The red spider mite, (Panonychus ulmi) infests mostly, fruit trees such as apple, pear, plum, and cherry. However, it also affects woody plants such as orchids, roses, and other ornamentals. The red spider mite, also known as the European red mite, originated in Europe but is now found around the globe and is considered one of the main pest attacking fruit trees around the world.

The red spider mite belongs to a group of plant-feeding mites called the Tetranychidae family; they are tiny arthropods measuring approximately 0.42 mm. ("European Red Spider Mite Panonychus Ulmi Winter 1 Koppert," n.d.) Adult females are about 0.4 mm long, brick red, and oval-shaped with white hairs on their back and white spots (tubercles) at the base of the hairs; males are about 0.3 mm long, yellowish red, and slenderer and tapered near the hind end. As for, the eggs they are about 0.15 mm in diameter, dark red, and oval with small slender stalk on top. ("European Red Spider Mite Panonychus Ulmi Winter 1 Koppert," n.d.)

The red spider mite eggs overwinter from mid-August to the end of April, in the wooden part of the tree, they start hatching during May. Their mating season is from the end of May till mid-August. According to a study done by Utah State University Extension and Utah Plant Pest Diagnostic Laboratory in which they monitored the life cycle of the red spider mite, they concluded that adult and Immature mites are found from the beginning of May till the end of September. While overwintering eggs can be monitored from fall through early spring. (Koveos, D. S., & Broufas, G. D. (2000). Functional response of Euseius finlandicus and Amblyseius andersoni to Panonychus ulmi on apple and peach leaves in the laboratory.)

The red spider mite affects peach trees, even a light infestation causes spots on the leaf, and a heaver infestation will cause the leaf to be bronze, pale in color, and drop.

This will cause a decrease in fruit quantity and quality. The overall tree will become under stress making it more sensitive to other diseases.

Management:

The first rule in managing red spider mites is regular monitoring for both the pest and its symptoms.

Cultural control

The development of the red spider mite from eggs to adults increase at higher temperature and it takes about 2 weeks at 21°C. In addition, red mites prefer hot, dry, and dusty conditions keeping the orchard well-irrigated and clean decreases the hatching of the overwintered eggs.

Proper pruning and adding an adequate amount of fertilizers will also help the tree overcome any infection and overwintering.

Monitoring

Monitor for mites at least weekly from May to August. Monitor the orchard every few days if there are any issue areas, such as trees beside roadways or water-stressed trees. Prior to July 1, concentrate surveillance on hot spots or regions of the orchard that grow mites first; these are frequently dusty or water-strained places. Once the treatment threshold in these locations has been reached, sample the rest of the orchard to evaluate whether a spot treatment is sufficient or if the entire orchard requires treatment. Monitor the entire orchard after July 1, separating it into sampling zones that can be treated independently. After August 15, populations begin to drop, and treatments are often no longer required.

Mite Ratings (percent of leaves with one or more mites)

- **low** (1-20%) = an occasional mite on occasional leaf; hard to find.
- **low/moderate** (21-39%) = mites easier to find but no colonies or webbing and few eggs.
- **moderate** (40-60%) = some leaves without mites, other leaves with small colonies; eggs easy to find but very little webbing.
- **moderate/high** (61-79%) = mites on most leaves, colonies with eggs, and webbing on some leaves.
- **high** (80-100%) = lots of mites on most leaves; eggs and webbing abundant.

("Webspinning Spider Mites / Peach / Agriculture: Pest Management Guidelines / UC Statewide IPM Program (UC IPM)," n.d.)

Biological Control

Biological Management The predatory mite, Zetzellia mali; the small black lady beetle, Stethorus picipes; green lacewings, Chrysopa spp. ; brown lacewings, Hemerobius spp. ; minute pirate bug, Orius tristicolor; and campylomma bug, Campylomma verbasci are the principal predators of European red mite. Western predatory mite (Typhlodromus occidentalis), the more frequent mite predator, will feed on immature stages to some extent, but preferring twospotted and McDaniel spider mites over European red mite. The biological control of European red mites by predators is not as reliable as the biological control of web spinning spider mites by the western predatory mite. As a result, the existence of predators in orchards should be taken into account in any management decision, although keep in mind that biological control of European red mite is often ineffective. ("Webspinning Spider

Mites / Peach / Agriculture: Pest Management Guidelines / UC Statewide IPM Program (UC IPM)," n.d.)

Chemical control

A study published in insect journal, to determine the best pesticide for the infection of red spider mite showed that the pesticide chemical treatments containing a mixture of zeta-cypermethrin and avermectin were determined to be effective in controlling P. ulmi population throughout the season without reducing populations of predatory mite species. Among other active ingredient chemicals, treatments containing fenpyroximate and etoxazole were not effective in reducing P. ulmi populations, and etoxazole had a significantly higher number of overwintering P. ulmi eggs compared to all other pesticide treatments. (Joshi, Phan, & Biddinger, 2023)

Maintaining populations of predatory mite species in peach orchards is crucial in the conservation and biological control of P. ulmi. Therefore, selecting pesticides that are less toxic to predatory mites and developing strategies to mitigate the non-target effects of pesticides could help maintain predatory mite species.

Case study: Management of Panonychus ulmi with Various Miticides and Insecticides and Their Toxicity to Predatory Mites Conserved for Biological Mite Control in Eastern U.S. Apple Orchards.

The field study aims to evaluate different pesticide options for managing the European red mite (Panonychus ulmi) in apple orchards. The study also assessed the

impact of these pesticides on non-target predatory mite species, including Neoseiulus fallacis, Typhlodromus pyri, and Zetzellia mali.

Target Pest and Study Context:

The European red mite (P. ulmi) is a polyphagous pest affecting various tree and small fruit crops, including apples.

Application Thresholds and Practices:

Pesticides were applied using a commercial airblast sprayer at the recommended economic Integrated Pest Management (IPM) threshold of 3–5 mites/leaf or prophylactically in the spring, ignoring IPM practices such as monitoring, reliance on biological control, and economic thresholds.

A field study was conducted to evaluate different pesticide options available for the management of P. ulmi, and their impact on the population of non-target predatory mite phytoseiid mite and Zetzellia mali in apple orchards.

The study covers the control of 3 stages, egg count, adult count, and overwintering eggs from each pesticide treatment.

The pesticides under study are as follows:

1: Cyflumetofen, organo-silicon surfactant

2: Cyflumetofen

3: Dicloromezotiaz

4: Spinetoram

5: Bifenthrin

6: Fenpyroximate

7: Etoxazole

8: Zeta-cypermethrin + avermectin B1 + mineral oil

9: Abamectin + mineral oil

10: Spirodiclofen

11: Untreated control

RESULTS:

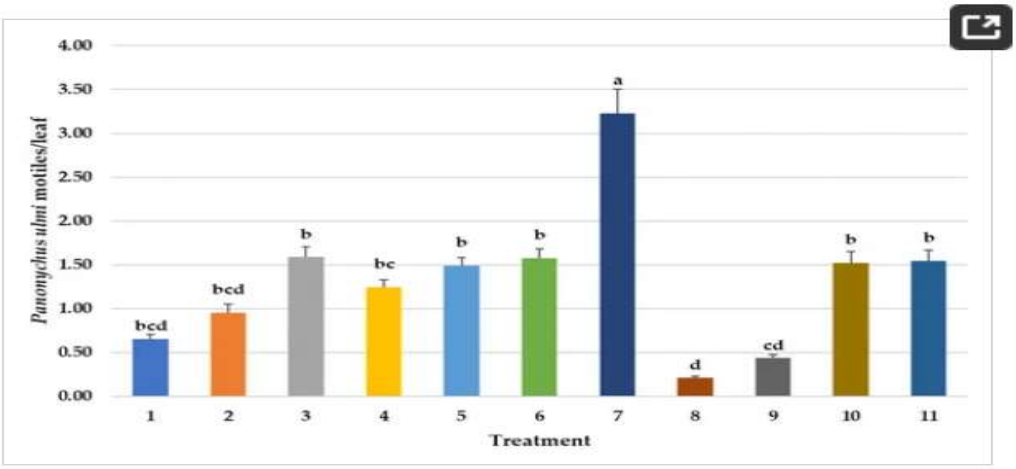

Figure 1. The mean number of Panonychus ulmi motile stages per sampled/leaf over time in different pesticide treatments.

Fig 1 shows the number of panonychus ulmi motile stage (adult stage) per leaf in different pesticide treatments. A small comparison will show us that the most effective treatments (treatment with the lowest number of Panonychus ulmi are treatments 8 and 9 (8: Zeta-cypermethrin + avermectin B1 + mineral oil, 9: Abamectin + mineral oil 10: Spirodiclofen). number 1 treatment (Cyflumetofen,

organo-silicon surfactant, also shows a slightly lower number of Panonychus ulmi adults.

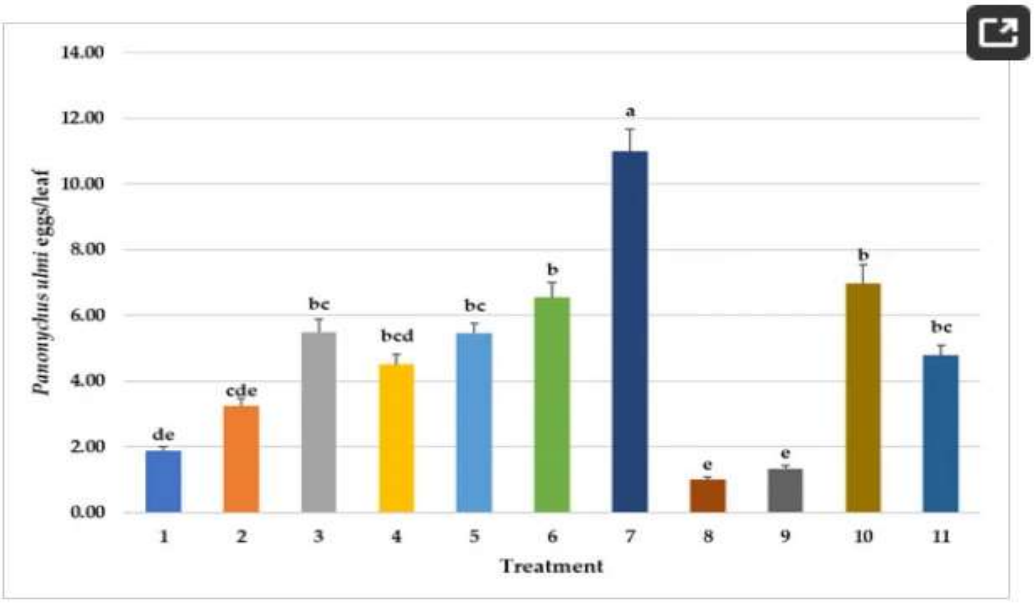

Figure 2. Mean number of Panonychus ulmi eggs per sampled/leaf over time in different pesticide treatments.

Fig 2, shows the number of eggs per leaf in different treatments, a small comparison will also show that the most effective treatment (treatment with the lowest number of Panonychus ulmi eggs are treatments 8 and 9 (8: Zeta-cypermethrin + avermectin B1 + mineral oil, 9: Abamectin + mineral oil 10: Spirodiclofen). In addition, we can also observe the effect of treatment number 1 treatment (Cyflumetofen, organo-silicon surfactant) with the number

of eggs around 2 mean per leaf which is on the low threshold.

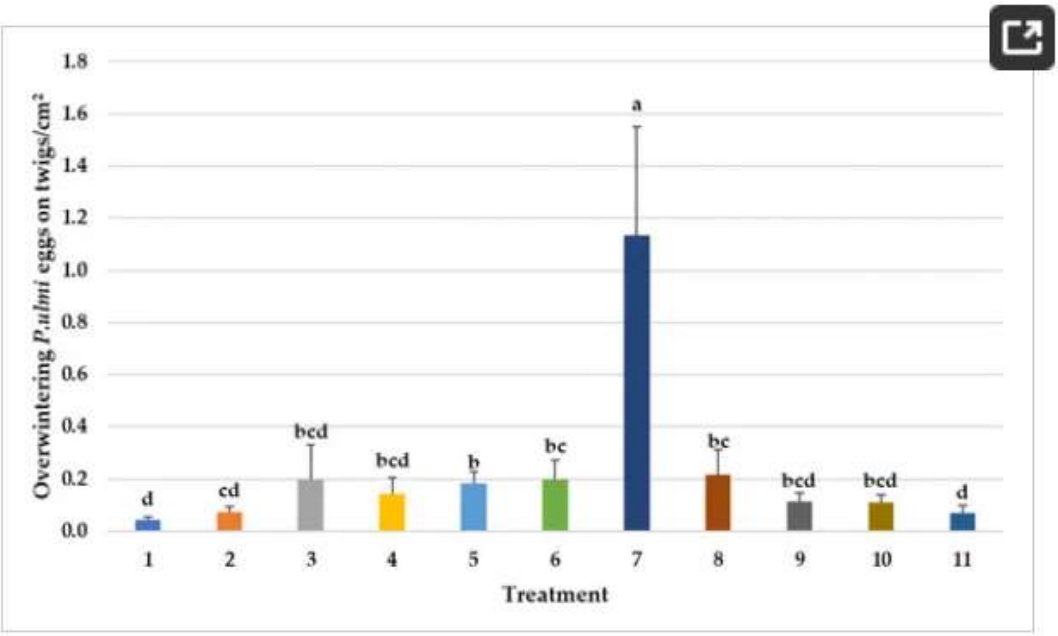

Figure 3. The mean number of overwintering eggs of Panonychus ulmi on twigs of apple trees.

Fig 3, shows the number of overwintering eggs of Panonychus ulmi on twigs of apple trees. As shown all pesticide treatments reduce the number of overwintering eggs, most of all treatments 1 and 2 (Cyflumetofen based). Treatments 8 and 9 also show effect.

We should note that Panonychus ulmi lays eggs as early as August till late October and the treatment admission was after this period.

Impact of different treatments on Predatory Mites:

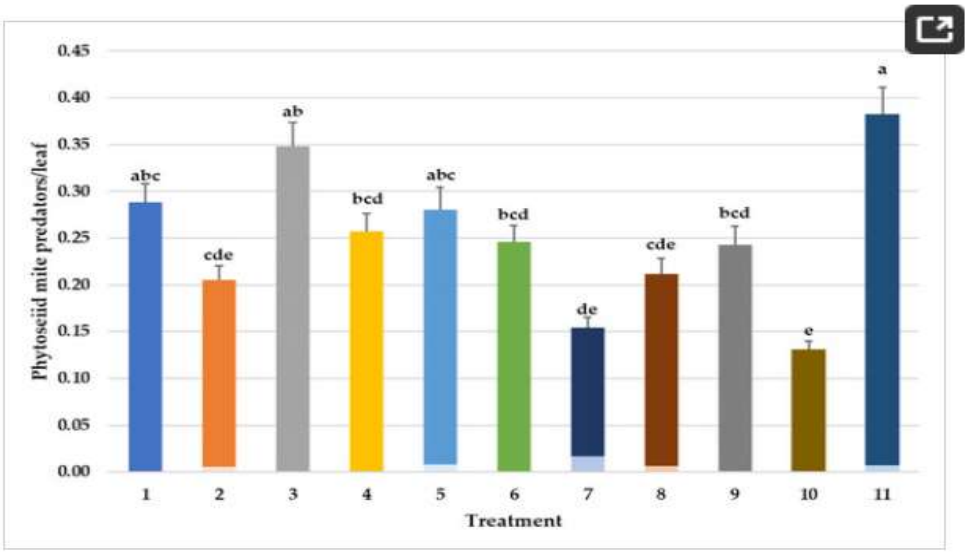

Figure 4. Mean abundance of phytoseiid mite predators (PMP) per sampled/leaf in various treatments over time and percent phytoseiid mite predators (PMP).

In fig 4, we measure the count of phytoseiid mite predators (PMP) per sampled/leaf in various treatments. We can conclude that none of the 10 treatments affect the PMP population greatly. Comparing different treatments, treatment number 7 and 10 decreased the number of PMP the most (7: Etoxazole, 10: Spirodiclofen)

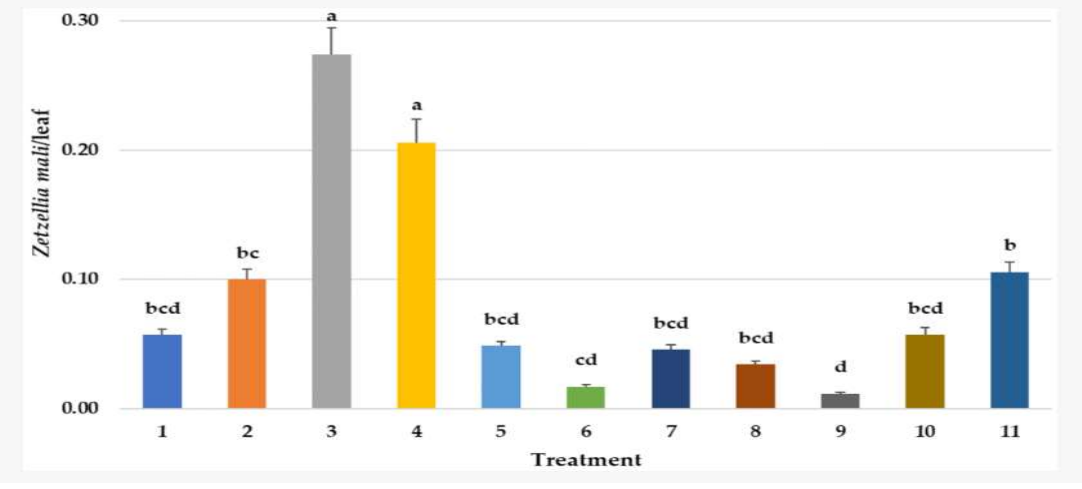

Figure 5. Mean abundance of stigmaeid mites *Zetzellia mali* per sampled/leaf over time in various treatments.

Fig 5, shows the result of different pesticide treatments on *Zetzellia mali* per sampled/leaf. Unlike PMP, almost all pesticide treatments affected on *Zetzellia mali* population, except treatments 3 and 4. (3: Dicloromezotiaz, 4: Spinetoram)

Conclusion:

In this study, pesticide chemical treatments containing a mixture of zeta-cypermethrin and avermectin were determined to be effective in controlling *P. ulmi* population throughout the season without reducing populations of predatory mite species. Maintaining populations of predatory mite species in apple orchards is crucial in conservation and biological control of *P. ulmi*. Therefore, selecting pesticides that are less toxic to predatory mites and developing strategies to mitigate the non-target effects of pesticides could help maintain predatory mite species.

It's important to note that the findings of this study are specific to the mentioned pesticides and conditions, and the effectiveness of pest management strategies can vary based on factors such as location, climate, and specific pest populations. Additionally, the use of prophylactic treatments may have implications for broader IPM practices and sustainability.

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(Koveos, D. S., & Broufas, G. D. (2000). Functional response of Euseius finlandicus and Amblyseius andersoni to Panonychus ulmi on apple and peach leaves in the laboratory. *Experimental & applied acarology*, *24*, 247-256.)

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