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Assessing the Effectiveness of Bifenazate Acaricide for Controlling *Panonychus ulmi* Infestations

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ABSTRACT

The management of *Panonychus ulmi* Koch in apple orchards is critical to reducing both qualitative and quantitative damage. *Panonychus ulmi* is one of the most common mite species, affecting a variety of plant hosts including non-fruit trees, fruit trees, stone fruits, and weeds across the country. This study investigated the effectiveness of three different concentrations of bifenazate in controlling *Panonychus ulmi* populations in apple orchards located in regions with distinct geographical locations and chemical histories of pest management. The treatment was applied via foliar spray, with an evaluation based on an average population of five mites and 30% leaf contamination. The effectiveness of each concentration was assessed by collecting 50 leaf samples from the upper side of the leaves. The findings showed that bifenazate concentrations of 6.0 and 7.0 ml/l were effective in reducing *Panonychus ulmi* populations to below 5 mites per leaf. However, while bifenazate reduced the number of natural predators, such as predatory mites, age bugs, and predatory thrips, it did not eliminate them.

Keywords: Apple orchards, *Panonychus ulmi*, Geographical diversity, Bifenazate, Pest management

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Introduction

Panonychus ulmi Koch, known after Tetranychus urticae Koch, is a significant pest affecting a wide range of plant hosts, including fruit trees, seed and kernel-bearing plants, non-fruit trees, and different weeds. This pest overwinters as eggs on branches, and trunks of apple trees, with egg hatching occurring as the apple blossoms begin to open. The first generation of larvae develops on the surface of leaves, and as the developmental stages progress and the adult female mite population increases, feeding damage becomes more evident, especially with rising temperatures and dry conditions, which shorten the generation time [1-3].

Tetranychus urticae, another prominent mite species on apple and other fruit trees, overwinters as adults in the upper layers of the orchard soil. Its first signs of activity are usually visible on the undersides of leaves of broad-leaved weeds in apple orchards. The first generation of this mite causes damage in some apple orchards across various regions. This mite was introduced by Uniroyal Chemical Company in 1990 and later commercialized by Crompton in 1999 [4-6].

Acaricides affect various physiological aspects of mites, including their nervous system, metabolism, fat storage, and developmental stages. They can also influence feeding patterns and the mite's ability to maintain water balance. Bifenazate is effective in controlling eggs of the European red mite and their active stages, which affects apple and cherry trees in regions like Michigan, Europe, and Western Australia. Additionally, it has proven effective against the false tartar mites in Chile and the cedar and greenhouse vegetable mites in British Columbia [7, 8]. Studies have also demonstrated its effectiveness in controlling the greenhouse rose mite in South Korea, with mixed results regarding resistance in some pest populations [9-11].

Bifenazate has been recognized as a resistance-reducing agent for *Tetranychus urticae* mites and is noted for its minimal adverse effects on natural predators like the predatory mite *Amblyseius womersleyi*, making it suitable for integrated pest management [12-14]. In citrus orchards, it has proven effective against *Panonychus citri* and *Tetranychus urticae* without harming natural enemies like *Phytoseiulus persimilis* and *Neoseiulus californicus* [15, 16]. This study evaluates the impact of three bifenazate concentrations on the population of *Panonychus ulmi* in various apple orchards with differing histories of chemical pest control and geographical conditions.

Materials and Methods

This study aimed to assess the efficacy of 3 concentrations (0.5, 0.6, and 0.7 ml/l) of bifenazate 24% SC on controlling the stages of *Panonychus ulmi* in red apple variety orchards. To compare its efficacy, the study also included four different acaricides—Spirodiclofen 240 SC, Fenproximate 5 percent SC, Fenazaquin 20 percent SC, and Fenpropimorph 10% FL—as well as water spraying as the control treatment.

The selection of study areas, including the apple trees' size, age, and variety, was consistent across all regions, and the experimental design employed a randomized block arrangement. A buffer row of untreated apple trees was left between each treatment row to prevent cross-contamination of treatment effects. To evaluate the effectiveness and duration of control for each treatment on *Panonychus ulmi*, 50 leaves were randomly collected at intervals before treatment and at 7, 14, 21, and 28 days after application. The number of live *Panonychus ulmi* mites on the upper surface of the leaves was counted using a binocular microscope. Additionally, the impact of the treatments on natural predators, such as predatory spiders, mites, and insects, was recorded and compared to pre-treatment and 28-day post-treatment observations.

The percentage of pest population reduction was calculated using the Henderson-Tilton formula, and statistical analysis was performed using ANOVA with SAS software. Duncan's test was applied to determine the grouping and treatment effectiveness in each region.

Results and Discussion

Before the treatments, the mean population of active *Panonychus ulmi* stages on apple trees was recorded across various study sites. The population noticed on the above surface of the leaves of the apple trees aligned most closely with the conditions predicted in the research methodology. A statistical evaluation of seven treatments, involving organic acaricides from five different chemical groups, was carried out over four sampling periods and for a total of 28 days across different apple orchards. The analysis of the mean percentage of mortality in the active stages of *Panonychus ulmi* showed significant differences in treatments at days 14, 21, and 28 ($P < 0.05$), but no significant difference was found for day 7 ($P > 0.05$). Specifically, the analysis revealed significant differences for fourteen days ($df = 2.6$; $F = 5.41$; $P < 0.00$), 21 days ($df = 2.6$; $F = 6.04$; $P < 0.00$), and 28 days ($df = 2.6$; $F = 3.13$; $P < 0.01$).

Regarding the effectiveness of bifenazate concentrations, after 7 days, the concentration of 0.5 ml/l achieved a 79.66% mite mortality rate, while the maximum effect (94.33%) was observed after 21 days at 0.7 ml/l. However, by the following day, all concentrations showed a decline in efficacy, with the 0.5 ml/l concentration dropping to a minimum of 44%. On the 28th day, the spirodiclofen acaricide achieved the highest mite mortality, with more than 96% reduction. Other treatments, particularly Fenproximate, exhibited similar trends, with mite mortality increasing over the first 7 days, peaking around day 21, and decreasing thereafter, dropping to under 40% by day 28.

The trend of increasing mite mortality with spirodiclofen was comparable to the bifenazate concentrations. Fenpropimorph, on the other hand, showed a steady decline in efficacy, with higher mortality rates observed than with Fenazaquin and Fenproximate. The highest mite mortality with Fenazaquin was recorded at 98.04% and 95.36% on days 7 and 14, respectively, but it dropped below 50% by days 21 and 28, indicating its higher efficacy against *Panonychus ulmi*. Fenproximate showed minimal efficacy, with mite mortality not exceeding 41%.

Regarding predatory mites, the lowest and highest populations recorded from 50 leaves were 3 and 14 mites, respectively, found in the 0.5 ml/l bifenazate treatment and the control. Only the 0.5 ml/l bifenazate concentration showed an increase in predatory mite numbers at the 28-day mark compared to pre-treatment levels. The effects of the treatment on Thrips populations were observed by shaking the leaves on oiled paper, with a noticeable decrease in their population after 7 days. However, Thrips populations showed a slight increase at days 14 and 21. The highest Thrips population was observed in the pyroxemia treatment. Despite the initial lower population of Thrips in the control group, their numbers increased in the treatments during sampling periods.
Overall, treatments hurt predatory mites, particularly at the 28-day mark, where their populations were reduced by more than 50%. In contrast, the effects on Thrips and predatory mite populations were much less pronounced. Factors such as mobility, flying ability, and the capacity to find new food sources likely helped reduce the adverse effects of foliar sprays on predatory insect populations **(Table 1)**.

Table 1. Comparison of the average population of natural enemies collected from 50 leaves of each treatment.

Predator / time	Orius	Thrips	Phytoseiids
1 day before	2.89 ± 0.39	2.62 ± 0.26	9.62 ± 1.25
7 days after	1.50 ± 0.26	1.37 ± 0.26	5.5 ± 0.62
14 days after	1.62 ± 0.26	1.38 ± 0.18	2.50 ± 0.82
21 days after	1.62 ± 0.26	1.62 ± 0.26	4.12 ± 0.83
21 days after	1.62 ± 0.26	2.12 ± 0.35	4 ± 0.53

Panonychus ulmi was not considered a significant pest globally until after 1940 [17, 18]. Following World War II, the use of carbonic hydrochloric compounds like DDT led to its rise as a pest [19], and today, it is recognized as one of the major pests of fruit trees worldwide [20]. This mite feeds on the green leaf cells of fruit trees, ranging from 70 to 120 microns, leaving behind yellow needle-like marks by draining the cell contents. The damage causes the leaves to turn yellow and fall prematurely, with the effects often lingering for several years. *Panonychus ulmi* infestation can stifle branch growth, decrease trunk diameter, reduce apple size, impair marketability, and negatively affect the chemical composition of the fruit [21, 22].
Bifenazate, a carbazate-based chemical, acts on the nervous system of *Panonychus ulmi*, and because it has short-term effects on plants, it poses a low risk to the environment, mammals, and natural enemies [4]. Different acaricides, such as bifenazate and fenpropathrin, affect the nervous system, while fenazaquin and fenpyroximate target the respiratory system and spirodiclofen impacts the developmental stages of the mite, leading to toxicity. The highest mite mortality was observed with all three bifenazate concentrations, with effects persisting up to 21 days. In Europe, bifenazate has been primarily used for mite control on ornamental plants and greenhouse crops during the summer [23].
The efficacy of 3 concentrations of bifenazate in controlling Phytonemus pallidus in Poland's greenhouse strawberry crops showed 87% control within two weeks of foliar spraying [24, 25]. The introduction of bifenazate in Canada for controlling *Panonychus ulmi* has been successful in preventing resistance development in the pest mite population [7]. However, high pest mite populations on fruit trees and the failure to apply foliar sprays promptly may limit the effectiveness of newly introduced acaricides.
This study demonstrated that as the concentration of bifenazate increased, the mortality of *Panonychus ulmi* also increased. Similar results were observed in tea gardens in eastern India, where spraying 50 grams of bifenazate caused a significant reduction in Oligonychus coffeae (Tartaran mite) populations after four to fourteen days, preventing the pest's reactivation after 35 days [26].
The effect of bifenazate at a concentration of 0.5 ml/l on the population of predatory mites showed an increase, while concentrations of 0.6 and 0.7 ml/l led to a decrease in mite numbers in apple orchards. A similar pattern was observed in the population of Orius sp., a predatory bug. Overall, more than 50% of natural enemy populations were reduced within 28 days after foliar spraying compared to pre-treatment levels in the apple orchard.
Laboratory tests indicated that bifenazate caused both lethal and sublethal effects on predatory mites, especially when compared to plant-based acaricides and fungicides, suggesting its potential for integrated pest management against tartan mites. Further studies have shown that bifenazate, along with other organic acaricides, poses a low risk to species like *Phytoseiulus persimilis* and *Neoseiulus californicus*, making it safe for use in preserving natural

enemies [27, 28]. Therefore, the use of low-risk acaricides like bifenazate is crucial for controlling *Panonychus ulmi* in apple orchards, ensuring the safety of natural enemies, and maintaining the quality of apple products, such as fruit juice, compote, and apple-based by-products.

Conclusion

Bifenazate has been recognized for its ability to reduce resistance in *Tetranychus urticae* populations and minimize harm to natural predators such as *Amblyseius womersleyi*, demonstrating its potential for use in integrated pest management [12]. It has also proven effective against *Panonychus citri* and *Tetranychus urticae* on citrus plants, showing no significant adverse effects on natural enemies like *Phytoseiulus persimilis* and *Neoseiulus californicus* [15]. This study evaluated three different concentrations of bifenazate for controlling *Panonychus ulmi* across multiple apple orchards located in regions with varying climates and past chemical control practices.

The results indicate that concentrations of 6.0 and 7.0 ml/l are effective in reducing *Panonychus ulmi* populations in the early stages of infection, maintaining an average of fewer than five European red mites. While bifenazate does lower the numbers of natural predators, including predatory mites and thrips, it does not eliminate them, allowing for the continued presence of beneficial species in the orchard.

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