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Biological Control Strategies for Insect Pests of Rosa Chinensis

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Abstract: This study explores biological control strategies for managing Rosa chinensis pests, specifically mites *(Tetranychus urticae)* and aphids *(Macrosiphum rosae)*, through agroecological approaches such as companion planting and habitat enhancement. Predatory mites *(Phytoseiulus persimilis)*, hoverflies *(Syrphidae)*, lacewings *(Chrysopidae)*, and ladybugs *(Coccinellidae)* were identified as effective natural enemies for pest suppression. Strategic intercropping with plants like *Lobularia maritima*, *Viburnum tinus*, and *Vitis riparia* was proposed to attract and sustain these predators, reducing pest populations while minimizing chemical inputs. The research highlights the ecological and economic advantages of biological control, including reduced environmental risks, enhanced biodiversity, and long-term sustainability, compared to conventional chemical pesticides. By integrating natural pest control methods, this study provides practical solutions for sustainable *Rosa chinensis* cultivation and contributes to the broader adoption of environmentally friendly agricultural practices.

Keywords: Rosa chinensis, Biological Control, Pest Management, Companion Planting

1. Introduction

Rosa chinensis (China Roses) is a widely cultivated ornamental plant, valued for its aesthetic and economic significance. However, it is highly susceptible to pests, particularly mites *(Tetranychus urticae)* and aphids *(Macrosiphum rosae)*, which can cause significant damage. Current pest control relies heavily on chemical insecticides, which pose risks of resistance development, environmental contamination, and harm to non-target organisms. This paper explores biological control strategies, emphasizing agroecological designs such as companion planting to enhance natural enemy populations. Based on agroecological principles, a design is proposed to provide habitats and alternative food sources for predators and parasitoids, thereby sustainably reducing pest populations.

2. Main insect pests of *R. chinensis*

2.1. Mites (Tetranychus urticae)

The two-spotted spider mite *(T. urticae)* is a major pest of R. chinensis. These mites reproduce rapidly and feed on plant cells, causing chlorosis, leaf desiccation, and eventual plant death. Their ability to spin webs over plant surfaces reduces the effectiveness of chemical sprays [1]. The mites are typically found on the underside of leaves, where they lay transparent eggs. Both nymphs and adults feed on plant tissues, leading to yellowing and death of leaves.

2.2. Aphids (Macrosiphum rosae)

Aphids are another significant pest of R. *chinensis*. They feed on plant sap, causing deformation of leaves, reduced plant vigor, and the secretion of honeydew, which promotes sooty mold growth and impairs photosynthesis. Aphids are also vectors of plant viruses, such as cytorhabdovirus, which can severely damage R. *chinensis* [2]. Their population growth is further supported by ants, which protect aphids in exchange for honeydew, complicating biological control efforts.

3. Control Methods

3.1. Chemical Control

Chemical insecticides, such as imidacloprid for aphids and acaricides for mites, are widely used. While effective in the short term, their long-term use often leads to resistance development, secondary pest outbreaks, and environmental contamination. Additionally, pesticides can eliminate natural enemies, exacerbating pest problems and creating a dependency cycle often referred to as the "pesticide treadmill"[3].

Excessive fertilization increases pest populations by enhancing plant nutrient levels. Research indicates that reducing fertilization levels by 50% can decrease mite egg density without compromising plant yield [4]. Proper fertilization practices can therefore play a role in integrated pest management.

3.2. Biological Control

Biological control employs living organisms, such as predators and parasitoids, to suppress pest populations. Natural enemies such as predatory mites *(Phytoseiulus persimilis)*, hoverflies *(Syrphidae)*, and lacewings *(Chrysopidae)* are effective against *T. urticae* and *M. rosae*. Conservation biological control, which enhances habitats for these natural enemies through intercropping and flower provision, offers a sustainable alternative to chemical pesticides [5].

3.3. Comparative Advantages of Biological Control Over Chemical Methods

Biological control offers significant economic advantages compared to chemical methods. While chemical pesticides require frequent applications and incur recurring costs, biological control involves one-time or periodic investments with long-term benefits. A study indicates that the costs incurred from the use of traditional pesticides exceed the economic returns generated from crop cultivation and harvest, with pesticide expenses amounting to twice the revenue produced [6]. And, A study in Brazil showed that biological control in *R. chinensis* greenhouses was cheaper and more effective than chemical methods. It reduced labor costs, avoided pesticide safety waiting periods, and improved work conditions [7]. Additionally, habitat enhancement strategies, such as planting *Lobularia maritima* or *Vitis riparia*, require minimal maintenance and support natural enemy populations over time. Biological control also reduces environmental harm and preserves biodiversity, contributing to sustainable agriculture and long-term savings.

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4. Main Predators of Mites and Aphids

Effective biological control of mites and aphids in *Rosa chinensis* cultivation relies on the establishment and conservation of natural predators. The following key predators have been identified for their significant contributions to pest management.

Predatory mites *(Phytoseiulus persimilis)*: Specializes in consuming all life stages of spider mites. Predatory mites detect spider mite webs and attack their prey by sucking out their contents, leaving behind empty shells [8].

Hoverflies *(Syrphidae)*: Adults feed on nectar and pollen, while their larvae prey on aphids, consuming up to 150 aphids per day [9]. Hoverflies are attracted by nectar-rich flowers such as *Lobularia maritima*.

Lacewings *(Chrysopidae)*: Lacewing larvae feed on aphids and other soft-bodied insects. Their unique egg-laying strategy, where eggs are suspended on silk stalks, protects them from predation [10].

Ladybugs *(Coccinellidae)*: Both larvae and adults are voracious aphid predators. A single adult can consume up to 50 aphids daily, making them highly effective biological control agents [11].

These predators not only help regulate pest populations but also contribute to maintaining ecological balance. Their effectiveness can be further enhanced by introducing flowering plants and companion crops that provide food and shelter, ensuring their long-term presence in agricultural systems.

5. Monitoring pest levels and presence of natural enemies in the *R. chinensis* garden

5.1. Monitoring pests

In *R. chinensis* cultivation, effective monitoring of mites and aphids is essential for implementing pest management strategies. Among the various monitoring techniques, the Presence/Absence (P/A) method serves as a rapid and practical approach, particularly under low pest density conditions [12][13]. This method is a binary monitoring system that records whether pests are present without needing to count their total number. Research indicates that infestation levels on leaflets correlate strongly with whole-leaf infestation, allowing sampling to focus on leaflets without losing accuracy [14]. For mites, sampling typically focuses on the underside of leaves in the middle and upper canopy, where the mites are most likely to colonize [15]. Similarly, for aphids, the inspection concentrates on new growth, such as young shoots and flower buds [16]. The data collected through P/A sampling can be used to estimate pest density and occurrence probability when combined with statistical models, providing a reliable basis for determining economic thresholds and guiding timely interventions [13]. By simplifying the monitoring process, the P/A method reduces labor intensity while maintaining sufficient accuracy for decision-making in pest management programs.

5.2. Economic threshold of *R. chinensis*

The economic threshold refers to the pest population level at which the cost of damage exceeds the cost of control measures. For *R. chinensis*, there are no established thresholds for mites, making it difficult to decide the timing of interventions. Preliminary studies suggest that very high mite densities are required for vertical movement onto harvested flowers, but even lower densities can cause visible damage and physiological stress to plants [14]. Developing a framework for economic thresholds is critical for optimizing pest management strategies.

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5.3. Monitoring natural enemies

Monitoring natural enemies is essential to evaluate their diversity and abundance. Four methods are particularly effective: floral observations, pitfall traps, foliar monitoring and aphid mummy monitoring.

Floral observation is a timed monitoring method designed to assess insects that visit open flowers for pollination [17]. Observers record insect activity on flowers along a 200-foot transect within a 3-foot radius for 15 minutes during optimal weather conditions. Key insects include honey bees, native bees, syrphid flies, predatory wasps, lady beetles, and green lacewings [18].

Pitfall traps capture ground-dwelling predators such as ground beetles. Containers are buried flush with the ground, and insects are counted before being released[19]. This method provides a cost-effective method of studying the diversity and abundance of ground-dwelling arthropods[20].

Foliar monitoring is a method of collecting and recording specific insects found on the leaves of plants by using a sweep net or beat sheet. Observers collect insects from plant leaves, which are then counted and classified. This ensures a detailed understanding of foliar predator populations [21].

Aphid mummy monitoring method assesses the parasitization rate of aphids by parasitoid wasps. Observers inspect *R. chinensis* plants for mummified aphids, which are the remains of aphids that have been parasitized. The percentage of mummified aphids compared to live aphids provides an indicator of parasitoid effectiveness [22]. This method offers a straightforward way to evaluate the success of biological control efforts.

By combining these methods, researchers can gain a comprehensive understanding of pest and natural enemy dynamics, forming the basis for informed pest management decisions.

6. Methods to attract natural enemies and control pests through companion planting

6.1. Using flowers to attract and retain natural enemies

The strategic use of flowering plants is one of the most effective ways to support populations of natural enemies. Predatory insects and parasitoids often require supplemental food sources, such as nectar and pollen, especially during periods when prey populations are low. Native flowering plants play a dual role by providing food and attracting prey insects that natural enemies feed on[5].

The combination of American grape *(Vitis riparia)* and European wayfarer tree *(iburnum tinus)* are considered superstar partners (BP). When they're intercropped with Rosa, their presence usually results in the healthiest *R. chinensis*, with the highest count of predatory mites that prey on pests, and the smallest number of pests. Both of these plants have special structures called domatia, which might be the reason why they're so good at hosting predatory mites. The shrub *Viburnum tinus* seems ideal as it doesn't attract any pests, but it attracts lots of natural enemies. Plus, it has a compact growth habit, perfect for use in greenhouses. [23].

6.2. Controlling pests via companion planting

In addition to planting plants that are purely attractive to predators, companion planting can also be used to prevent pests from harming the main plants, acting as trap plants or repellent plants. Many herbivorous insects show a marked preference for certain plant organs, cultivars, species, or phenological stages. Using such attractive plants can attract aphids and divert them away from host plants, thereby reducing damage.

Repellent plants include plants that release chemicals that are known to affect the movement, feeding, and reproductive behaviors of aphids. These directly interferes with the host plant (HP) selection process by affecting the aphids' habitat and host selection, or indirectly interferes with the selection process by altering the aphids' acceptance of the HP. Similarly, certain companion plants

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have shown potential in disrupting the behavior of mites. For instance, plants like *Mentha* (mint) release volatile organic compounds (VOCs) that can deter mites from infesting nearby plants [24].

Other companion plants release specific volatile compounds that act as masking agents to cover the odor of the host plants, thereby reducing the ability of aphids to find the HP. This disrupts the orientation and recognition of the host plants by the aphids.

Due to chemical signaling between companion plants and host plants, companion plants can alter the biochemical characteristics of the host plants, leading to the release of chemicals unsuitable for aphids from the host plants, thus making the HP unsuitable for pests. Several studies have shown that the HP can detect chemical signals emitted by neighboring plants, triggering their active VOCs emission or changes in their chemical composition [25].

7. How to assess if the habitat created is conducive to enhance natural enemies?

Naturally occurring predators and parasitoids play a crucial role in controlling pests, and there are various strategies for improving their habitats to maintain and increase their populations. The Xerces Society's guide provides a comprehensive method for assessing and enhancing beneficial insect habitats on farms, which includes five key sections.

Specifically, the first section is determined by the ecological diversity of the landscape, the proportion of field area and boundaries to judge its potential to use natural enemies for pest control. The specific assessment criteria are based on the percentage of natural or semi-natural vegetation within half a mile of the farm and the dominant vegetation in non-cultivated areas.

The second section claims that the natural environment within the farm has a significant impact on the quantity and diversity of natural enemies. The assessment is based on the percentage of natural or semi-natural habitats on the farm and any other characteristics present on the farm.

The third section is related to the food requirement of natural enemies. This section is assessed by the percentage of vegetation cover and the diversity of species of beneficial flowering plants, shrubs, or trees.

The fourth section is an assessment of whether the habitat meets the shelter needs of beneficial insects, including whether it can help them overwinter, reproduce, and avoid predation.

The fifth part is about the impact of pesticide use on the number of natural enemies. The assessment criteria include the use of non-chemical crops and pest management techniques on the farm, as well as the use of insecticides.

The assessment includes scoring each category, and a total score of at least 110, with a minimum improvement of 40 points post-implementation, indicates a habitat that is conducive to supporting natural enemies [26].

To maximize effectiveness, habitats for natural enemies should be located near pest-prone areas. Although some natural enemies, such as parasitic wasps, can travel long distances, closer proximity enhances their efficiency in regulating pest populations. A well-designed habitat not only supports biodiversity but also reduces the likelihood of pest outbreaks, ensuring sustainable pest control.

8. A proposed design for *R. chinensis*

A proposed greenhouse design for *R. chinensis* includes intercropping with *L. maritima, V. tinus, and V. riparia. L. maritima* clusters are placed around *R. chinensis* to attract hoverflies, while *V. tinus* serves as a trap plant for aphids. *V. riparia* is planted at greenhouse corners to support predators. This design ensures optimal sunlight exposure and minimizes nutrient competition.

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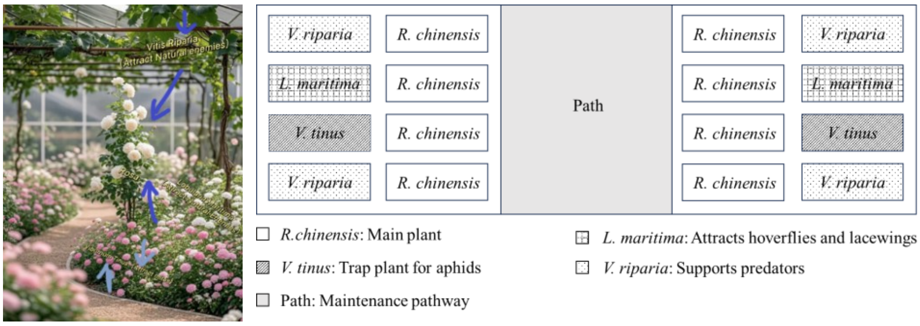

Figure 1: Greenhouse design for R. chinensis

In detail, there should be a pathway in the middle of the greenhouse for people to walk along, and plant *R. chinensis* on both sides as shown in figure 1. A cluster of *Lobularia maritima* should be placed around an *R. chinensis*, which can bring many benefits to the cultivation of *R. chinensis*. It adapts well to a variety of environments, making it easy to cultivate. And compared to other flowers, it has a relatively long blooming period, which makes it attractive to natural predators and therefore it serves a biological control function [27]. Additionally, the root system of the *R. chinensis* can extend about 40 centimeters underground, while the roots of *L. maritima* are typically not deep or extensive, so it means that the nutrients of the *R. chinensis* will not be contested by *L. maritima*. As previously mentioned, the intercropping of *V. tinus* and *V. riparia* with *R. chinensis* can enhance the efficiency of growing *R. chinensis*. It's because *V. tinus* is naturally attractive to aphids, so growers can also plant a cluster of *V. tinus* next to an *R. chinensis*, as it can attract pests like aphids to itself, preventing the R. chinensis from aphid damage. *V. riparia* can attract natural enemies for *R. chinensis*. It is important to note that the roots of *V. riparia* are deeper and longer, which may compete for the nutrients of the *R. chinensis*. The best option is to plant *V. riparia* only in the four corners, ensuring that the gaps between the top supports for *V. riparia* climbing are large enough, and trimming the branches and leaves of *V. riparia* in time to ensure that at least about 80% of sunlight can reach the plants below, rather than being blocked.

9. Conclusions

This study demonstrates the effectiveness of agroecological strategies in managing pests of *Rosa chinensis*, particularly mites *(Tetranychus urticae)* and aphids *(Macrosiphum rosae)*. By integrating biological control methods, such as habitat enhancement and companion planting, growers can attract and sustain natural enemies, including predatory mites, hoverflies, lacewings, and ladybugs, to achieve sustainable pest regulation. These strategies not only reduce reliance on chemical pesticides but also mitigate environmental risks, delay resistance development, and minimize harm to non-target organisms. The proposed greenhouse design, featuring intercropping with *Lobularia maritima, Viburnum tinus, and Vitis riparia*, highlights the potential of optimizing plant combinations to enhance natural enemy populations and suppress pests. These findings underscore the economic benefits of biological control, including reduced labor costs, long-term pest management, and enhanced biodiversity.

However, to further optimize pest management strategies for Rosa chinensis, it is essential to integrate the biological control methods proposed in this study within the framework of Integrated Pest Management (IPM) [28]. Future research should focus on how to more effectively integrate companion plants with other management measures under the IPM framework, such as developing suitable companion plant combinations for different cultivation environments, optimizing habitat designs for natural enemies, and exploring the synergistic effects between companion plants and pest-resistant cultivars. Additionally, establishing economic thresholds for Rosa chinensis pests and

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improving monitoring techniques based on IPM principles will help achieve precise management and reduce unnecessary interventions [29][30]. By strengthening research and promoting the adoption of IPM, this study provides scientific support for sustainable *Rosa chinensis* cultivation and serves as a reference for advancing eco-friendly agricultural practices globally.

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