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Post-harvest paraffinic oil dips to disinfest lychee fruit of lychee erinose mite

Alexandra M. Revynthi[1,], Rita E. Duncan[1], Catharine Mannion[1], Paul E. Kendra[2], and Daniel Carrillo[1]*

The lychee erinose mite, *Aceria litchii* (Keifer) (Acari: Eriophyidae), is one of the most important pests of lychee (*Litchi chinensis* Sonn.; Sapindaceae). This eriophyid mite pest has been reported in Southeast Asia (Alam & Wadud 1963; Huang 1974), Australia (Pinese 1981), South America (Raga et al. 2010; Fornazier et al. 2014), and Hawaii (Nishida & Holdaway 1955), causing up to 80% yield reduction (Prasad & Singh 1981; Navia et al. 2013). Its recent interception in Feb 2018 in Lee County, Florida, triggered a quarantine and eradication program (Carrillo et al., unpublished). *Aceria litchii* feeds on leaf epidermal cells and causes gall formation, also known as erinea (Nishida & Holdaway 1955). Young new flush is the most susceptible part of the lychee plant; however, the mites also may attack stems, panicles, and the fruit (Alam & Wadud 1963; Azevedo et al. 2013).

Due to the quarantine currently imposed, no movement of lychee fruit is allowed from the quarantine zone to other areas in Florida, or to other states where lychee is produced. A post-harvest treatment that can disinfest the fruit of the pest and allow the growers to move the fruit outside the quarantine area is necessary.

There are several quarantine treatments for lychee in the USDA treatment manual (USDA 2019); however, none of them are approved for the lychee erinose mite. In Australia, post-harvest dips with paraffinic oil have been shown to disinfest lychee of fruit surface dwelling insects and mites (Diczbalis 2018). The paraffinic oil STYLET® (JMS Flower Farms, Inc., Vero Beach, Florida, USA) is a highly refined, superior technical food grade mineral oil that is exempt from residue tolerances and is available for use in Florida (EPA Registration No. 65564-1). Using 2 lychee cultivars and 2 concentrations of STYLET® oil, we tested whether post-harvest dips for 60 s can control *A. litchii* on lychee fruit.

Lychee branches infested with *A. litchii* were collected from a grove (managed by Brooks Tropicals, LLC) in Bokeelia, Pine Island, Florida, USA, and transported to the containment facility at the University of Florida Tropical Research and Education Center in Homestead, Florida, USA, under Florida Department of Agriculture and Consumer Services permit 2018-029. An established laboratory colony of lychee erinose mites maintained at the Tropical Research and Education Center since Jan 2019 was used to supplement the mite populations necessary for experiments.

Commercial grade lychee 'Mauritius' fruit was harvested from an unsprayed lychee grove at the Tropical Research and Education Center and introduced to the containment facility. 'Brewster' lychee fruit was donated by Bill and Lynn Masters, Lake Placid Fruit and Nut Grove (Lake Placid, Florida, USA) and Matthew Porter (Homestead, Florida, USA).

The fruit was separated from the bunches, leaving a small stem attached to the fruit, and then covered for 1 d with *A. litchii* infested leaves from Pine Island or the Tropical Research and Education Center laboratory colony. Preliminary assays showed that this infestation method was more efficient than hand transferring the mites, which resulted in high mortality due to manipulation. The number of mites, however, could not be standardized using this method. Subsequently, the presence of the pests on the fruit was verified by carefully inspecting each fruit under a high magnification (400×) stereoscope (Nikon® SMZ1270, Nikon Instruments Inc., Melville, New York, USA). Sets of 90 fruit of each variety, with verified presence of the mites, were used for treatment evaluations. Treatments were applied to fruit from both lychee varieties. Groups of 30 infested fruit of each variety were dipped in 3% or 5% solutions of STYLET® paraffinic oil for 1 m with constant agitation and allowed to air dry under laboratory conditions (23 °C, 50% RH, and a 12:12 h [L:D] photoperiod). A control group of 30 infested fruit was not treated. Twenty-four h later, each fruit was reinspected for the presence of dead and live *A. litchii* mites.

Separate groups of 90 fruit of each variety were used to evaluate the effect of treatment on fruit quality. Groups of 30 uninfested lychee fruit were subjected to the same treatments described above. All fruit (treated and non-treated) were placed inside a plant growth chamber (Panasonic® MLR-352H-PA at 7.2 °C and 90% RH, complete darkness) immediately after treatment and monitored daily for changes in fruit quality.

Due to the non-normal distribution of the data, the number of dead and live mites per fruit was analyzed using the Kruskal-Wallis nonparametric test ($\alpha = 0.05$). Data were analyzed using R version 3.5.2 (R Development Core Team 2019).

Post-harvest dips in paraffinic oil solutions for 60 s resulted in complete disinfestation of lychee fruit of *A. litchii* motile stages. The number of live mites in the untreated control fruit averaged 3.75 ± 1.21 (average ± standard error) for the Mauritius cultivar and 1.16 ± 0.38 for the Brewster. No live healthy mites were found on the fruit dipped in paraffinic oil at the 2 concentrations tested for both lychee cultivars (Fig. 1). Only 1 moribund mite was recorded on 1 Mauritius fruit dipped in 5% STYLET® oil. In both lychee cultivars, the post-harvest treatment was effective in controlling *A. litchii* motile stages, and there were no differences between the 2 concentrations tested (Mauritius: $\chi^2 = 38.6$; df = 10; $P < 0.0001$; Brewster: $\chi^2 = 24.5$; df = 5; $P < 0.0001$). The number of dead mites was similar across treatments, averaging approximately 1 dead mite per fruit (Mauritius: $\chi^2 = 3.4$; df = 4; $P = 0.49$; Brewster: $\chi^2 = 2.01$; df = 3; $P = 0.57$).

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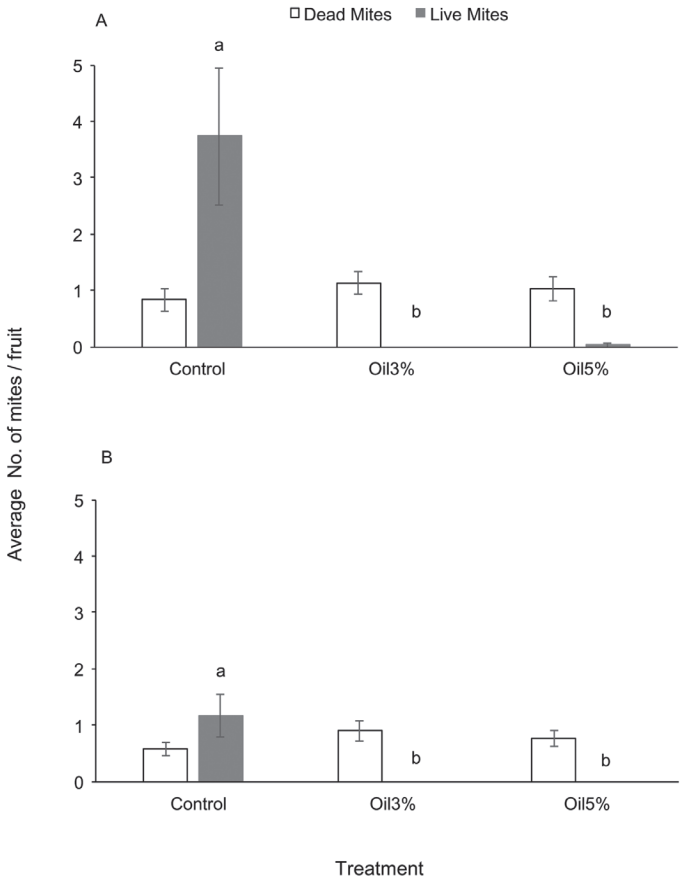

Fig. 1. Average number of *Aceria litchii* mites on (A) Mauritius and (B) Brewster lychee fruit dipped in paraffinic oil (STYLET®) at 3 or 5% solutions for 60 s. Shown are average (± SE) number of live (grey) and dead (white) *A. litchii* mites on fruit 24 h after treatment. Different letters indicate significant differences (Kruskal-Wallis, $P \leq 0.05$). $N = 30$ for each treatment.

The paraffinic oil dips also showed potential for disinfesting fruit of other mites (*Brevipalpus* spp., *Tetranychus* spp., Tydeids, Phytoseiids, and Tuckerellids) and insects (thrips and mealybugs). These arthropods were abundant and active on the untreated control fruit and only cadavers were found on the treated fruit, but only rarely.

In both lychee cultivars, the paraffinic oil dips had a beneficial effect on fruit quality for the first 10 d after treatment. Treated fruit had brighter color and was free of dust and arthropods. The peel began to darken slightly 1 wk post-treatment in all fruit, but the darkening was slightly more conspicuous on dipped fruit (Fig. 2). No evaluation was made, however, in the fruit pulp quality. The effect of this pest control method on fruit quality requires further investigation.

Post-harvest dips in paraffinic oil showed effective control of the lychee erinose mite without reduction in fruit quality. Both oil concentrations completely disinfested lychee fruit. *Aceria litchii* and other arthropods were dislodged during the dipping and agitation process, and those that were not dislodged were found dead. Phytosanitary irradiation in doses ranging from 300 to 400 Gy has been found to be effective in providing quarantine control for *A. litchii* (Arthur & Machi 2016). Quality of lychee fruit was not affected by an irradiation dose of 400 Gy, and external appearance as well as fruit taste were rated as acceptable in fruit that had been irradiated (Follett & Sanxter 2003). USDA-Animal and Plant Health Inspection Service has approved a generic irradiation dose of 400 Gy for all insect pests except adults and pupae of the order Lepidoptera (USDA 2019). Our study shows that dips in paraffinic oil may provide an effective level of control, which is necessary when a quarantine is imposed. Use of this post-harvest treatment may allow growers in Lee County, Florida, USA, to export lychee fruit.

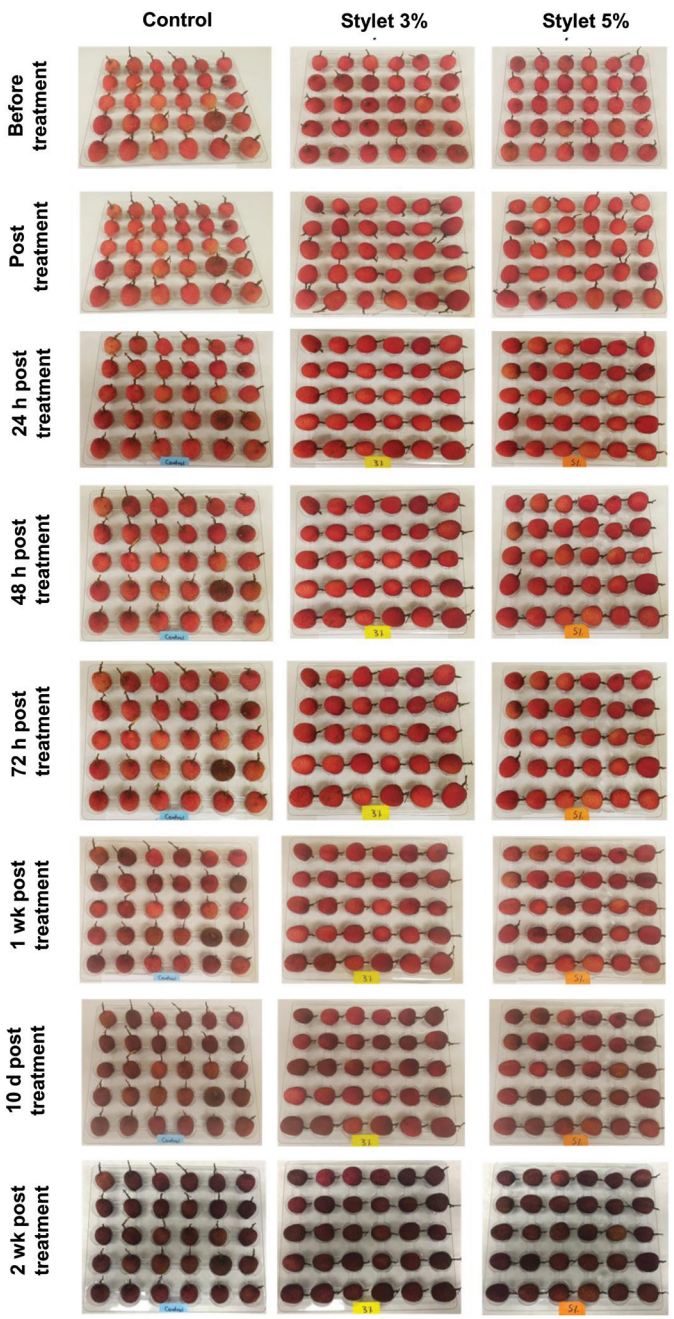

Fig. 2. Fruit quality assessment on Mauritius lychee fruit after post-harvest dips in different concentrations (3 or 5%) of paraffinic oil (STYLET®) for 60 s.

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Summary

The lychee erinose mite, *Aceria litchii* (Keifer) (Acari: Eriophyidae), is an important pest of lychee (*Litchi chinensis* Sonn.; Sapindaceae). Its recent interception in Lee County, Florida, USA, resulted in a quarantine whereby no lychee material, including fruit, can be transferred outside the county. Therefore, there is an urgent need for post-harvest treatments that can disinfest the fruit of the pest. Results of this study indicate that post-harvest dips in paraffinic oil solutions, 3 and 5%, for 60 s can achieve complete disinfestation of lychee fruit of *A. litchii* motile stages as well as other arthropods. In both 'Mauritius' and 'Brewster' cultivars the treatments had a beneficial effect on fruit quality for the first 10 d after treatment. Post-harvest dips in paraffinic oil showed effective control of *A. litchii* without a noticeable reduction in fruit quality. Hence, this treatment might allow growers in Lee County to transport lychee fruit outside the quarantine zone.

Key Words: quarantine; treatments; Acari; invasive pest; biosecurity; Eriophyidae

Sumario

El ácaro erinoso, *Aceria litchii* (Keifer) (Acari: Eriophyidae), es una plaga importante del lichi (*Litchi chinensis* Sonn.; Sapindaceae). Su reciente detección en el condado de Lee en Florida resulto en el establecimiento de una cuarentena, por lo cual, ningún material de lichi, incluida la fruta, puede ser transportada fuera del condado. Se necesitan urgentemente tratamientos de post-cosecha que puedan desinfestar la fruta de estos ácaros. Los resultados de este estudio indican que la inmersión de frutos en una solución de aceite parafínico al 3 y 5% durante 60 segundos puede desinfestar la fruta completamente de *A. litchii* y otros artrópodos. En los cultivares 'Mauritius' y 'Brewster' este tratamiento tuvo un efecto positivo en la calidad de la fruta durante diez días posteriores al tratamiento. La inmersión de frutos en soluciones de aceite parafínico durante la post-cosecha mostro un control efectivo de *A. litchii* sin afectar la calidad de los frutos. Este tratamiento podría permitir que los productores de lichi en el condado de Lee puedan transportar y vender frutos afuera del área cuarentenada.

Palabras Claves: cuarentena; tratamientos; Acari; especie invasora; bioseguridad; Eriophyidae

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