

Original Research Article

The effectiveness of neem (*Azadirachta indica* Juss) and aloe vera (*Aloe barbadensis* Miller) leaf extracts against cucumber aphids (*Myzus persicae* Sulzer) and melon flies (*Bactrocera cucurbitae* Coquillet) in a field setting.

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ABSTRACT

Cucumber (*Cucumis sativus* L.) plays a pivotal role in global agriculture, contributing significantly to food security and economic prosperity. However, insect pests such as melon flies (*Bactrocera cucurbitae* Coquillet) and aphids (*Myzus persicae* Sulzer) threaten cucumber production. While synthetic pesticides are effective, their detrimental effects on human health, wildlife, and ecosystems have prompted interest in alternative, natural pest control methods, such as neem (*Azadirachta indica*) and aloe vera (*Aloe barbadensis*). The experiment was conducted on a cucumber field at Sokoine University of Agriculture (SUA), Tanzania, from July to November 2023. A Randomized Complete Block Design (RCBD) with three treatments arranged in split-split plot structure was used. The treatment consisted of 40%, 60%, and 80% of neem and aloe vera leaf extracts, respectively, as well as a control (water). Each treatment was replicated three times to ensure reliability. Neem and aloe vera extract at 60% and 80% concentrations significantly promoted plant growth. Furthermore, fewer instances of fruit rotting and deformation were observed. Neem extracts also resulted in higher quality and larger fruits compared to the control with the smaller, lighter and higher case of fruit rotting and deformation. These findings suggest that neem and aloe vera leaf extracts, particularly at 60% and 80%, can be an effective and eco-friendly alternative to synthetic insecticides in controlling cucumber pests, improving plant health, and increasing yield. This approach can be scaled for use in other crops, promoting sustainable agriculture practices that protect human health, conserve biodiversity, and reduce environmental impact.

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Keywords: cucumber, pest control, neem, aloe vera, botanical pesticides, melon fly, aphid, sustainable agriculture.

UNDER PEER REVIEW

1. INTRODUCTION

Cucumbers (*Cucumis sativus* L.) are actually fruits with numerous health benefits for humans, although it is consumed as a vegetable (1). Cucumbers are widely consumed for their numerous health benefits, including aiding digestion, controlling blood sugar, and promoting skin health (2). They are also used in the cosmetic industry due to their hydrating and anti-aging properties. Cucumbers contain fiber, potassium, manganese, magnesium, and vitamins K, C, and A (3). In addition, cucumbers can detoxify the body, contain antibacterial and hydrating qualities, and an ability to guard against cancer and other diseases (4). Cucumber's pharmacological and therapeutic properties, such as their anti-aging and anti-wrinkle properties, antimicrobial properties, antidiabetic properties, hypolipidemic properties, ulcer-prevention properties, and anti-parasitic properties, contribute to their economic significance. Cucumber is also used in cosmetics; it is used to clean skin, treat a variety of skin issues (5), including wrinkles and sunburn; it is used as a skin-care product similar to face packs, facials, and juice; it soothes skin and reduces swelling; it is used to treat warts, xerosis, and chemical skin peeling; it also thins the stratum corneum by reducing corneocyte cohesion; it is used for dry skin and has a cooling effect (6). Additionally, cucumber is a source of employment to farmers, middle men and other people in the cosmetic industries.

The global production of vegetables went up by 71 percent since 2000, reaching 1.17 billion tons in 2022. Cucumber comprises 28.7% of all vegetables produced in the World. With 95 million tons produced globally in 2022, cucumbers are one of the most widely cultivated vegetables (7). In Tanzania, cucumbers are grown mainly in Ruvuma, Arusha, and Dar es Salaam regions, with the industry facing challenges from pest infestations (8).

Several variables, including the cultivars, production technologies, cultivation methods, marketing system, infrastructure, control system, grading and packing materials employed in each nation, can be used to explain the variation in yield between nations (9). Cucumbers are especially susceptible to pest attack when growing conditions are less than ideal and when sound cultural practices have not been followed (10). Cucumber beetle, aphids, whiteflies, caterpillar, thrips, cutworms, seedcorn maggot, leafminers, melon flies, wireworms, and mites can all cause crop losses of up to 100% when not monitored below threshold (11). Cucumber production faces threats from various insect pests, including aphids (*Myzus persicae*) and melon flies (*Bactrocera cucurbitae*), which

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can reduce yields and affect fruit quality (12). Effective pest management is therefore critical to ensuring the productivity and profitability of cucumber farming (13). Melon flies (*Bactrocera cucurbitae*) are known to cause subsequent fruit rotting and deformation (14), which can drastically lower yield and quality (15).

Although chemical pesticides offer rapid control of pests, they pose significant risks to non-target organisms, including pollinators and beneficial insects (16). This has led to increasing interest in botanical alternatives, such as neem and aloe vera, which offer environmentally friendly solutions to pest problems. Development of resistance in various insect ~~pest-pests~~ has also been reported (17). Therefore, it is imperative to find safer, effective and sustainable control strategies against insect pests such as melon flies and aphids on cucumber.

Neem (*A. indica*) belongs to the family Meliaceae, where the utilized parts are leaf, bark, root, seed and fruit. This biopesticide was reported to be effective ~~to-against~~ pests such as *Aphis spp.*, *Aspergillus niger*, *B. tabaci*, *Colletotrichum spp.*, *Echinochloa crusgalli*, *Fusarium oxysporum*, *Geotrichum candidum*, *H. armigera*, *Meloidogyne incognita*, *Meloidogyne javanica*, *Rhizopus stolonifer*, *Sitophilus zeamais* (18). While aloe vera (*Aloe barbadensis* Miller) belongs to the family Liliaceae where the utilized parts are peels or rinds and stems. It contains minerals and vitamins as antioxidants, enzymes that aid in the breakdown of sugars and fats, sugars like glucose, glucomannans and anthraquinones used as laxatives. Salicylic acid, which has anti-inflammatory and antibacterial qualities found in hormones like auxins and gibberellins, fatty acids that have anti-inflammatory action and antiseptic and analgesic properties, and aloin and emodin, which function as analgesics, antibacterials, and antivirals (19).

Due to their natural pesticidal effects, neem (*Azadirachta indica* Juss) and aloe vera (*Aloe barbadensis* Miller) have become notable contenders. Neem's active ingredient, Azadirachtin, Nimbin, Salannin, Melandriol, has shown strong insecticidal effects by upsetting a number of pests' physiological functions in the Endocrine System by ~~Inhibit-inhibiting~~ Prothoracicotropic hormone (PTTH); ~~distort-distorting~~ phagostimulant disruptor by cholinergic transmission (20;21). Aloe vera has demonstrated insecticidal and repellent properties against agricultural pests due to its high content of secondary metabolites with numerous biological activities such as antimicrobial, antifungal, antibacterial and anti-oxidant (22). Despite the widespread use of neem and aloe vera for pest management in other regions, there is limited information on the optimal dosages of these

botanicals to effectively control pests like melon flies and aphids in Tanzania, particularly in the Morogoro region. The findings from this study will not only help farmers in Tanzania optimize the use of neem and aloe vera leaf extracts but also contribute to the broader effort of reducing dependence on harmful chemical pesticides, supporting both human health and environmental sustainability.

2. MATERIALS AND METHODS

2.1 Study area

The study was done at the Crop Museum of Sokoine University of Agriculture (SUA) which lies on the slopes of the Uluguru Mountains, in Morogoro region, Tanzania, found at an altitude of about 500 - 600 meters above mean sea level and receives an average annual rainfall of between 600 – 1000 mm. It is found at latitude 06° 50' 53" S and longitude 37° 39' 25" E, with average temperatures between 25 and 28 °C, respectively, and a relative humidity between 80-~~and~~85%. These climatic conditions significantly influence cucumber growth.

2.2 Land preparation, layout and seed sowing

A field experiment was conducted during July to November, 2023. Grasses and weeds in the experimental plot were removed by hand hoe and the land was ploughed and the ground was properly tilled. Compost manure was added to enhance soil fertility. The hybrid seeds were bought from AGROVET market, Kingaru Street, Morogoro town. Plots were planted on raised beds; plots measuring 2×2 m were meticulously prepared for the sowing of Ashley variety cucumber seeds. For optimal seed placement, 2 to 3 seeds/ft. were sown, 1/2" deep, in rows 6' apart, thinned to 12" apart with the implementation of mulching to preserve soil moisture content. The plants were thinned to two plants per hill after they have two leaves. Twenty-one hills were made ~~in~~on the farm. There were ~~for~~four treatments of neem and aloe vera leaf extract with three levels (40, 60, and 80%) as well as the control (water), each replicated three times. Split-split plot design under Randomized Complete Block Design (RCBD) ~~were~~was used as the general layout of the experiments.

2.3 Watering and fertilizer application

Watering occurred twice daily, early morning and late evening, immediately after sowing, based on specific weather conditions (dry season). Diammonium phosphate (DAP) fertilizer was introduced one week post-sowing (25g per plant) due to its exceptional role as a source of phosphorus (P) and nitrogen (N) essential for plant nutrition. Notably, DAP boasts high solubility, ensuring rapid dissolution in the soil to release readily available phosphate and ammonium for plant uptake. To safeguard germinating seedlings from potential damage, the fertilizer was strategically placed 5 cm away from each emerging seedling at a low concentration. This comprehensive fertilization regime aims to support optimal plant growth and development throughout the cucumber cultivation cycle.

2.4 Plant extracts preparation

A machete was employed for harvesting 10 kgs of neem leaves and 10 kgs of Aloe vera leaves and carefully stored fresh in plastic bags for subsequent use. Neem and aloe vera leaves underwent a meticulous preparation process for the aqueous formulation. Initially, they were thoroughly washed under a running tap, followed by chopping into small pieces. Subsequently, a blender machine was employed to blend the chopped leaves by adding water to aid the blending process. The aqueous formulation was created by mixing freshly cut neem and aloe vera leaves 400, 600, and 800g with 1L of water to achieve concentrations of 40%, 60%, and 80%, respectively (23). The choice of these particular concentrations is based on experimental goals. This mixture was left undisturbed for 48 hours, to enhance the dissolution of active ingredients in the solvent, water. After the stipulated custody period, the formulation underwent filtration by using polypropylene cloth and was stored in tightly sealed plastic containers, ready for use.

2.5 Treatment application

Treatments from the two botanicals (neem and aloe vera at dose levels of 40, 60, and 80%), and negative control (only water), were replicated three times and sprayed under the field. Each block had 7 subplots with 3 rows and 4 columns with a total of 12 plants. Five (05) plants per subplot made a total of 35 plants from the entire experimental unit that were selected randomly for the observation. The aqueous solutions of 40%, 60%, and 80% were prepared from 400g, 600g, and 800g of neem and aloe vera leaves mixed with one liter of water, respectively. The dosage was chosen based on reports on the preparation of botanical extracts for insect pest control (24).

Application of botanical pesticides ~~were beginning~~began 15 days with ~~the-an~~ interval of 7 days after observation of aphid populations on 5 cucumber plants per treatment. The botanical extracts were sprayed on experimental plants once a week, either early in the morning or late evening, to avoid heat stress by using a knapsack sprayer.

Fig 1. To illustrate the design.

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List 1: Three treatments with corresponding dose levels (%)

	R1			R2			R3		
Treatments	Dose levels (%)			Dose levels (%)			Dose levels (%)		
Neem	T1	T2	T3	T1	T2	T3	T1	T2	T3
Aloe vera	T4	T5	T6	T4	T5	T6	T4	T5	T6
Control	T7			T7			T7		

T1=Neem extract at 40%, T2= Neem extract at 60% and T3= Neem extract at 80%

T4=Aloe vera at 40%, T5= Aloe vera at 60% and T6= Aloe vera at 80%

T7= Control (only water)

2.6 Aphid abundance

Data on aphid abundance, damage severity and percent incidence were collected 1 day before spraying and 7, 14 and 21 days after spraying across all treatments and controls for ultimate estimates of pest populations. Aphid abundance measurements were obtained by visual observation and scoring numbers using an index. Due to the high reproductive rate of aphids categorical scale was used to assess aphid abundance, 1= no aphids; 2 = a few scattered aphids (1–100); 3 = a few small colonies (101–300); 4 = several small colonies (301–600); 5 = large isolated colonies (601–1000); and 6 = large continuous colonies (>1000) (25). The data were collected from five randomly selected plants from the inner two rows falling within the sampling area in each treatment (5 ~~×~~ 7 = 35 plants). The severity of damage caused by aphids on cucumber was determined by visually observing and scoring the level of damage over the same assessment times and selected plants. The severity of damage was assessed using a 1–5 scale widely adopted in the literature, where; 1= no infestation or damage, 2 = light damage and infestation, <25% plant parts damaged or infested, 3 = average damage and infestation, 26%–50% plant parts damaged, 4 = high

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infestation and damage, 51%–75% plants parts damaged showing yellowing of lower leaves and 5 = severe infestation, >75% damage resulting to plants with high infestation levels with yellow and severely curled leaves or dead plant (25). The incidence of aphids was determined by visually examining and counting the number of aphids on damaged/infested plants by randomly sampling 15 plants from the inner two rows in each replicate. Assessments were made over the same sampling times and expressed as percentage incidence.

2.7 Data collection

Data were collected 1 day before spraying and 7, 14 and 21 days after spraying for the two applications across all treatments and controls (26). The data were collected from five randomly selected plants from the inner two rows falling within the sampling area in each treatment. The data were collected with a separate ANOVA test for pest counts, yield, and plant health. The yield was evaluated through the number of fruits per plant, size and weight of each fruit at harvest. Plants were monitored for aphid infestation, and application of biopesticides was carried out (27). Melon flies were monitored by visual inspection performed whereby the adult flies were not affected by the dosage, but their fecundity and longevity are-were highly affected through neem and aloe vera extracts application (28).

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2.8 Statistical data analysis

Data collected were analyzed using GenStat software 16th edition 32. The analysis of variance among treatments were analyzed by ANOVA, while the mean difference among treatments were analyzed by Tukey-Kramer Multiple Comparison Test (TKMCT) at $P < 0.05$ level of significance.

3. RESULTS

3.1. Aphid abundance

The Analysis of Variance indicated interactive effects between all neem and aloe vera treatments for aphid abundance. The botanical insecticides were able to reduce aphid numbers in comparison to the untreated control (Table 1).

Table 1: Analysis of variance for the aphid abundance, on cucumbers, botanical insecticides (neem and aloe vera), and untreated control.

Source of variation	d.f.	s.s.	R ²	F	Pr > F
Rates	3	20852.7	6950,9	40.77	<.001
DAYS_x_Rates	6	6503.6	1083.9	6.36	<.001

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In this study, neem extract reduced the average number of aphids per plant pest populations (2.6 ± 0.7 aphids) at 80% and 5 ± 0.7 aphids at 60% while aloe vera reduced 4.0 ± 1.3 aphids at 80% and 6.0 ± 1.3 aphids at 60%, whereas a high number of insect injuries were found in control (76.67 ± 4.7). [Fig. 2&-5].

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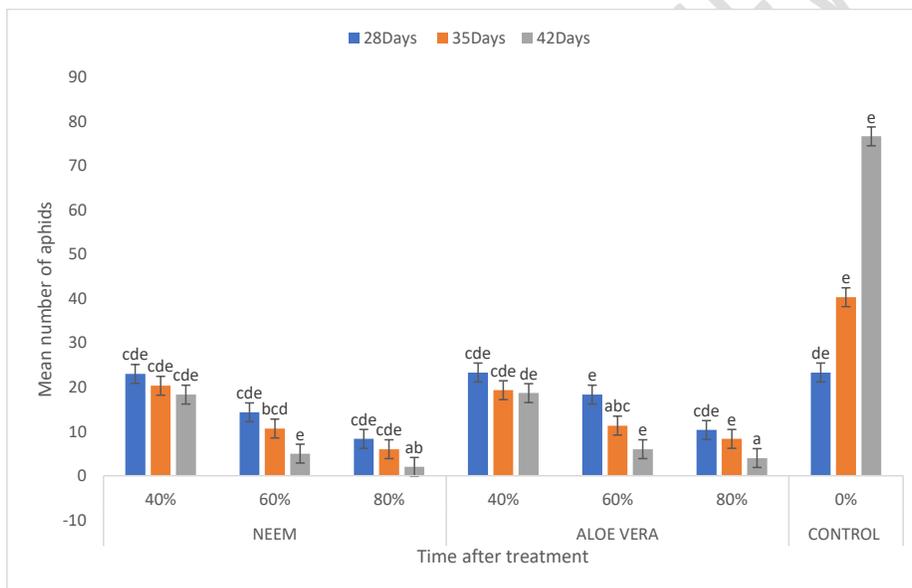
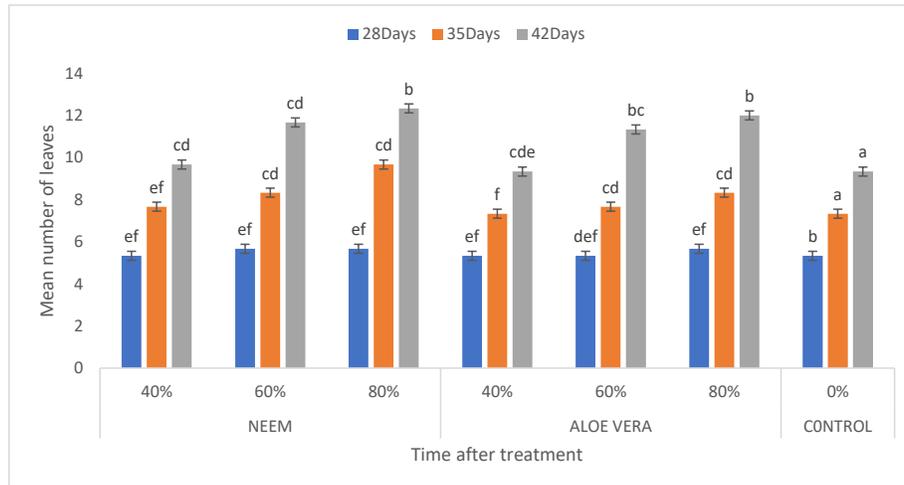


Figure 2: Effect of botanical extracts (N-neem and A-aloe vera) against pest attack on cucumber leaves.

3.2 Effect of Botanical Extracts on Cucumber Growth

The cucumber growth parameters showed significant differences ($P \leq 0.05$) between treatments and control. The highest number of leaves was observed in the neem and aloe vera treated at 80%. Neem extract promoted 12.3 ± 5.3 leaves at 80% and 11.6 ± 5.3 leaves at 60% while aloe vera promoted 12.0 ± 5.0 leaves at 80% and 11.3 ± 5.0 leaves at 60% compared to the control (9.33 ± 5.33

leaves). Separate analyses were conducted for each outcome of the results for pest control and growth parameters, but at the same time of inspection days (28, 35 and 42 after planting). [Fig. 3.]



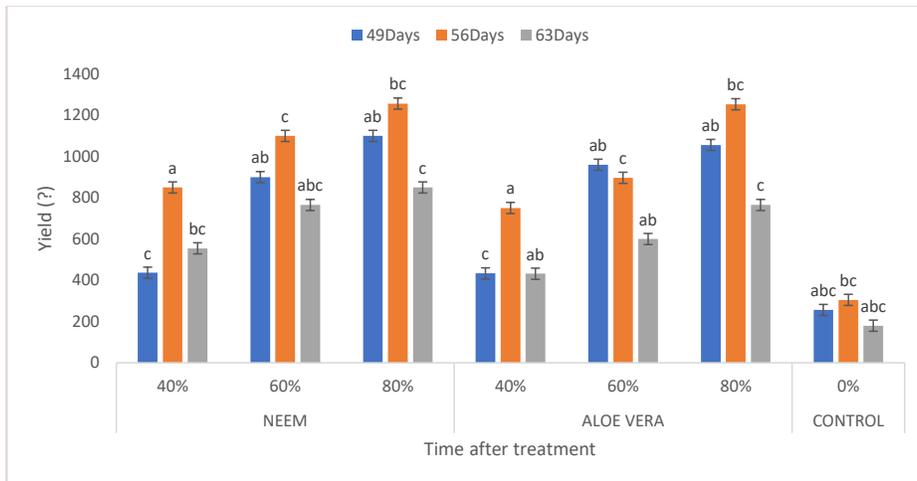
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Figure 3: Effect of botanical extracts (Neem and Aloe vera) on cucumber plant growth

3.3 Effect of Botanical Extracts on Fruit of Cucumber

The number of cucumber fruits showed significant differences ($P \leq 0.05$) between treatments and control, as determined by ANOVA. The results clearly show that, among the tested plant extracts, the neem and aloe vera treatments at 80% concentration produced the highest cucumber yield, with neem yielding 1256.7 ± 3.5 fruits and aloe vera yielding 1200 ± 2.5 fruits, followed by treatments at 60% concentration with neem yielding 1100 ± 3.5 fruits and aloe vera yielding 960 ± 2.5 fruits whereas a lowest cucumber production was found in control (305 ± 2.8 fruits per plant). [Fig. 4.]



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Figure 4: Cucumber yield after time exposure to botanical extracts (N-neem and A-aloe vera).

4. DISCUSSIONS

The findings of this study revealed a clear effect of neem (*A. indica*) and Aloe vera (*A. barbadensis*) in the reduction of aphids (*M. persicae*) and melon flies (*B. cucurbitae*) as compared to their untreated control. This supports previous studies that have demonstrated the potential of neem and aloe vera extracts in controlling aphids and melon flies (29,30). At both 80% and 60% dose levels, fewer insect attacks were observed, with fewer individuals surviving compared to the untreated control (Fig. 5). Fruit rotting and deformation were observed less frequently in treated plants. Similar findings demonstrated the efficacy of neem and aloe vera extracts in controlling a variety of pests on cucumber, including aphids, mites, and whiteflies (31,32). The biopesticide activity of aloe vera may also contribute to improved plant health and resilience against pest infestations and enhance disease resistance in cucumber plants, although this is less well-studied compared to neem (33,34). When compared to untreated cucumber plants, those treated with neem and aloe vera extracts consistently ~~shown~~ show reduced pest infestations and associated damage. Untreated cucumber plants often become susceptible to a range of pests, leading to compromised growth, decreased yield, and poor fruit quality (35). These results were consistent with previous studies (36).

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Fig 5. A photograph showing insect infestation/damage symptoms in cucumber growth parameters

The use of neem and aloe vera extracts was effective in controlling both aphids and melon flies, as evidenced by a reduction in pest populations and associated damage. Aphids pose a significant threat to cucumber crops, causing damage through feeding on sap and transmitting plant viruses, while melon flies cause subsequent fruit rotting and deformation, which can drastically lower yield and quality. Neem and aloe vera have been extensively studied for their pesticidal properties, with their active compounds such as alkaloids, flavonoids, steroids, terpenoids, glycosides, carbohydrates, and tannins. The presence of bioactive compounds such as azadirachtin and nimbin in neem, and auxins and gibberellins in aloe vera, likely contributed to the observed improvements in pest control and plant growth. Similar studies have shown that neem-based formulations can

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effectively control aphids by disrupting their feeding and reproductive processes (37,38). Neem's active compound, azadirachtin, is known to disrupt the feeding and reproductive processes of aphids, while aloe vera's auxins may promote root development and enhance nutrient uptake. Neem and aloe vera extracts ~~was-were~~ found to enhance the efficacy of pest control, providing a broader spectrum of activity against aphids and melon flies while minimizing the risk of resistance development (39). The reduction in pest populations likely contributed to the observed improvements in plant health, as untreated plants often suffer from stunted growth and poor fruit quality due to pest damage.

Also, the ~~finding-findings~~ of the present study exhibited a clear positive effect on cucumber plant growth of botanical extracts as the highest number of cucumber leaves was found on plants treated with a dose level of 80% and 60% of neem and aloe vera extracts compared to the least number of ~~eucumbers-cucumber~~ leaves in untreated control. The active compounds in neem, such as azadirachtin, nimbin, and salannin, and the gel extracted from aloe vera leaves contains compounds like auxins, gibberellins, and cytokinins, have been shown to exhibit various bio-stimulant properties, including promoting root development, promote cell division and elongation, thus influencing overall plant growth, enhancing nutrient uptake, and improving overall plant vigor (40,41). The reduction in pest populations likely contributed to the observed improvements in plant health, as untreated plants suffered from stunted growth and poor fruit quality due to pest damage. The findings also observed highest cucumber production at 80% and 60% dosage of neem and aloe vera extracts compared to a lowest cucumber production found in untreated control. These results ~~described-describe~~ that, neem and aloe vera extracts have the potential to positively impact cucumber fruit quality by mitigating pest pressures and enhancing plant health. Their bioactive compounds may contribute to improved fruit setting, size, and overall quality. Neem (*Azadirachta indica*) and aloe vera (*Aloe barbadensis*) extracts are two natural substances that have been studied for their potential benefits in plant growth and disease management (42,43). The quality and yield of cucumber fruit are crucial factors in cucumber cultivation, and various factors, including pest infestations, can significantly impact these outcomes (44,46). Additionally, information to help with the safe production, use, and disposal of botanicals as well as an examination of the differences between homemade and commercially produced pesticide products ~~are-is~~ implemented today for the benefit of human health, the environment, pollinators, and beneficial insects.

However, the American people's USAID mandates that commercial products be used in compliance with the pesticide label. The limited number of neem and aloe vera products that are sold commercially may be advantageous to Tanzanian growers. Most commercially available neem products, including certified neem leaf powder and neem oil, are imported from India and the United States, respectively. Despite for smallholder farmers, they are more expensive than the homemade extracts, which are available year-round and free.

5. CONCLUSIONS AND RECOMMENDATIONS

Our findings demonstrated the effective control of aphids (*M. persicae*) and melon flies (*B. cucurbitae*) using neem and aloe vera extracts at a dosage of 80% and 60% under field conditions. Both neem and aloe vera extracts were found to be highly effective in controlling pests and improving cucumber plant health. The recommended concentrations of 80% and 60% provide smallholder farmers with practical, eco-friendly pest control options that are both effective and sustainable. These biopesticides are well-suited for sustainable agriculture and can be integrated into organic farming practices or as part of an Integrated Pest Management (IPM) strategy. Further research is needed to explore the long-term effects of neem and aloe vera extracts on soil health and their efficacy in different environmental conditions.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) ~~here by~~ hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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