USDA, APHIS and BAPHIQ] 2008) for such purposes.

A systems approach can be defined as "the integration of pre- and postharvest practices, from the production of a commodity to its distribution and commercialization, which cumulatively meet predetermined requirements for quarantine security" (Aluja and Mangan 2008). The systems approach could include a postharvest treatment (Follett and Neven 2006) such as shipping under a specified time-temperature protocol, providing partial disinfestation of fruit (i.e., less than probit 8.7 or probit 9), but would still mitigate risk sufficiently, as a final step in the system. This may enable inclusion of cultivars which are more sensitive to developing chilling injury (Lafuente et al. 2003, Cronjé 2007) and thus considered unsuitable for conventional cold-sterilization at subzero temperatures.