Postharvest system approach to control trade barrier pests of California citrus

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Introduction

- Key export markets (South Korea, Australia, New Zealand, and China) valued ~$270 million annually for California fresh citrus have recently been critically impacted by pest related trade barriers.
- California red scale (*Aonidiella aurantia*, CRS), bean thrips (*Caliothrips pergande*, BT), Fuller rose beetle (*Naupactus godmanni*, FRB), and citrus flat mite (*Brevipalpus californicus*, CFM) are among the major trade barrier pests of the export markets.
- Upon arrival at national ports of import country, fruits are normally treated with methyl bromide (MB) under the prevalent phytosanitary disinfestation guidelines.
- However, there is an urgent need to develop effective MB alternative to address the regulatory amendment of target country as well as the concerns regarding ozone depletion and human health risks associated with MB.
- The overall goal of this project is to develop MB alternative system approach treatments to control pests so that pest-free and high-quality California fresh citrus enters the export markets.

Materials and Methods

Insects, rearing, and infestation

Four insect species reared/maintained in the laboratory were used to infest fruits (Figure 1A–D).

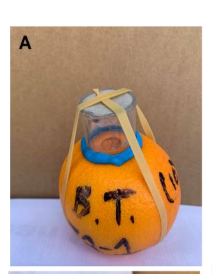

Fig 1A. Bean thrips were aspirated into modified plastic vials and secured using rubber bands.

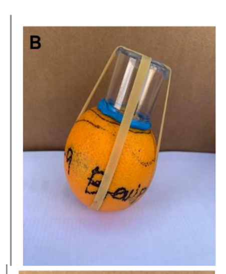

Fig 1B. Adult mites were transferred to each fruit and were then enclosed in a modified plastic vial to prevent mites from escaping.

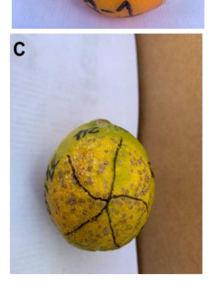

Fig 1C. Fruits were infested with mature CRS females and allowed to produce crawlers and develop them for 4–5 weeks.

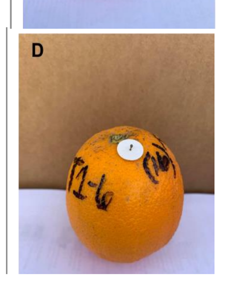

Fig 1D. Fuller rose beetle eggs were harvested on folded wax paper sheet and were pinned to fruit under a ~1cm piece of paper to simulate calyx.

Treatment and calibration of standards

- Four postharvest system events, **EF**: ethyl formate (EF) fumigation - required for domestic Asian citrus psyllid (*Diaphorina citri*, ACP) quarantine; **Packline**: standard packing (washing, spraying, brushing, waxing, drying); **PH_3**: phosphine fumigation at pulp T > 40°F for 12 h (regulatory treatment for bean thrips for Australia and New Zealand); and **Cold**: 21-d shipping (37°F and 45°F for oranges and lemons, respectively), were tested (Figure 2A–D) in two lemon and one orange varieties.
- Three treatment scenarios, namely, **S1**: EF→Packline→PH_3→Cold; **S2**: Packline→PH_3→Cold; **S3**: EF→Packline→Cold, were compared to **S4**: Packline→Cold (standard practice). The control samples received no treatment.

Fig 2. Events of the systems approach; Event 1 (EF)- Vapormate™ fumigation under the tarpaulin (A), Event 2 (Packline) – pressure wash and waxing in the packline (B), Event 3 (PH_3)- 300-1,000 ppm phosphine fumigation under tarpaulin at 41°F (C), and Event 4 (Cold)- 3-week cold storage at 37°F (D).

Mortality evaluation

- For each insect species, mortality was diagnosed by lack of motion upon prodding and was calculated by subtracting the number of survivors from the number of treated specimens.
- Mortality of non-treated control specimens was treated numerically using Abbott's method (Abbott, 1925).

Fruit quality evaluation

- The effects of treatment on fruit quality were evaluated through pH and brix of fruit juice and percentage fruit decay.
- Insect mortality and fruit quality data were subjected to ANOVA analysis to determine the difference between treatments.

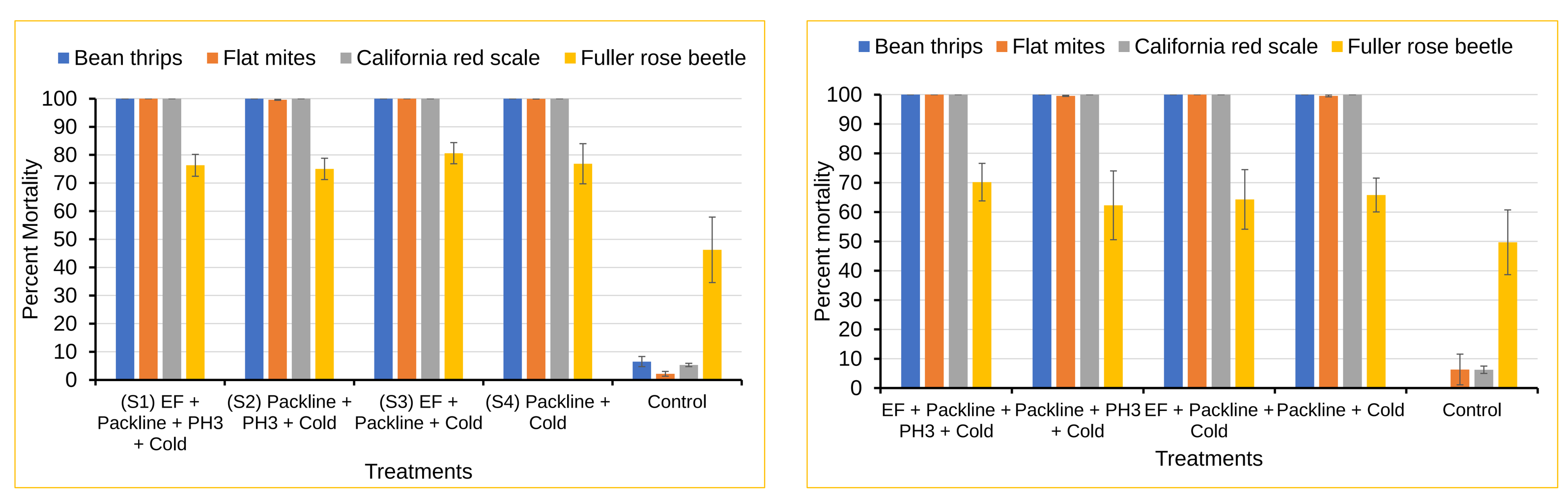

Fig 3. Effect of system approach treatment on pest mortality in lemon (left) and orange (right). S1: EF→Packline→PH3→Cold; S2: Packline→PH3→Cold; S3: EF→Packline→Cold; and S4: Packline→Cold (standard practice).

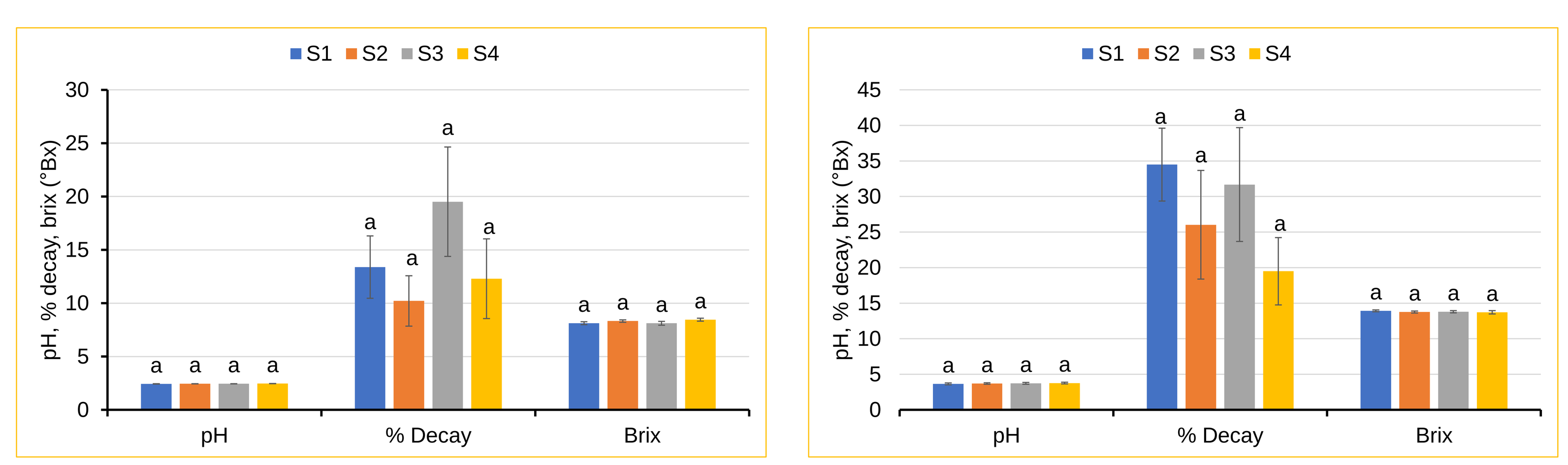

Fig 4. Effect of system approach treatment on pH, percentage decay, and brix of lemon (left) and orange (right). S1: EF→Packline→PH3→Cold; S2: Packline→PH3→Cold; S3: EF→Packline→Cold; and S4: Packline→Cold (standard practice).

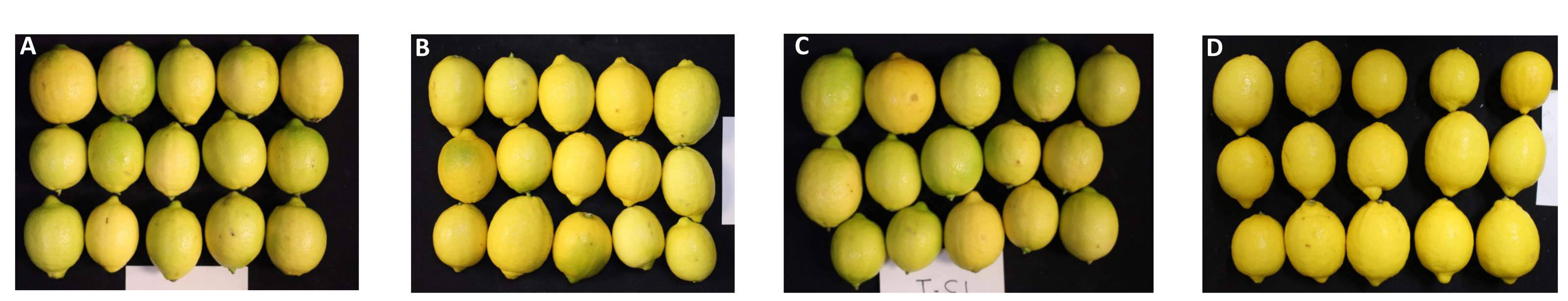

Fig 5. Posttreatment photographs of lemons. A (S1): EF→Packline→PH3→Cold; B (S2): Packline→PH3→Cold; C (S3): EF→Packline→Cold; and D (S4): Packline→Cold (standard practice).

Results and Discussion

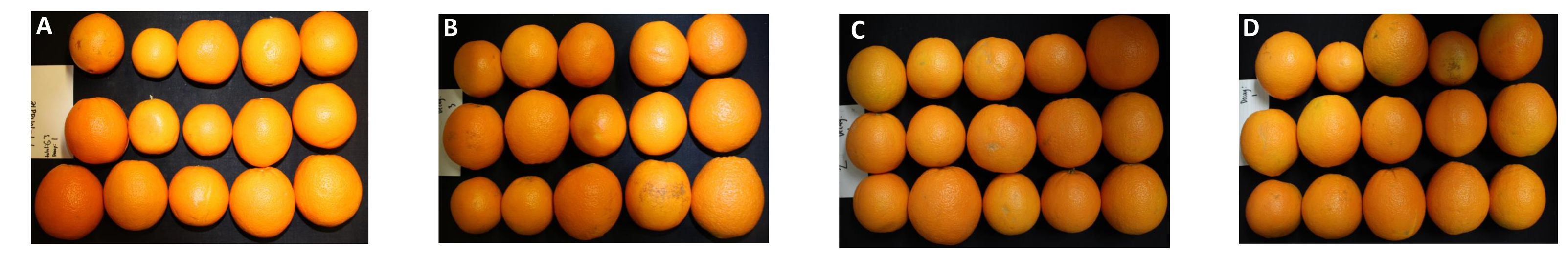

Fig 6. Posttreatment photographs of oranges. A (S1): EF→Packline→PH3→Cold; B (S2): Packline→PH3→Cold; C (S3): EF→Packline→Cold; and D (S4): Packline→Cold (standard practice).

- We found 100% mortality for bean thrips and California red scale and 99.6−100% mortality for flat mite (Fig. 3). S2 and S3 had 100% mortality for all three insect species.
- Although a significantly high mortality rate was observed for Fuller rose beetle eggs in one experiment, overall results show that systems approach did not fully control eggs.
- Remarkably, a significant percentage of specimens was washed by the pressure wash in all treatments but varied for different species, ranging up to 90, 54, 98, and 32% for bean thrips, citrus flat mite, California red scale, and Fuller rose beetle, respectively.
- The pH, percentage fruit decay, and brix of treated fruits both lemon and orange were not significantly different (Fig. 4), suggesting no adverse effect of system approach treatments on those qualities.
- The posttreatment effect on fruit appearance of lemon (Fig. 5) and oranges (Fig. 6) also indicates no negative impact of system approach treatment on fruit quality.
- System's approach was comparatively evaluated based on technical efficacy, as well as logistical and operational considerations.

Conclusions and Recommendations

- System approach treatment method was effective to control bean thrips, California red scale, and citrus flat mites.
- Fuller rose beetle eggs were not fully controlled with system approach treatments although they were remarkably killed in one experiment.
- The treatments did not significantly affect the pH and brix values of fruits.
- Percentage fruit decay was also not significantly altered by system approach treatment.
- Overall, system approach treatment is effective against controlling trade barrier pests like bean thrips, California red scale, and citrus flat mites without impairing some fruit qualities.

Acknowledgements

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