Experiment of Turmeric Infusion in Neem Oil for Effective Pest Control

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Abstract

This study examines the potential of neem and turmeric as cost-effective, natural alternatives to conventional chemical pesticides. Despite their known benefits, there is still little field-based evidence of their combined efficacy, particularly in tropical agriculture. Therefore, this study aims to evaluate the insecticidal performance of neem turmeric formulations in enhancing plant resistance to pests and fungal infections. The research specifically addresses the need for sustainable pest control solutions that are safe, biodegradable and environmentally friendly. The neem extract was produced using an extraction process and combined with natural additives such as turmeric, garlic and chilli to improve adhesion, repellency and overall efficacy. The presence of curcumin in turmeric shows a synergistic effect with the active compounds of neem. The field trials were conducted on maple trees in Bukit Pasir, Muar, Johor, under controlled environmental conditions. As part of the study, a turmeric-infused neem oil was developed that has a pH of 8 after 14 days, is skin-friendly, and has a pleasant odour. The application of 15 ml of this pesticide resulted in no insects being found on the plants for 14 days. The optimum concentration of neem and turmeric (0.05 mol L^{-1}) showed the best effect on the plants after 14 days. These results indicate that the combination of turmeric with neem oil at a concentration of 0.05 mol L^{-1} is optimal for plant performance over 14 days. The use of these natural insecticides in agricultural practice ensures crop safety and promotes ecological balance.

Keywords: Neem Oil; Pesticide; Turmeric.

1.0 Introduction

Pesticides, as substances or mixtures designed to destroy or weaken pests such as insects and plants, have become an integral part of modern agriculture. In recent decades, various types of pesticides have been used on a large scale to achieve high crop yields (Akanda et al., 2012). These applications have secured almost a third of the world's crop production and have contributed significantly to improving food production to meet the needs of an ever-growing population. Effective control of pests through pesticides is crucial to preventing dangerous diseases in crops. In addition to agriculture, pesticides are also used in non-agricultural areas such as industrial vegetation control (e.g., roads and railways), indoor pest control, pet care, and lawn care. The extensive use of pesticides continues to increase, contaminating the environment. The trend of increasing pesticide use is expected to continue in response to the rising population and the resulting demand for food. In addition, rapid urbanisation is reducing available agricultural land and necessitating high-yield agricultural production (An et al., 2021). Despite their benefits, the rigorous use of pesticides has been criticised for contributing to pest resistance, human health problems and environmental damage.

Over time, pests can gradually develop resistance to pesticides, leading to ongoing research into more effective chemicals. Humans can come into contact with pesticides through three primary routes: food or ingestion, which is the main source of exposure; dermal contact, especially through the use of pesticides in the home; and inhalation of contaminated air, especially for people living near agricultural areas (Mahmood et al., 2016). While pesticides offer undisputed benefits in producing abundant and high-quality vegetables at relatively low cost, their excessive use can leave harmful residues, including metabolites and degradation products, in the environment, such as soil. These environmental impacts emphasise the need for careful management and regulation of pesticide use to balance agricultural productivity with health and environmental considerations (Rani et al., 2021).

The production of neem insecticides is associated with several challenges, which primarily depend on the quality and maturity of the neem leaves used. Mature, unblemished leaves must be used for optimal oil production, and the quality of the seeds can be significantly affected by the methods used in harvesting and processing. Contaminants such as dust and residues can affect the purity of the oil, and improper storage conditions such as light, heat, and humidity can lead to decomposition and spoilage (Ayilara et al., 2023). In addition, contamination with other chemicals and oils during production can impair the effectiveness of neem oil as an insecticide. The impact of chemical pesticides on the environment and ecology is well documented. These pesticides contribute to soil, water, and atmospheric pollution and leave residues that remain in the environment, damaging ecosystems and accumulating over time (Liano et al., 2023). Runoff from agricultural fields contaminates surface and groundwater, negatively impacting aquatic life and water quality. In addition, chemical pesticides harm beneficial organisms such as pollinators and natural predators and disrupt ecological balance and biodiversity. Excessive use of these chemicals can lead to increased production costs and market restrictions as consumers favour pesticide-free products. Regulatory standards for chemical pesticides vary around the world, leading to inconsistent safety measures and controls. Prolonged exposure to chemical pesticides poses a health risk to farm workers, consumers, and residents in contaminated areas and contributes to acute and chronic health problems (Lykogianni et al., 2021).

Neem oil, extracted from the seeds of the neem tree (Azadirachta Indica), is a versatile and natural remedy with a wide range of applications in medicine, agriculture, and cosmetics. Known as the "village pharmacy" in various cultures, neem oil has long been used in traditional medicine and practices in India. Ancient Sanskrit scriptures describe Neem as "Sarva Roga Nivarini", which means "the one who cures all diseases. Neem oil is used to treat skin diseases, for oral hygiene, and as an organic insect repellent. Its bioactive compounds, especially azadirachtin, give it strong insecticidal properties, making it an effective and environmentally friendly option for pest control. Other active ingredients, including nimbin, nimbidin, and limonoids, contribute to its diverse properties (Sule et al., 2022). The primary objective of this study is to investigate the effectiveness of neem oil as an eco-friendly insecticide, particularly when combined with turmeric and other natural additives. The research aims to support the development of sustainable pest control methods that do not harm beneficial insects or leave long-term environmental residues. Neem oil is highly valued as a natural and biodegradable insecticide. It interrupts the feeding and reproductive behaviour of pests and thus provides effective plant protection without harming beneficial insects. This method is becoming increasingly popular in organic and sustainable agriculture. Due to its antibacterial and anti-inflammatory properties, neem oil is used in traditional medicine to treat various skin conditions, such as acne, eczema, and psoriasis. It also promotes oral health by reducing plaque, gingivitis, and bad breath. Neem oil's minimal ecological footprint, rapid degradation, and non-accumulating nature make it a sustainable alternative to synthetic pesticides (Umapathi et al., 2022).

2.0 Literature Review

Garlic (Allium) is known for its pesticidal properties due to its bioactive compounds, including allicin, diallyl disulfide, and diallyl trisulfide. These compounds have a strong antimicrobial and insecticidal effect, making garlic an effective natural pesticide. The insecticidal properties of garlic are attributed to its ability to disrupt the nervous system of pests, resulting in their paralysis and death. In addition, garlic has a strong repellent effect on many insect species, which further increases its usefulness in pest control. Combining garlic with neem oil creates an effective pesticide that utilises the strengths of both substances. The garlic-infused neem oil pesticide combines the bioactive compounds of neem and garlic to create an effective natural pesticide (Tudi et al., 2021). In the formulation, the neem oil is extracted from the seeds of Azadirachta Indica by cold pressing or solvent extraction to obtain the bioactive components such as azadirachtin. At the same time, a garlic extract is produced by crushing garlic cloves to release allicin and other sulfur-containing compounds. These extracts are then mixed in a specific ratio to create a synergistic mixture that enhances the pesticidal properties of neem oil. The environmental impact of the garlic-infused neem oil pesticide is minimal compared to synthetic pesticides. Both neem and garlic are biodegradable and do not persist in the environment, reducing the risk of soil and water contamination. The use of natural ingredients is also in line with organic farming practices and meets the growing consumer demand for pesticide-free products (Karimi et al., 2024).

Chilli (Capsicum) is known for its pungent compounds, especially capsaicin, which have strong insecticidal properties. Capsaicin acts on the nervous system of insects, causing paralysis and death. In addition, chilli is an effective deterrent to various pests due to its repellent properties. The combination of chilli with neem oil can enhance the effectiveness of neem-based pesticides and provide an effective natural solution for pest control. The chilli-infused neem oil pesticide combines the bioactive compounds of neem oil and chilli to form an effective natural insecticide. In the formulation, the neem oil is extracted from the seeds of Azadirachta Indica by cold pressing or solvent extraction so that its active components, such as azadirachtin, are retained. At the same time, the chilli extract is produced by crushing the chillis to release capsaicin and other pungent compounds. These extracts are then mixed in specific proportions to create a synergistic blend that enhances the pesticidal properties of neem oil (Shahid et al., 2022).

Turmeric (Curcuma longa), a flowering plant from the ginger family, is native to South Asia and is mainly cultivated for its rhizomes, which are processed into a bright yellow-orange powder known as curcumin. Turmeric is a staple in South Asian and Middle Eastern cuisine and has significant cultural and medicinal value. Curcumin, the bioactive component of turmeric, has antioxidant and anti-inflammatory properties and is used in traditional medicine for various therapeutic purposes. The bright colour of turmeric has made it a natural dye for clothing. In many cultures, it has a sacred status and is used in religious rites and ceremonies. Turmeric has proven to be a natural pesticide due to the insecticidal and repellent properties of curcumin. It acts as a defence against certain pests and has antimicrobial properties that help to combat plant diseases caused by microbial pathogens. Curcuma-based pesticides are biodegradable, environmentally friendly, and have lower toxicity to non-target organisms compared to synthetic pesticides. They are considered a viable component of integrated pest management strategies that promote sustainable and ecologically sound agricultural practices (Rasool et al., 2022). The synergistic use of neem oil and turmeric in pest control combines the benefits of both natural substances in this study. This approach increases the efficacy of neem-based insecticides through improved adhesion to plant surfaces, enhanced pest defence and improved insecticidal properties through interactions between curcumin and the bioactive compounds of neem. The development of turmeric-infused neem oil with this formulation not only ensures crop yields but also promotes ecological balance and offers a sustainable and environmentally friendly solution to the challenges of pest control.

3.0 Methodology

In the first phase, the sturdy branches of the neem tree in Bukit Pasir, Muar, Johor, are carefully collected, and the leaves are carefully picked, considering factors such as size and colour to ensure high quality. The neem leaves (150 grams) undergo an extensive cleaning and washing process to remove all impurities. After thorough cleaning, the leaves are placed on baking trays to prepare them for the drying process. The trays are placed in an oven set at 80 °C for 24 hours. This controlled heating step is crucial for the subsequent extraction, as it ensures optimum drying without overdrying. After drying, the neem leaves are finely ground and placed in a cellulose extraction pod. The prepared sleeve is then placed in the Soxhlet extractor. 0.1 M ethanol (99.5%)

is poured into the bottom flask of the Soxhlet apparatus to create the solvent environment required for extraction (Lykogianni et al., 2021). The apparatus is assembled to create a closed loop to allow continuous extraction of the compounds from the neem leaves. The bottom of the flask is heated so that the neem compounds dissolve in the ethanol and form a neem solution. Once the extraction is complete, the Soxhlet apparatus is dismantled, and the neem solution is carefully collected in a volumetric flask to evaporate the remaining ethanol (Campanale et al., 2021). For the extraction of garlic, turmeric, and chilli, the item is first crushed to release its bioactive components and then left to rest for at least 10 minutes to activate the enzymes. About 10 grams of the product are crushed and placed in a beaker of distilled water. Another beaker containing 80 ml of distilled water is carefully heated to below 60 °C to serve as the extraction medium (Umapathi et al., 2022). The beaker containing the garlic is then placed over the heated water so that the heat facilitates the release of the garlic compounds into the water, creating a solution. This solution is then filtered to remove any solid residue and transferred to an Erlenmeyer flask. The residue is added to a cellulose extraction tube in the Soxhlet extractor. The solvent used is 1 M ethanol (99.5%), and the Soxhlet apparatus is designed to ensure continuous extraction. The solvent is heated, causing the residue to dissolve in the ethanol. After extraction, the apparatus is dismantled, and the residue is collected in a volumetric flask. The residue is prepared with neem solution at concentrations of 0.005 mol L^{-1}, 0.050 mol L^{-1}, and 0.100 mol L^{-1}. Each pesticide solution is subjected to physical characterisation (appearance, skin sensitivity tests, odour tests) and pH, and the pesticides are applied to the plants for 14 days to observe their effect (Karimi et al., 2024). In the skin sensitivity tests, the pesticides are applied to human skin for 10 minutes (Sule et al., 2022). Odour tests are conducted in a controlled indoor environment, and pH tests are performed to determine the acidity or alkalinity of the pesticide solutions (Trellu et al., 2021).

4.0 Results and Discussion

The originally dark green neem extract turned slightly yellowish-green when garlic was added. The neem with garlic pesticides had a strong, pungent garlic odour. The texture of this mixture was sticky and viscous. This sticky texture could improve adhesion to plant surfaces, but dilution may be required to facilitate spraying. The chilli extract gave an orange colored liquid, which, when combined with the neem extract, gave a reddish-orange solution. The chilli neem pesticides had a strong, pungent chilli odour. The texture of this mixture was relatively liquid and not sticky (Murcia et al., 2022). The turmeric extract produced a yellowish liquid, which, when combined with the neem extract, produced a light yellow-colored solution. The turmeric neem pesticides had a pleasant, mild odour. The texture of this mixture was liquid and not sticky. This liquid texture and pleasant odour make it very suitable for spray application. The garlic neem pesticide formulation had a high adhesion due to its stickiness, while the chilli neem pesticide formulation and the turmeric neem pesticide formulation were less sticky but easier to reapply. The turmeric neem pesticides had the most pleasant odour, while the garlic neem pesticides and chilli neem pesticides formulations had a strong odour, which may be less desirable. The chilli neem pesticides and turmeric neem pesticides formulations were ideal for spray application, while the garlic neem mixture may require additional processing for optimal application. The turmeric neem pesticides were easy to spray, had a pleasant odour, and were user-friendly to apply. These formulations represent versatile options for sustainable pest control in agriculture (Jain et al., 2022). Future research should focus on optimising these formulations for specific crops and pests and assessing their long-term environmental impact. Figure 1 shows the product of the pesticides.

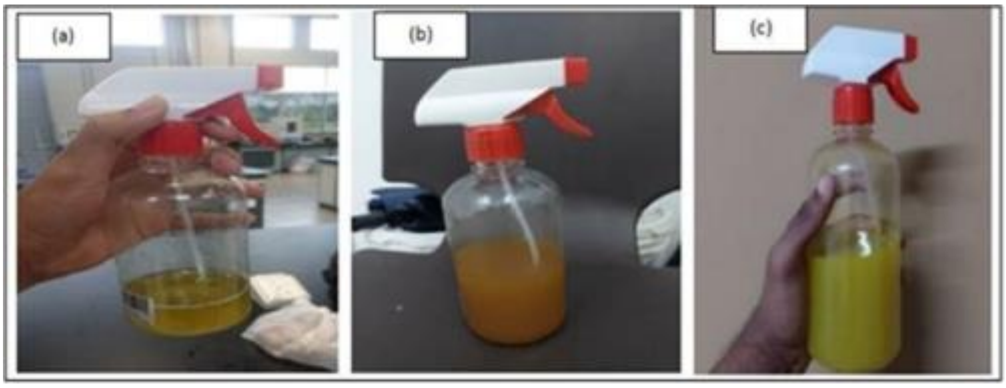

Figure 1: Product of pesticides (a) garlic neem pesticides, (b) chilli neem pesticides, (c) turmeric neem pesticides

The neem-based pesticides in combination with garlic, turmeric, and chilli extracts showed different pH values and corresponding effects on the human skin sensitivity. The pH of the garlic neem pesticide was 4, indicating an acidic nature. Despite initial concerns that the acidic pH could damage the plants due to possible aluminium toxicity, the plants tested showed no adverse reactions. The garlic neem pesticide was tested under different temperature conditions: cold (5 °C), room temperature (22 °C), and warm (60 °C) for 15 minutes. At cold temperatures, the garlic odour was more pronounced; at room temperature, the neem odour was stronger; and at warm temperatures, a garlic-like odour prevailed. The results indicate that room temperature is optimal for the effectiveness of the garlic neem pesticide against insects and provides a balance between odour intensity and pest deterrence (Serrao et al. 2022). The chilli neem pesticide had a pH of 9.6, indicating an alkaline nature. This higher pH did not adversely affect the plants, and the alkaline nature of the solution may have contributed to its pest repellent properties. The odour of the chilli neem pesticide formulation, characterised by the pungent smell of chilli, remained the same at different temperature conditions, although its intensity decreased slightly at warmer temperatures. This consistent odour and the liquid nature of the pesticide facilitated application and provided effective defence against pests. The turmeric neem pesticide had a pH of 8, which is slightly alkaline and within the optimum pH range for use in plantations (pH 6–8). This formulation did not cause any adverse reactions in the plants and proved to be highly effective in pest control (Souto et al., 2021).

The turmeric neem mixture had a pleasant, mild odour, which was conducive to user acceptance. The pH stability of the turmeric neem pesticides under different temperature conditions ensured consistent efficacy and suitability for use. The garlic neem pesticides had a pH of 5.4 and were most effective at room temperature, providing a strong balance between garlic and neem odour. The chilli neem pesticides, with a pH of 9.6, maintained their efficacy across temperature fluctuations and had a consistent pungent chilli odour. The turmeric neem pesticides with a pH of 8 provided optimal pH conditions for use on plantations, combined with a pleasant odour and high pest control efficacy. The pH of each formulation and the corresponding temperature responses provide valuable insights into their practical application and efficacy in different agricultural environments.

The study investigated the effects of neem-based pesticides infused with garlic, chilli, and turmeric on human skin to assess their safety for users. The turmeric neem pesticides did not cause redness or itching, making it a safe and non-irritating option for human use. The mild nature of this formulation suggests that it is suitable for regular use without causing discomfort to users. In contrast, the pesticides chilli neem neem, and garlic neem caused itching when applied to the skin, indicating a potential risk of skin irritation. The strong, pungent odour of these formulations, particularly the garlic neem pesticide mixture, also contributed to general discomfort during application. These findings highlight the need for caution and protective measures when handling the chilli, garlic and turmeric formulations to ensure the safety of users. Figure 2 illustrates the skin condition after exposure to pesticide spray.

Figure 2: Skin condition after exposure to pesticide spray (a) garlic neem pesticides, (b) chilli neem pesticide, (c) turmeric neem pesticides

The effect of neem-based pesticides infused with garlic, chilli, and turmeric was investigated on maple trees in Bukit Pasir, Muar, Johor, at three different concentrations: 0.005 mol L^{-1}, 0.050 mol L^{-1}, and 0.100 mol L^{-1}. In the study, the leaves of maple trees were observed over a period of 14 days under constant environmental conditions. The leaves treated with the garlic neem pesticides were dull and showed scattered black and white spots. Despite these visual changes, the leaves remained robust, indicating tolerance to the acidity of the pesticide. The garlic neem pesticide mixture emitted a strong garlic odour that persisted throughout the observation period. The pesticides effectively reduced the presence of pests on the treated plants. In contrast, the turmeric neem pesticides, which were applied daily for 14 days, had a positive effect on the maple trees. The treated foliage became shinier and had a more vibrant colour. No insects or pests were observed, and the fungal spots on the leaves disappeared. The mild acidity of the turmeric neem pesticides did not hinder the healthy development of the plants, indicating good compatibility with maple trees. However, the chilli neem pesticides left an unpleasant odour and caused initial dryness on the leaves when applied. Despite these initial effects, the overall health of the plant improved over time, as evidenced by shinier leaves and better colouration. The chilli neem pesticides were also effective in reducing pests on the treated plants. The study shows that neem-based pesticides infused with garlic, turmeric, and chilli have different effects on maple trees. Although each formulation had different properties and effects, they all contributed positively to pest control and plant health under controlled conditions. In particular, the turmeric neem pesticides at a concentration of 0.050 mol L^{-1} showed the best results, with leaves remaining insect-free more effectively than at other concentrations. Figures 3, 4 and 5 display the state of maple leaves after being exposed to pesticide solutions at concentrations of 0.005 mol L^{-1}, 0.050 mol L^{-1}, and 0.100 mol L^{-1} after 14 days. The pesticides used are garlic neem, chilli neem, and turmeric neem. Future research could investigate further optimisations and applications of these natural pesticide formulations in different 2 agricultural environments to improve their efficacy and safety.

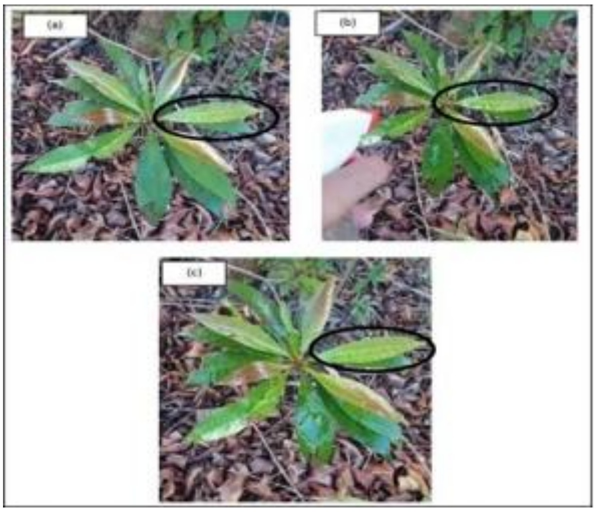

Figure 3: State of maple leaves after being exposed to pesticide solutions at concentrations of 0.005 mol L-1 (a) garlic neem pesticides, (b) chilli neem pesticide, (c) turmeric neem pesticides

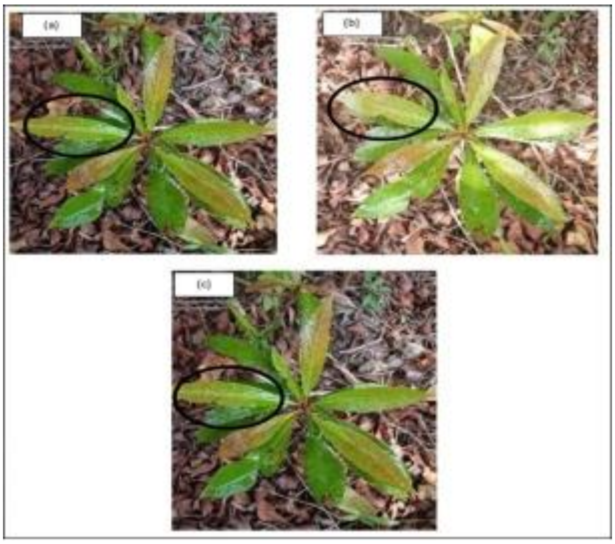

Figure 4: State of maple leaves after being exposed to pesticide solutions at concentrations of 0.050 mol L^{-1} (a) garlic neem pesticides, (b) chilli neem pesticide, (c) turmeric neem pesticides

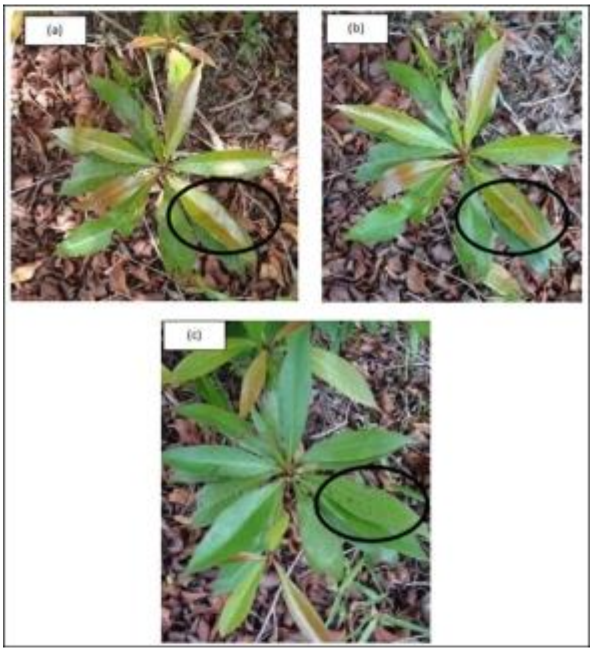

Figure 5: State of maple leaves after being exposed to pesticide solutions at concentrations of 0.100 mol L^{-1} (a) garlic neem pesticides, (b) chilli neem pesticide, (c) turmeric neem pesticides

5.0 Conclusion

The study investigated the efficacy and properties of neem oil formulations in combination with garlic, chilli, and turmeric extracts as pesticides on maple trees in Bukit Pasir, Muar, Johor. Each formulation showed different physical properties and effects on plant health and pest control efficacy. The garlic neem pesticides, which were characterised by their light yellowish green colour and strong garlic odour, showed high adhesion due to their sticky texture. Despite concerns about its acidic pH of 4, which could potentially cause aluminium toxicity, no negative effects on plant health were identified in the study. The garlic neem mixture proved to be optimally effective at room temperature and provided a good balance between odour intensity and pest repellency. In contrast, the chilli neem pesticides, which produced a reddish orange solution with a pungent chilli odour, had a pH of 9.6, indicating alkalinity. This formulation provided effective pest control and showed consistent odour and application quality under varying temperature conditions. Despite the initial dryness of the leaves upon application, the chilli neem pesticides contributed to improved plant health over time. The turmeric neem pesticides, which produce a light yellow solution with a mild, pleasant odour and a pH of 8, proved to be highly suitable for spray applications. It improved the gloss and colour brilliance of the leaves while effectively controlling pests and eliminating fungal spots. The pH stability of the formulation ensured consistent efficacy under different temperature conditions and emphasised its compatibility with maple trees. Overall, neem oil in combination with garlic, chilli, and turmeric extracts offers versatile options for sustainable pest control in agriculture. Each formulation offers unique advantages, such as high adhesion, effective pest deterrence, and user-friendly application properties. Future research should focus on optimising these formulations for specific crops and pests and further investigating their environmental impact and long-term effectiveness in different agricultural environments. These efforts will help to improve integrated pest management strategies and promote sustainable agricultural practices worldwide.

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Author Contributions
Leong Kok Seng: Conceptualisation, Original Draft, Review & Editing, Data Curation, Visualisation, Validation. **Burhanuddin Bin Harun:** Conceptualisation, Original Draft, Review & Editing, Data Curation, Visualisation, Validation. **Omar Syah Jehan Elham:** Review & Editing, Visualisation, Validation, Funding Acquisition.

Conflicts of Interest
The authors declare that they have no competing, actual, potential or perceived conflict of interest.

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