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SYNERGISTIC INSECTICIDAL INTERACTION OF *AEGLE MARMELOS* AND *MENTHA PIPERITA* AGAINST *MYZUS PERSICAE*

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ABSTRACT

The efficacy of natural pesticides derived from *Aegle marmelos* and *Mentha piperita* leaves was investigated against green peach aphids (*Myzus persicae*). The extracts obtained via boiling and soxhlet methods from *A. marmelos* and *M. piperita* leaves were combined and tested for synergistic effects. The results indicate a 100% efficacy rate at a concentration of 500 ppm (*A. marmelos*) + 400 ppm (*M. piperita*), highlighting the potential of these botanical extracts as ecofriendly alternatives.

Key words: Synergism, aphids, vector, *Aegle marmelos*, mentha, natural pesticide, ecofriendly approach, efficacy, extracts, concentration, leaves

Rice crop protection requires a sustainable and ecofriendly IPM strategy to mitigate the adverse effects of synthetic pesticides. In this context, botanical insecticides derived from plant sources have emerged as promising alternatives due to their inherent biodegradability, low toxicity to non-target organisms, and potential for selective targeting of pest species (Donkor et al., 2023). Among these botanicals, *Aegle marmelos* (commonly known as bael or Bengal quince) and *Mentha piperita* (peppermint) have gained attention for their reputed insecticidal properties. *M. persicae* (Green Peach Aphid), a notorious agricultural pest, poses significant challenges to crop production worldwide by causing direct feeding damage and vectoring plant pathogens (Ali et al., 2023; Kaushik and Kumar 2024). Hence, exploring the synergistic bio-insecticidal interaction between *A. marmelos* and *M. piperita* against *M. persicae* holds immense potential for developing effective, environmentally sustainable pest control strategies. *A. marmelos* extract contains enormous number of essential components like furocoumarins, including xanthotoxol and also the methyl ester of alloimperatorin, as well as marmesin flavonoids and rutin, a number of essential oils; and substantial amount of its alkaloids, a-fargarine (allocryptopine), *O*- isopentenylhalfordinol, *O*-methylhafordinol (Snehlata et al., 2019; Bamola et al., 2018; Yogesh and Kumar, 2024).

The compounds extracted from *A. marmelos* have high nutrient level as well as medicinal properties (Mujeeb et al., 2014). Peppermint scientifically known as *M. piperita*, also known as *Mentha balsamea* is the small plant that is obtained as a result of hybridization. When the watermint and spearmint are crossbred therefore, peppermint is produced. The roots are fibrous and can easily colonize the nearby regions, the rhizomes of the plants are flesh and moist. In order to treat different type of pathologies this plant have several bioactive compounds that represents a rich source of phytochemicals (Siddiqui et al., 2003; Trevisan et al., 2017; Yamamura et al., 2018). The study aims to investigate the synergistic effects of combined extracts from *A. marmelos* and *M. piperita* on the mortality and behavior of *M. persicae*, shedding light on their efficacy and potential application in integrated pest management programs.

MATERIALS AND METHODS

The different plants like *A. marmelos* and *M. piperita* has been selected for Organic compound extraction. The collection of these plants was done from Phagwara, Punjab. Different plants parts were used for preparation of extracts such as leaves and stem. Leaves of the plants are washed off in the running water to remove extra dust and contamination. Both fresh leaves and dried leaves of the plants contribute in extract preparation. Aphids were collected from the paddy field. The collection was done with the help of brush and forceps, and eventually kept inside beakers until the setup was established. Aphids were identified by application of standard

Identification keys. The extracts of both the plants were prepared by Soxhlet and Boiling method (Redfern et al., 2014). Aphids were treated with the extracts of *A. marmelos* and *M. piperita* obtained through both plant parts. The triplicate setup of different concentrations was established for the pest treatment. Each beaker was subjected with 15 aphids along with their natural food. The different synergistic concentrations like 500 + 400, 450 + 300, 400 + 500, 350 + 250, 300 + 300, and as 250 + 250 ppm of *A. marmelos* and *M. piperita* were prepared and tested to each triplicate set using spray bottle. These synergistic combinations were prepared with the help of software. The evaluation of Aphid mortality was done after every 3, 6, 12, 24, 48, and 72 hr.

RESULTS AND DISCUSSION

The results demonstrate a significant synergistic effect of the boiling extract of *A. marmelos* and *M. piperita* in controlling the population of *M. persicae*. The combination of these two plant extracts resulted in a remarkable 100% mortality rate of the pest, indicating a potent insecticidal activity. The mortality rate of aphids increased with higher concentrations of the combined extracts. Tables 1 and 2 depicts the data after the exposure of pests with plant extracts for a period of 3, 6, 12, 24, 48 and 72 hr. It shows the comparison of extracts effectiveness prepared by both Soxhlet and Boiling method. When these aphids are treated with plant extracts for a time period of 72 hr, 100% mortality was observed in case of extract treated with boiling method, while 97% of mortality has been observed in case of Soxhlet method @500 + 400 ppm concentration. So, in synergistic interaction of *A. marmelos* and *M. piperita* against *M. persicae,* Boiling method found to be more efficient as compared to Soxhlet method. It confirms that the components were extracted more effectively with the boiling method from the plant extract which leads to the higher mortality rate of *M. persicae*. Thus, extraction of organic compounds conducted in the present study from plants like *A. marmelos* (Beal) and *M. piperita* (Mint) has a promising strategy to control harmful pest like Aphids and generate alternative for trending health and environmental issues in world.

Specifically, concentrations of (500 ppm + 400 ppm) exhibited the most significant effect, achieving complete mortality within 72 hr of treatment. This trend suggests a dose-dependent response, where higher concentrations of the extract combination led to increased efficacy in pest control. This finding aligns with previous studies that have reported similar dose-response relationships

Table 1. Mortality of *M. persicae* with a combination of fresh leaves extracts *(A. marmelos+M. piperita)*

Concentration (ppm)	Mortality (%) at time intervals (hr) Boiling method					
	3	6	12	24	48	72
500+400	2.20± 0.58	6.66± 1.00	15.53± 0.58	51.06± 0.58	68.86± 0.58	100.0± 0.00
400+500	6.60± 1.00	9.00± 1.15	17.73± 1.15	42.22± 0.58	80.00± 1.00	95.50± 0.58
300+500	6.60± 0.00	9.90± 0.58	13.00± 1.00	40.00± 0.00	71.06± 1.15	84.00± 0.58
450+300	2.20± 0.58	6.66± 0.00	10.66± 0.58	35.53± 0.58	71.06± 0.58	86.66± 0.58
350+250	4.42± 0.58	6.62± 0.00	9.00± 0.58	33.00± 0.00	62.22± 0.58	82.20± 1.00
250+250	0.00± 0.00	9.00± 0.58	13.00± 0.00	44.00± 0.58	56.00± 0.58	80.00± 1.00
300+300	4.40± 0.58	9.00± 0.58	13.00± 1.00	46.66± 1.00	64.40± 0.58	91.00± 1.15
400+400	9.00± 1.15	13.00± 0.00	24.00± 1.52	62.2± 0.58	75.53± 0.58	91.00± 0.58
Control	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00
	Soxhlet method					
500+400	6.66± 1.00	10.66± 0.58	15.53± 1.15	40.00± 1.15	60.0± 0.00	97.70± 0.58
400+500	10.6± 0.58	15.53± 0.58	28.86± 0.58	56.00± 0.58	71.06± 1.15	95.70± 0.58
300+500	10.62± 0.58	17.73± 0.58	33.00± 1.00	42.22± 0.58	68.86± 0.58	91.00± 1.15
450+300	9.00± 0.58	13.00± 1.00	33.00± 1.00	42.22± 0.58	64.42± 0.58	91.00± 0.58
350+250	9.00± 0.58	10.66± 0.58	26.66± 1.73	37.06± 1.15	57.73± 0.58	91.00± 1.00
250+250	0.00± 0.00	2.20± 0.58	17.73± 0.58	24.00± 0.58	44.00± 0.58	66.66± 1.73
300+300	2.22± 0.58	4.44± 0.58	17.73± 1.15	24.00± 0.58	44.00± 1.15	66.66± 0.58
400+400	4.44± 0.58	6.66± 1.00	20.00± 0.00	42.22± 1.15	68.86± 1.15	91.00± 0.58
Control	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00

in the context of botanical insecticides (Sarwar 2013; Sarwar 2015; Pang et al., 2020). For instance, Smith et al., 2023 demonstrated a dose-dependent effect of neem extract on the mortality of cabbage aphids, with higher concentrations leading to increased efficacy in pest control. Similarly, Gupta and Patel 2024 found that increasing concentrations of marigold and garlic extracts resulted in a proportional increase in mortality rates of cotton bollworms, highlighting the importance of dosage considerations in botanical pest management strategies.

The observed synergistic effect could be attributed to the complementary mechanisms of action of the individual plant extracts. *A. marmelos* and *M. piperita* are known to contain various bioactive compounds with insecticidal properties, including alkaloids, terpenoids, and phenolics (Papachristos and Stamopoulos, 2002). The combination of these compounds may act synergistically to disrupt vital physiological processes in aphids, leading to their mortality. The previous research has suggested that synergistic interactions between plant compounds can amplify their individual effects, leading to enhanced efficacy in pest control (Singh et al., 2022; Ahmed and Vogel et al., 2020). Therefore, the combination of these two extracts at higher concentrations may elicit a stronger synergistic effect, resulting in increased mortality of aphids.

Furthermore, the mode of extraction, boiling, might have contributed to the enhanced efficacy of the combined extracts. Boiling is known to facilitate the release of active compounds from plant tissues, thereby increasing the concentration and bioavailability of insecticidal agents (Chaudhari et al., 2021). The absence of mortality in the control sets further supports the specificity and effectiveness of the combined extract in targeting aphids, ruling out any confounding factors that could have influenced the results. The efficacy of boiling extraction in enhancing the insecticidal activity of plant extracts has been corroborated by several previous studies. For instance, Gupta et al., 2023 demonstrated that boiling extraction significantly increased the concentration of bioactive compounds in neem extract, resulting in improved efficacy against whiteflies. Similarly, Patel and Sharma 2022 reported that boiling extraction enhanced the insecticidal activity of marigold extract against tomato fruit worms, underscoring the importance of extraction methodology in optimizing the efficacy of botanical insecticides.

Overall, these findings highlight the potential of utilizing plant-based formulations as eco-friendly alternatives for pest management in agriculture. Further research is warranted to elucidate the underlying mechanisms of action and optimize the formulation for practical application in pest control strategies.

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AUTHOR CONTRIBUTION STATEMENT

Amaninder Kaur conceptualized and framed the research proposal, Primila Neopaney Sharma conducted the experiment, curated the data and prepared original draft. Shaista Jabeen, Samara Sultana, Palika Sharma and Sunakshi Sharma contributed to the samples, analyzed the results and corrected draft. All authors read and approved the manuscript.

CONFLICT OF INTEREST

No conflict of interest.

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