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Effectiveness of Crude Extracts from Aromatic Plants against Crop's Insect Infestation

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ABSTRACT

Agricultural productivity and food security are increasingly threatened by insect infestations, particularly in vegetable crops. The widespread use of synthetic insecticides raises concerns regarding human health, environmental pollution, and biodiversity loss, prompting the need for sustainable alternatives. This study evaluates the effectiveness of crude extracts from turmeric, pandan, lemongrass, and mint as biopesticides in Amaranthus viridis. The objectives were to assess their effects on plant weight, insect population, and leaf infestation. Crude extracts were prepared by water bath extraction and applied at a 1:4 ratio in a field experiment. Insect identification and observations were conducted over 17 days. Results indicated that all treatments showed varying levels of effectiveness. Lemongrass extract significantly enhanced plant growth and yield, while mint extract was the most effective in reducing insect infestations. Additionally, some treatments attracted beneficial insects, suggesting ecological benefits. These findings demonstrate the potential of aromatic plant extracts as eco-friendly alternatives to synthetic pesticides. This study contributes to the United Nations Sustainable Development Goals, particularly SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being), and SDG 12 (Responsible Consumption and Production), by promoting sustainable and safe agricultural practices.

Keywords: Biopesticide, Crude Extracts, Lemongrass, Pest, Turmeric.

1. INTRODUCTION

Insect pests remain a persistent and widespread challenge in global crop production, significantly reducing yield and quality. Conventional pest management has largely relied on synthetic pesticides due to their rapid effectiveness; however, their extensive and prolonged use has raised serious concerns regarding toxicity to humans, non-target organisms, and the environment. Studies have shown that excessive pesticide application contributes to soil nutrient depletion, threatens soil invertebrate populations, and accelerates the development of pesticide-resistant pests and herbicide-resistant weeds [1][2]. These adverse effects underscore the urgent need for safer, sustainable pest management strategies. Such efforts align with the United Nations Sustainable Development Goals, particularly SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being), and SDG 12 (Responsible Consumption and Production).

In this context, plant-based biopesticides derived from aromatic plants present a promising alternative. Crude extracts obtained through primary extraction processes contain diverse bioactive compounds, such as terpenes and phenolics, that exhibit insecticidal and antimicrobial

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properties [3]. These natural compounds are generally biodegradable, environmentally friendly, and less harmful to humans and non-target organisms [4][5]. Aromatic plant extracts have long been utilized in traditional practices and are increasingly recognized for their multifunctional roles in sustainable agriculture, including pest suppression and plant growth enhancement [6][7].

In Malaysia, the indiscriminate and continuous use of chemical pesticides has contributed to increased pest resistance, environmental persistence, and potential accumulation of harmful residues in soil, water, and food products [8][9]. These challenges not only increase production costs for farmers but also pose risks to consumer health and environmental sustainability. Therefore, exploring aromatic plant crude extracts as alternative pest control agents is both timely and essential. This study aims to evaluate the effectiveness of crude extracts from turmeric, pandan, lemongrass, and mint as biopesticides in *Amaranthus viridis*. Specifically, it investigates their effects on plant growth, insect population dynamics, and leaf infestation levels. We hypothesized that aromatic plant crude extracts would significantly improve plant growth and reduce insect populations and leaf infestations in *Amaranthus viridis*, with varying levels of effectiveness across plant species.

2. MATERIAL AND METHODS

2.1 Samples collection and preparation

Approximately 3.0 kg of fresh leaves from four aromatic species, pandan (*Pandanus amaryllifolius*), lemongrass (*Cymbopogon citratus*), mint (*Mentha spp.*), and turmeric (*Curcuma longa*), were sourced from a local market in Perlis, Malaysia. The samples were thoroughly rinsed with running tap water to remove surface contaminants and extraneous debris. Subsequently, the leaves were subjected to oven-drying at 60 °C for 24 h until a constant weight was achieved. The dried samples were then reduced in size and pulverized into a fine powder using a laboratory-grade mechanical grinder (MF 10 basic, IKA, Germany). The resulting powder was stored in airtight containers prior to the extraction process.

2.2 Crude extracts from aromatic plants

Approximately 5.0 g of pulverized lemongrass, turmeric, pandan, and mint leaves were accurately weighed using an analytical balance (UWA series, AccuTEC, USA). Each sample was transferred into a 100 mL Erlenmeyer flask, and 50 mL of absolute ethanol was added. The flasks were hermetically sealed with Parafilm to prevent solvent loss. The extraction was conducted using a thermostatic water bath shaker (Maxturdy-30, Wisd Laboratory Instruments, South Korea) at 45 °C with a constant agitation speed of 120 rpm for 3 h.

Following the extraction period, the mixture was filtered through Whatman No. 1 filter paper (125 mm diameter) to separate the suspended solids from the liquid extract. The resulting filtrate was concentrated to a final volume of 20 mL by evaporation in a convection oven at 70 °C for approximately 3 h. The concentrated crude extracts were then transferred into amber glass vials and stored at 4 °C to maintain stability.

For field application, the concentrated extracts were diluted with water at a ratio of 1:4 (v/v) to prepare the working solution. This solution was used in field trials to evaluate the insecticidal efficacy of aromatic plant extracts with a manual sprayer.

2.3 Field experiment set-up

A pot experiment was conducted under open-field conditions at the Institute of Sustainable Agrotechnology (INSAT), Universiti Malaysia Perlis, in Padang Besar (6.652°N, 100.260°E). Prior to cultivation, weeds were manually removed from the vegetable plots to minimize nutrient competition from non-target species.

Six treatments were evaluated: T1 (control without spray), T2 (mixed extracts), T3 (turmeric leaf extract), T4 (mint leaf extract), T5 (lemongrass leaf extract), and T6 (pandan leaf extract). The extraction solution was applied at a 1:4 ratio (100 mL extract diluted with 400 mL tap water) and sprayed at 15 days after planting (DAP). The experiment was arranged in a completely randomized design (CRD) with five replications. The test crop was F1 hybrid green amaranth (*Amaranthus tricolor*). Plants were irrigated with tap water, maintaining soil moisture at approximately 60% field capacity. Organic fertilizers were surface-applied at 10 and 20 DAP. The crops were grown for 30 days and subsequently harvested for dry weight determination.

2.4 Insect identification and leaf infestation

The extent of insect damage on spinach leaves across treatments T1–T6 was assessed by estimating the percentage of leaf area affected. Leaves exhibiting ≥30% surface damage were classified as damaged. Prior to harvest, data were collected from five replicates per plot, and the percentage of leaf infestation was calculated using the following formula (Eq. 1).

$$Percentage\ of\ leaf\ infestation = \frac{Number\ of\ infested\ leaves}{Total\ number\ of\ leaves} \times 100\% \qquad (1)$$

Yellow sticky traps were used to monitor pest infestation throughout the experimental period. For each treatment row, five PVC pipes were installed adjacent to the spinach plants, and the traps were securely fastened to the pipes using cable ties to prevent dislodgement by wind or rain. Insects captured in the traps were manually counted, and the total number per plot was determined from four traps.

Captured insects were examined and recorded for identification purposes. Preliminary species identification was conducted using the *iNaturalist* application, followed by verification through comparison with standard taxonomic references. Insect occurrence and abundance were monitored and recorded over 17 days following planting.

2.5 Statistical analysis

Analysis of variance (ANOVA) was used to determine the significant effects of treatments, and the treatment means were compared using the Tukey test at $p \leq 0.05$. The Statistical Analysis System (SAS) software version 9.2 was used for the statistical analysis.

3. RESULTS AND DISCUSSION

3.1 Quantitative analysis of insect abundance across treatment plots

Figure 1 illustrates the temporal occurrence of ebony grasshoppers (*Boopedon nubilumover*), a 17-day observation period in spinach plots subjected to six different treatments. Grasshoppers have been among the most important pests of agriculture in the tropical region. No grasshopper presence was recorded in the control (T1), mixed treatment (T2), and turmeric-treated plots (T3). In contrast, a low incidence was observed in the mint-treated plots (T4), with only 2 individuals recorded. The highest abundance was documented in lemongrass-treated plots (T5), with five grasshoppers observed, followed by pandan-treated plots (T6), which recorded a single individual. These findings suggest that the lemongrass treatment (T5) was the least effective in deterring ebony grasshoppers, whereas the control, mixed, and turmeric treatments demonstrated potential deterrent effects. This observation is consistent with previous reports [10][11], which indicate that essential oils possess bioactive properties, including antibacterial, antiviral, antifungal, and insecticidal activities, and may also act as feeding deterrents by reducing herbivore preference for treated plants.

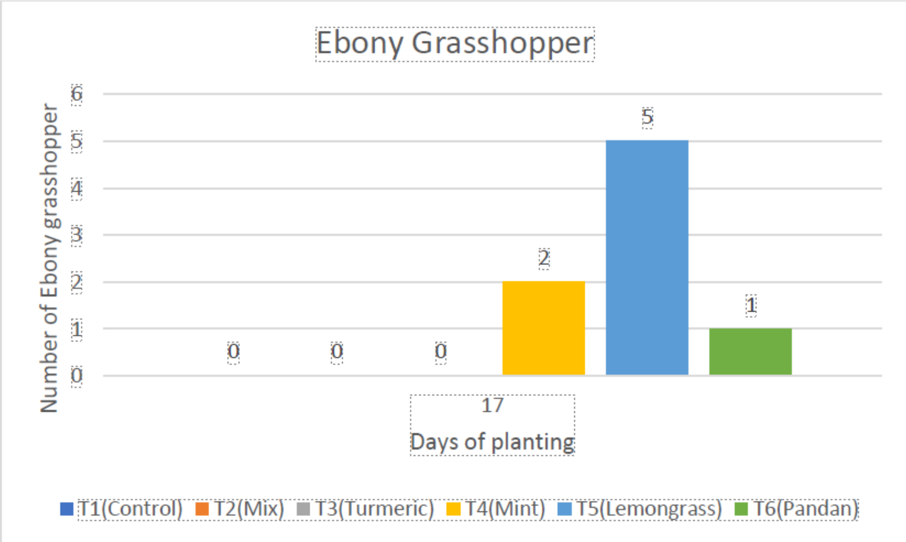

Figure 1: Temporal dynamics of ebony grasshopper presence in spinach plots across six treatments over a 17-day observation period.

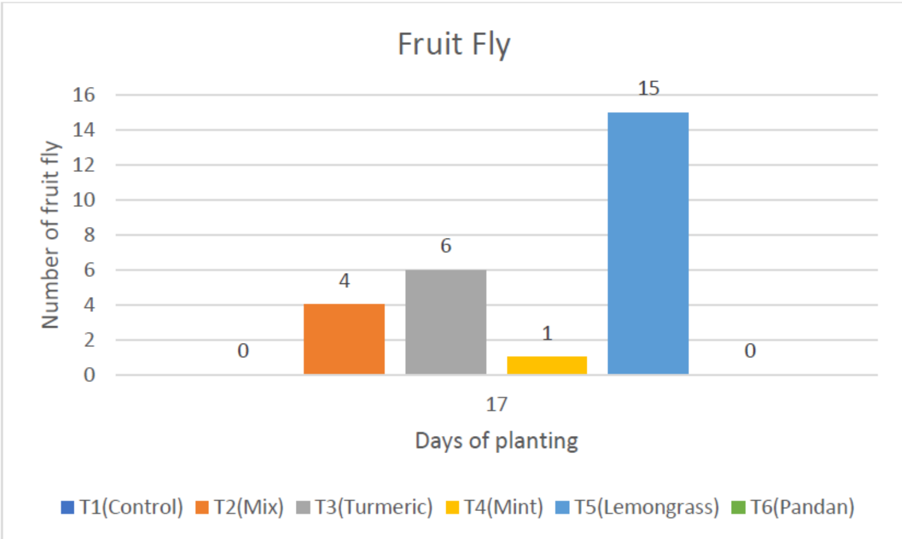

Figure 2: Temporal dynamics of fruit fly presence in spinach plots across six treatments over a 17-day observation period.

Figure 2 shows the variation in fruit fly (*Bactrocera dorsalis*) presence among the six treatment plots during the 17-day spinach cultivation period, indicating differences in the repellent effectiveness of the botanical treatments. No fruit flies were observed in the control (T1) and pandan-treated (T6) plots, suggesting that pandan may possess strong repellent properties against the fruit fly. This effect may be attributed to the presence of volatile aromatic compounds such as 2-acetyl-1-pyrroline, which can interfere with insect host-finding behavior [12]. The mint-treated plot (T4) also recorded a low fruit fly incidence, with only one individual observed, likely due to the repellent activity of essential oils such as menthol and menthone, which are known to disrupt insect olfactory responses. In comparison, moderate fruit fly presence was observed in the mix-treated (T2) and turmeric-treated (T3) plots, with 4 and 6 individuals, respectively, indicating limited repellent effectiveness. The lemongrass-treated plot (T5) showed the highest fruit fly presence, with 15 individuals recorded, suggesting that the treatment was ineffective in repelling B. dorsalis under the conditions of this study, despite the presence of insect-repellent compounds such as citral and geraniol. Overall, the results indicate that pandan was the most effective botanical treatment for reducing fruit fly presence, highlighting its potential as a natural repellent in sustainable pest management.

Figure 3 illustrates the temporal occurrence of mole crickets *(Gryllotalpa gryllotalpa)* over a 17-day observation period in spinach plots subjected to six different treatments. Mole crickets are subterranean insects that burrow through the soil using enlarged forelegs adapted for digging, resembling mole-like paws [13]. While some species contribute positively to soil aeration and nutrient cycling, others are recognized as agricultural pests due to their root-feeding activity and tunneling behavior, which can adversely affect crop growth and establishment.

The control plot (T1) recorded no mole cricket presence throughout the observation period. In contrast, plots treated with the mixed extract (T2), turmeric (T3), mint (T4), lemongrass (T5), and pandan (T6) each recorded the presence of one or two individuals. These findings suggest that the tested botanical treatments exhibited limited effectiveness in suppressing mole cricket occurrence, as all treated plots showed some level of infestation. Among the treatments, lemongrass-treated plots (T5) recorded the highest mole cricket presence, with two individuals observed during the study period.

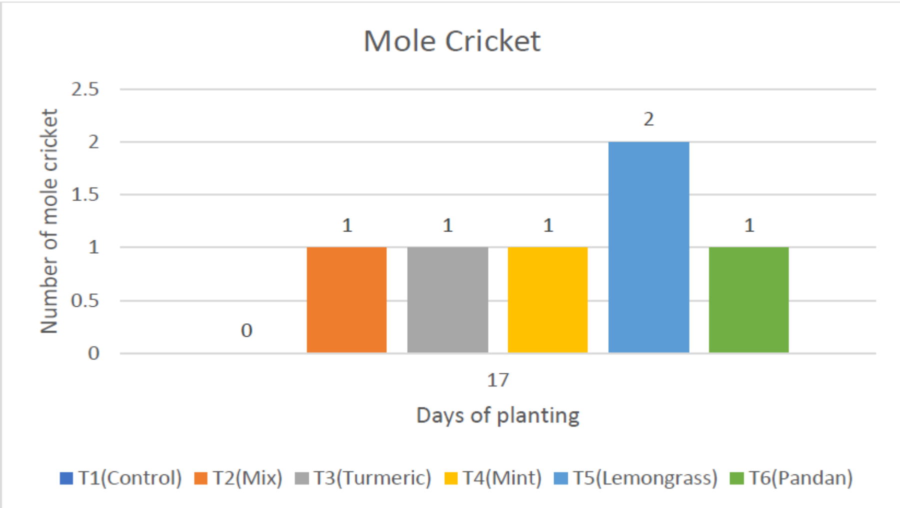

Figure 3: Temporal dynamics of mole cricket presence in spinach plots across six treatments over a 17-day observation period.

3.2 Leaf Infestation of Spinach

The average percentage of leaf infestation in spinach plants is presented in Table 1. The control treatment (T1) and lemongrass extract (T5) recorded the highest levels of leaf infestation, with mean values of 34.58% and 34.20%, respectively. In contrast, Treatment T2, which consisted of a combination of turmeric, pandan, lemongrass, and mint extracts, showed a substantially lower average leaf infestation of 5.75%. This result suggests that the combined botanical extract treatment has considerable potential as an effective strategy for reducing leaf infestation in spinach cultivation.

Table 1: Average percentage of leaf infestation in spinach plants.

Treatments	Leaf infestation (%)
T1 - control	34.58^{a} ± 2.39
T2 - mixed extract	5.75^{c} ± 0.46
T3 – Turmeric extract	19.90^{b} ± 1.42
T4 – Mint extract	10.87^{b} ± 0.79
T5 – Lemongrass extract	34.20^{a} ± 2.80
T6 – Pandan extract	19.15^{b} ± 1.61

Remarks: Values reported within column are the means ± standard error and the means are compared with ANOVA at $p < 0.05$ (n=5). The different letters represent a significant difference among the seedling trays.

The observed reduction in infestation is consistent with previous studies reporting the insecticidal and pest-repellent properties of botanical extracts similar to those used in T2 [14]. The effectiveness of the treatment may be attributed to the synergistic effects of the individual plant extracts. Turmeric is widely recognized for its antimicrobial and insecticidal activities [15], while pandan and lemongrass possess natural insect-repellent properties [16]. Similarly, mint extract has been reported to exhibit strong pest-repelling activity [17]. Therefore, the combination of these extracts in T2 may have provided a broader and more effective protective effect against leaf infestation in spinach plants.

3.3 Yield of Spinach

The comparison of average dry weight across different plant extract treatments is presented in Table 2. The control treatment (T1) recorded the lowest dry weight of 1.95 g, indicating reduced plant growth in the absence of botanical extract application. In contrast, all extract-treated plants showed higher dry weight values compared to the control, suggesting that the plant-based extracts contributed positively to spinach growth and biomass accumulation. Among the treatments, lemongrass extract (T5) produced the highest dry weight (8.50 g), followed by mint extract (T4) with 6.35 g, indicating superior plant growth performance compared to the control and other extract treatments.

Although T5 was less effective in suppressing pest infestation, the treatment still resulted in the greatest biomass accumulation. This response may be associated with the presence of bioactive compounds such as citral, geraniol, and citronellal in lemongrass, which possess antimicrobial and antifungal activities that may enhance plant physiological performance and nutrient utilization [18]. Improved physiological activity may subsequently contribute to greater photosynthetic efficiency and dry matter accumulation [19]. These findings indicate that lemongrass extract has potential as a plant growth-promoting biostimulant.

Table 2: Comparison of average dry weight (g) across different plant extract treatments (T1–T6).

Treatments	Average dry weight (g)
T1 - control	1.95^{e} ± 0.19
T2 - mixed extract	3.23^{d} ± 0.28
T3 – Turmeric extract	3.90^{c} ± 0.31
T4 – Mint extract	6.35^{b} ± 0.62
T5 – Lemongrass extract	8.50^{a} ± 0.87
T6 – Pandan extract	4.30^{c} ± 0.49

Remarks: Values reported within column are the means ± standard error and the means are compared with ANOVA at $p < 0.05$ (n=5). The different letters represent a significant difference among the seedling trays.

Interestingly, the mixed extract treatment (T2) resulted in lower dry weight compared to several individual extract treatments, despite demonstrating effective pest suppression and reduced leaf infestation. This finding suggests that combining multiple plant extracts did not produce a synergistic effect on plant growth. Possible antagonistic interactions among phytochemicals or dilution of active compounds within the mixed formulation may have reduced its growth-promoting efficacy. Similar observations have been reported in studies on botanical pesticides, where combinations of plant-derived compounds occasionally produced antagonistic rather than synergistic effects on crop performance [20][21].

4. CONCLUSION

Among the tested botanical treatments, pandan extract showed the greatest potential to reduce fruit fly populations, indicating its suitability as a natural repellent for sustainable pest management. In contrast, lemongrass-treated plots recorded the highest abundance of ebony grasshoppers, fruit flies, and mole crickets, suggesting limited effectiveness in pest suppression under the conditions of this study. Despite this, lemongrass treatment produced the highest biomass accumulation, possibly due to bioactive compounds such as citral, geraniol, and citronellal that may enhance plant physiological performance. The mixed extract treatment effectively reduced leaf infestation but did not increase plant biomass, suggesting that combining multiple extracts may not yield synergistic growth-promoting effects, potentially due to antagonistic phytochemical interactions or dilution of active compounds. Further research is recommended to identify the specific bioactive compounds responsible for the repellency and growth-promoting effects observed in individual plant extracts.

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Declaration of Generative AI Use

During the preparation of this work, the authors used ChatGPT-4 to improve readability and language. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Data Availability Statement: All data generated or analyzed during this study are included in this published article.