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Research Article

Evaluate the Effect of *Lantana camara* Extract and some Environmental Factors on the Population Density of *Bemisia tabaci* and *Tetranychus urticae* on Cucumber

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Abstract | In this study the population densities of whitefly *Bemisia tabaci* (Gennadius) and two-spotted spider mite *Tetranychus urticae* Koch were studied on Cucumber Plants, and the effect of the environmental factors (temperature and relative humidity) on cucumber cultivation in the 2023 autumn season and the outbreaks of these pests were evaluated. The efficacy of an ethanolic extract of *Lantana camara* leaves for controlling these Pests was also assessed in two concentrations (3 and 6%). The results showed that the highest population density of whitefly eggs and nymphs occurred at the end of October, reaching 16.67 eggs/leaf and 9.67 nymphs/leaf, when the average temperature was 25.93°C and the average relative humidity was 36.6%. The data also indicated two peaks in the population of whitefly life stages during October. As for two-spotted spider mite, the highest population densities were observed in the second half of October, with egg and immature instars reaching 66.33 eggs/leaf and 116.33 individuals/leaf, respectively, under average conditions of 23.4 °C and 39.66% relative humidity. Adult mites peaked at 35.0 adults/leaf by the end of October. The results showed two peaks for eggs and immature instars for *T. urtica*, and one peak for adults during the same month. Statistical analysis showed a negative correlation between pest populations and temperature, and a positive correlation with relative humidity. The evaluation of the ethanolic *L. camara* leaf extract at concentrations of 3and 6% demonstrated that high mortality occurred in both *B. tabaci* and *T. urticae* after seven days post treatment.

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Introduction

Cucumber (*Cucumis sativus* L.) is a highly susceptible crop to many pest Species which prevent its efficient yield which may be up to 70-90% (Akinkunmi 2020). The whitefly *Bemisia tabaci* (Gen.) (Hemiptera:Aleyrodidae) has been one of the most damaging pests, and it is a highly polyphagous insect that attacks a various host plants but highly prefers cucumber, It causes damage to the host directly by sucking phloem sap and indirectly due to the excretion of honeydew (Solanki and Jha 2018).

This sweet liquid promotes soot and honeydew and the buildup of dust and cast skins that interferes with photosynthesis, causing chlorosis and, later, plant vigor decline. In addition, *B. tabaci* is an important vector of plant viral diseases, which can also enhance plant susceptibility, contributing to significant yield reduction (Gorayeb *et al*., 2021; Alwan *et al*., 2025; Talib *et al*., 2025). The two-spotted spider mite, *Tetranychus urticae* Koch (Acari:Tetranychidae) is another economically important pest to Cucumber. This pest is an imminent threat to several economically important crops, such as fruits and ornamental plants. It is well known for its worldwide distribution and the wide adaptation to various environmental conditions. All stages feed by puncturing plant tissues with their mouthparts and sucking out cell contents, causing the patches on leaves, with the yellow or white spots, from which the green of the chlorophyll is removed (Gonçalves, 1996; Park and Lee, 2005). *T. urticae* is not only a direct destructor of many plants but also feared for being a responsive species owing to its rapid rate of reproduction, a short life cycle, and an excellent capability to develop resistance to classical acaricides, which laid out several challenges to control this pest (Qessaoui *et al*., 2017; Park and Lee, 2005).

If we are to apply means of production and quicker methods for controlling pests to new situations, we must consider the biology of the pests. Should the dew point be reached during it's slow growing season happens at midday when temperatures are still high. In the process of controlling cotton bollworms, for example, if you know which environmental conditions go with which degree of what density of pests, timely measures can be forecast with ease and balance so that they will not result in yield losses on any scale (Ferreira Rodrigues *et al*., 2022; Liu et al. 2023). An important matter receives only the briefest mention but is apt to have profound consequences on the crop, should it be ignored by farmers. Quantitative relations between whitefly populations in the field and insect population can be inferred from such indirect indices as adult temperature. Thus, for instance, Kumar and Gupta (2016) found that numbers of adult whiteflies increases when there are higher temperatures. Similarly, Hameed *et al*. (2013) observed that at low levels in early January

Substances used to kill pests and diseases cannot be employed in agriculture on a commercial or large scale. It will usually start with scientific research, then advanced training offered to farmers and coordination of demonstrations by national institutions for technology transfer.But the widespread and indiscriminate use of pesticides has given rise to many pests and aphids which develop resistance to pesticides, the pollution to non-target organisms such as natural enemies and bees. All of this has had a series of harmful consequences for both environment and human health. As a result, some scholars have begun research into environmnetally friendly materials Artificial hypothesis, and make vulner-ability a basic requirement for control technology Ahmed and Ali, 2009; Whalon *et al*., 2011; Shweet and Al-Khazraji, 2024).The way can be opened gradually to get more people participating in the research we need on environmental cleaning.

In plants there are many active secondary substances which serve as natural insecticides, they fully deserve a place in this vital research. In a short time they will turn into harmless material and avoid the problems caused by chemical pesticides. Such substances having their own characteristic reactions: say, some can cause the result of mass sterilization and others are repellent, or the reaction is to prevent insect feeding in some other cases. A number of studies have conclusively demonstrated that someseem to poison insects greatly. Laboratory assessments are a crucial step in testing the value of plant extracts for pest control (Khater 2012; Al-Naemi *et al*., 2012; Al-Jobori and Esmaeel 2011).

Lantana camara is a member of the Verbenaceae family and is commonly found in tropical, subtropical and temperate latitudes worldwide. It is a prickly deciduous shrub growing to 2 m (Priyanka and Joshi 2013). According to research, the ethanolic extract of *L. camara* leaves possesses different bioactive constituents. Rajashekar *et al*. (2012) narrated the identities of 13 aromatic compounds in the extract, with 4H-1-benzo pyran-4-one as the principal aromatic compound, making up 54.2%, the highest in abundance as compared to the 2- methoxy -5 Vinyl Phenol, Dihydro -1, 3- oxathiole, Coumaran, 3 methoxy 4,5,7 TriHydroxy Flavone, P- Hydroxy Benzaldehyde, Proponoic acid , 1, 2 - Benzenediol, Benzoic acid, 2, 6- Dimethoxy phenol, 2-Hydrozinopyridine, Oxymethylfurfurole, and Phytol.

Patil (2009) also reported that plant extracts of *L. camara*, *Azadirachta indica* and *Argimone mexicana* were effective against whiteflies, with mortality recorded at 80% after 8 h of treatment, while 90% mortality occurred after 12 h of treatment at a 3% solution size. Srimongkolchai *et al.* (2013) reported two-spot mite toxic and repellent activities for *L. camara* flower extracts, as well as its oviposition suppressing potential by its adults. Kumar *et al.* (2019) analyzed the influence of the methanolic extract of *L. camara* leaves on the management of mealybug *Phenacoccus solenopsus*. The extract caused 46.6-93.3% mortality depending on the concentrations. Ayalew (2020) revealed considerable active functional groups, such as steroids, flavonoids, tannins, glycerol, and saponins in the extracts of *L. camara* leaves (methanol, ethanol, and ethyl acetate), the alkaloids were found to be present in methanol and ethanol extracts.

The main objective was to determine the population density of the main cucumber pests in the fall season and the influence of climatic factors during the study period, including temperature and relative humidity on their population dynamics. Furthermore, the study tested the insecticidal activity of *L. camara* leaf ethanolic extract in field conditions as a new environment-friendly pest control approach.

Methods

Field preparation and monitoring of pest population density on cucumber

An open field belonging to the College of Agricultural Engineering Sciences, University of Baghdad, Baghdad, Iraq with an area of 210 m^2 was selected and divided according to a randomized complete block design (RCBD) into three planted lines, each one 15 m in length, and space was 150 cm between lines. Cucumber seeds (hybrid cultivar 'Kareem') were planted at the beginning of September for the autumn growing season, with 45 cm spacing between planting holes.

The field was split into two sections. The first section was dedicated to studying the population density and seasonal occurrence of the whitefly *B. tabaci* and the two-spotted spider mite *T. urticae* on cucumber plants, and the influence of average temperature and relative humidity on pest population dynamics. Meteorological data on temperature and relative humidity were obtained from the Agricultural Meteorological Center (Ministry of Agriculture), Abu Ghraib Station, Baghdad Governorate. Leaf samples were collected weekly using a systematic-random sampling method. Three replicates were taken, with 10 leaves per replicate. The samples were placed in labeled polyethylene bags and transported to the laboratory for examination. Pests were identified and counted under a light microscope to determine their density per leaf. The second section of the field was reserved for evaluating the in-field efficacy of the plant extract against the target pests.

Preparation of plant extract

The leaves of the *L. camara* plant were isolated from the plants grown in the University of Baghdad-Al-Jadriyah campus. Leaves were then brought to the laboratory, washed with tap water, air-dried at lab temperature with leaves turned daily to dry, and then ground to get powder. *L. camara* ethanol extract leaves were obtained from the central laboratory of the College of Agricultural Engineering Sciences, University of Baghdad. 30 g of *L. camara* were added to a glass beaker, 600 ml of ethanol was added, and the extract was left for 24 h in the laboratory (AL-Jourany and Al-khazraji 2021). Magnetic stirring was continued for 1 h after 24 h, and extraction was carried out. This procedure was repeated several times.

The resulting extract was filtered through muslin cloth, and the filtrate was collected and placed in an oven at 40 °C to evaporate the solvent. The concentrated extract was stored in tightly sealed, opaque containers until use. Two concentrations were prepared: 3% by dissolving 3 g of the extract in 97 mL of distilled water, and 6% by dissolving 6 g of the extract in 94 mL of water.

Evaluation of the field efficacy of L. camara extract

To assess the field efficacy of *L. camara* ethanolic leaf extract against *B. tabaci* and *T. urticae*, and to compare its performance with the chemical pesticide Levo 2.4% (the active ingredient is oxymatrine 24%, the manufacturer is Sineria Cypriot) used as a standard control, as well as with a water-treated control, the field was arranged into three replicates. Each replicate consisted of one furrow divided into four experimental plots. The trial was laid out using a randomized complete block design (RCBD), the cucumber plants were treated on 12-10-2023 before flowering and treated only once.

Observations were recorded one day before and on days 3, 7, 14, and 21 after treatment application. The relative efficacy of each treatment was calculated using the Henderson and Tilton formula, as cited by Ahmed and Al-Khazraji (2024). Treatments were applied using a 5L handheld sprayer.

The experimental treatments included:

- *L. camara* extract at 3% concentration
- *L. camara* extract at 6% concentration
- Levo 2.4% pesticide at the recommended rate of 0.3 mL/L
- Control treatment (water only)

Statistical analysis

Results were analyzed using GENSTAT version 12, using a completely randomized block design. Results were compared using the least significant difference criterion at a probability level of 0.05%.

Results and Discussion

Population density of whitefly on cucumber in the field

The results illustrated in Figure 1 indicate that whitefly *B. tabaci* infestation on cucumber plants began early in the growing season, coinciding with initial leaf development. By the end of September, egg and nymph densities reached 1.67 eggs/leaf and 0.67 nymphs/leaf, respectively, under average environmental conditions of 31.68 °C and 20.7% relative humidity (Figure 2).

Whitefly numbers increased gradually, reaching 4.0 eggs/leaf in the first half of October when the mean temperature was 28.21 °C and relative humidity was 29.17%. The highest recorded egg density was 16.67 eggs/leaf at the end of October, coinciding with an average temperature of 25.93 °C and 36.6% relative humidity. Subsequently, egg numbers declined toward the end of the growing season, reaching 1.67 eggs/leaf as temperature dropped to 21.8 °C and humidity rose to 45.82%.

As for the nymph stage, the initial density at the end of September was 0.67 nymphs/leaf (temperature: 31.68 °C; humidity: 20.7%). This number rose to 9.67 nymphs/leaf in early October, followed by a decline in mid-October, and then a second peak, again reaching 9.67 nymphs/leaf by the end of the month. By the end of the season, the nymph density dropped again to 1.0 nymphs /leaf under cooler and more humid conditions (21.8°C and 45.82% RH).

Results shown in Table 1 indicated a negative correlation between whitefly population density and temperature, and a positive correlation with relative humidity. The decrease in whitefly population during the period from October 17–21, 2023, despite relatively favorable humidity levels, could be attributed to other environmental factors such as wind or reduced solar radiation, which were particularly low during that time.

Furthermore, graphical analysis revealed two distinct peaks for egg density: one during the first half of October and another at the end of the month. Similarly, two peaks in nymph density were recorded in early and late October. Statistical analysis revealed significant differences among the developmental stages of the pest.

Table 1: *The correlation coefficient between Environmental Factors and pests*

The correlation coefficient		
T. urticae	*B. tabaci*	Environmental factors
- 0.325	- 0.385	Temperature average
0.271	0.468	Relative humidity average

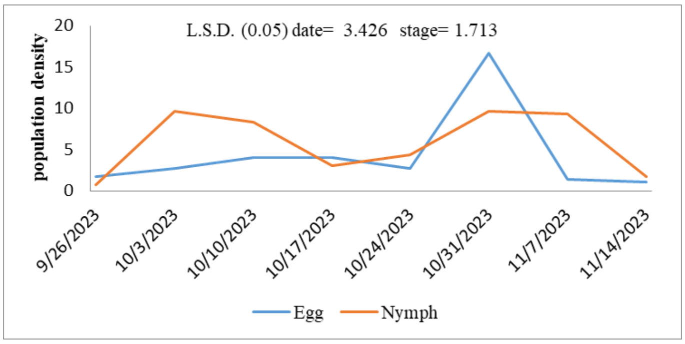

Figure 1: *Population density of B. tabaci on cucumber plants, Kareem cultivar, during the whole season*

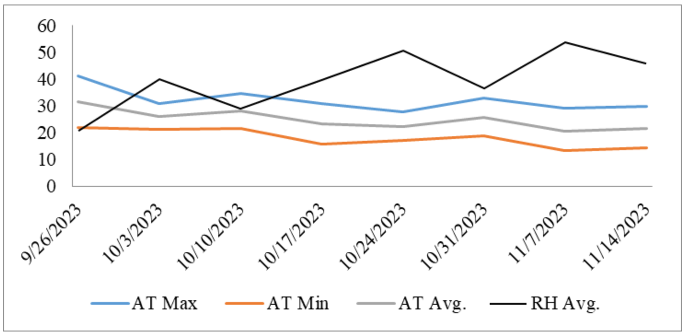

Figure 2: *Environmental Factors of the autumn season in 2023*

- AT Max: Air Temperature Maximum
- AT Min: Air Temperature Minimum

- AT Avg: Air Temperature Average RH
- Avg: Relative Humidity Average

Population density of the two-spotted spider mite on cucumber in the field

The results of Figure 3. showed that the different stages of the two-spotted mite began to appear on cucumber leaves at the beginning of growth, with low population densities of 0.67 eggs/leaf and 1 individual/leaf for immature stages (larvae and nymphs) at the end of September, when the average temperature was 31.68°C and the average relative humidity was 20.7% (Figure 2). Adult mites were first detected at the beginning of October.

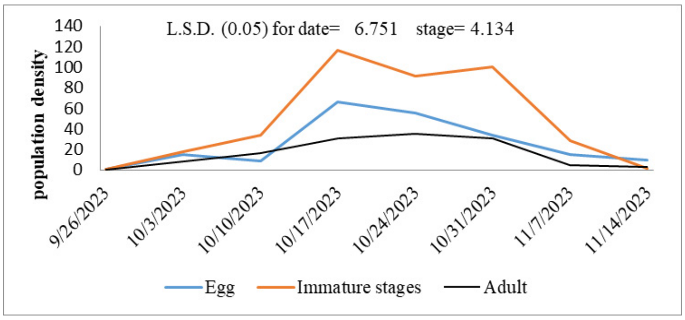

Figure 3: *Population density of T. urtica on cucumber plants during the fall season*

The mite population increased gradually, reaching its peak in the second half of October. Egg density rose to 66.33 eggs/leaf, and immature stages reached 116.33 individuals/leaf, corresponding to average environmental conditions of 23.4 °C and 39.66% relative humidity. The highest adult density was recorded at the end of October, reaching 35.0 adults/leaf. Following this peak, the population declined significantly, with the lowest densities recorded at the end of the growing season: 10 eggs/leaf, 2 immature individuals/leaf, and 3.33 adults/leaf, when the temperature averaged 21.8 °C and relative humidity was 45.82%. Notably, the lowest density of mite stages was observed in the latter half of October, coinciding with decreasing temperatures and increasing humidity levels.

Table 1 shows a negative correlation between mite population density and temperature, and a positive correlation with relative humidity. The graphical data also suggests the presence of two peaks in egg density, one in early October and another in the second half of the month. Immature stages also exhibited two peaks in the second half and at the end of October. In contrast, adults displayed a single peak in late October.

The decline in pest population density on cucumber plants at the end of the growing season may be attributed not only to environmental changes specifically, decreasing temperatures and increasing relative humidity but also to a reduction in the availability of essential nutrients due to plant senescence and leaf yellowing. Moanaro and Choudhary (2019) reported that whitefly populations began to emerge in September, reaching their peak in November. Similarly, Kataria *et al.* (2019) cited a significant positive relationship between whitefly population and relative humidity and a negative relationship with the morning maximum and minimum temperatures. Ferreira Rodrigues et al. (2022) emphasized the significance of investigations into the seasonal presence of Pests and their distribution in time and space, since these are among the most important factors in determining the pattern of their spread in environmental and plants infection possibilities, and hence the possibility of using the results of these studies to develop plans for the monitoring of pests in agricultural programs. By the end of the season, the density of whitefly was found to be reduced, and the adults were found to have the highest density, as reported by the researchers. Additionally, environmental factors affect the population density and dispersal of the insect. Densities of the pest were positively correlated with relative humidity, and wind was associated with whitefly dispersal. The authors advised that early intervention should be implemented when favorable environmental conditions for pests are observed. Bakry *et al.* (2023) reported a continuous rise in the whitefly population density and number during 2021 and 2022. They found that the weekly gradient of the curve, which represents the increase in pests per week, indicates the best time to intervene. Moreover, the study demonstrated a highly significant positive correlation between whitefly density and rising temperatures, a significant negative correlation with relative humidity, and a very strong positive association with plant growth rate.

Regarding *T. urticae*, Ammar and Abolmaaty (2016) reported that its population density on cucumber increased with rising temperatures, whereas a negative correlation was observed with relative humidity during the 2015 and 2016 seasons. Discrepancies among these studies may be due to variation in environmental conditions across agricultural regions, differences in plant cultivars, the presence and effectiveness of natural enemies, and the availability of alternate host plants.

Efficacy of L. camara extract in controlling pests on cucumber in the field

The results in Table 2 demonstrate that all tested treatments effectively controlled *B. tabaci*. The ethanolic *L. camara* leaf extract at a 3% concentration for the egg stage. Achieved a relative efficacy of 78.0% three days after application, peaking at 88.3% after seven days, before declining to 42.67% by day 21. The highest efficacy recorded for the extract was 100% at the 6% conc., observed seven days post-treatment. In comparison, the chemical pesticide Levo (2.4%) achieved 100% efficacy three days after application, which declined over time, reaching 75% by day 21. The 6% extract treatment followed a similar trend, dropping to 59.6% after 21 days. Statistical analysis revealed no significant differences among treatments for the egg stage.

Table 2: *Relative efficacy of the plant extract and pesticides in whitefly control*

Stage	Treatment	Relative effectiveness %				Mean
		3 day	7 day	14 day	21 day	
Egg	*L. camara* 3%	78.0	88.3	61.5	42.6	67.6
	L. camara 6%	81.5	100.0	67.0	59.6	77.0
	Levo 0.3 ml/L	100.0	97.5	89.0	75.0	90.3
Mean		86.5	95.2	72.5	59.0	78.3
Nymphs	*L. camara* 3%	79.5	92.0	65.6	58.5	73.9
	L. camara 6%	83.3	100.0	76.9	61.5	80.4
	Levo 0.3 ml/L	100.0	100.0	89.3	72.5	90.4
Mean		97.6	87.6	77.2	64.1	81.5
L.S.D. (0.05)	Days=9.13 Treatment= 7.23 S*D*T=18.86 Stages=6.82					

Regarding nymphs, all treatments showed the highest efficacy on day 7: 92% for the 3% extracts, and 100% for both the 6% extract and Levo2.4%. The lowest efficacy values were recorded 21 days after treatment, reaching 58.5%, 61.5%, and 72.5% for the 3% extract, 6% extract, and Levo2.4%, respectively. Again, no statistically significant differences were detected among treatments. Overall, the average relative efficacy across the study period was 78.3% for the egg stage and 81.5% for the nymph stage.

Efficacy of treatments against the two-spotted spider mite on cucumber

The results in Table 3. indicate that the highest efficacy of the ethanolic extract of *L. camara* was observed 7 days post-treatment. The relative efficacy is at 3% conc. reached 84.3%, 85.5%, and 84.5% for the egg, immature, and adult stages of the two-spotted spider mite, respectively. Statistical analysis revealed no significant differences among the treatments. At the 6% conc., the extract achieved slightly higher efficacy values: 88.5% for eggs, 86.1% for immature stages, and 91.0% for adults. In comparison, the chemical pesticide Levo (2.4%) demonstrated the highest efficacy across all mite stages just three days after application, with relative effectiveness reaching 96.5% for eggs, 98.2% for immature stages, and 100% for adults. Efficacy of the 3% extract declined over time, reaching the lowest values by day 21: 48.6%, 51.2%, and 44.8% for eggs, immature stages, and adults, respectively. Similarly, the 6% extract showed a decrease in efficacy to 60.8%, 65.7%, and 57.6%, respectively, after 21 days. Again, no statistically significant differences were detected among treatments. The Levo 2.4% pesticide treatment maintained comparatively higher residual activity, though it also showed reduced efficacy by day 21, recording values of 73.0% for eggs, 75.7% for immature stages, and 80.0% for adults.

Table 3: *Relative efficacy of the plant extract and pesticides in T. urticae control*

Stage	Treatment	Relative effectiveness %				Mean
		3 day	7 day	14 day	21 day	
Egg	*L. camara* 3%	80.0	84.3	68.5	48.6	67.9
	L. camara 6%	83.7	88.5	74.3	60.8	75.1
	Levo 0.3 ml/L	96.5	89.7	77.5	73.0	81.0
Mean		86.7	87.5	73.4	60.8	77.0
immature stages	*L. camara* 3%	75.8	85.5	61.2	51.2	68.4
	L. camara 6%	81.0	86.1	72.9	65.7	76.4
	Levo 0.3 ml/L	98.2	87.5	80.6	75.7	85.5
Mean		85.0	86.3	71.5	64.2	76.7
Adults	*L. camara* 3%	68.5	84.5	63.3	44.8	65.2
	L. camara 6%	84.3	91.0	82.6	57.6	78.8
	Levo 0.3 ml/L	100.0	95.4	85.2	80.0	90.1
Mean		84.2	90.3	77.0	60.8	78.1
L.S.D. (0.05)	Days= 11.02 Treatment= 9.56 S*D*T=27.67 Stages=9.93					

To sum up from Table 2 and Table 3, the effectiveness of the plant extract in controlling pests that infect the cucumber crop in the field and the relative effectiveness increases with the increase in the concentration used, and the treatment was superior after 7 days in causing the highest effect and reducing the number of pests. The reason for the effect of the extracts and their effectiveness in reducing the number of eggs may be due to the presence of some compounds with a repellent effect that cause the adults to stay away or the presence of compounds that make the surface of the plant leaf unsuitable to lay eggs and thus a decrease in the numerical density of the resulting nymphs. In addition to the toxic compounds present in the extract, which cause the mortality of the pest stages. The extracts also work to encapsulate the eggs and affect the respiration process of the embryo, causing its death and failure to hatch, which leads to a decrease in the other stages of the pests.

Several studies have shown the effectiveness of plant extracts in pest management, and their essential oils are known to act as repellents for insects to the host plant. Plant extracts might also contain active molecules of toxicity similar to chemical pesticides (Al-khazraji *et al*. 2016). Ghisalberti (2000); and Mishra *et al.* (2014) reported that *L. camara* contained variations and a broad spectrum of chemical constituents with different biological activities, such sesquiterpenes, triterpenes, iridoids, phenyl ethanoid glycosides, and flavonoids. These have shown comparable insecticidal activity to that of synthetic insecticides. Baidoo *et al.* (2017) reported the efficacy of ethanolic extracts of *L. camara* leaves and roots in the management of *Aphis gossypii*, *B. tabaci*, and *Podagrica puncticollis* on okra, with a significant reduction in the population of insects on the treated plants over the untreated control. The efficacy of methanol, ethanol, and ethyl extract of leaves of *L. camara* against insects might be due to the existence of phytochemicals (e.g., Phytol, Pyrroline, Paromomycin, Pyrrolizin, 1-Eicosanol, and others) in these plants (Ayalew, 2020). Merlin *et al.* (2023) in a study conducted on sixteen plant extracts of 13 plant species, recorded that the 5% concentration of *L. camara* leaf extract caused the highest mortality rate on two-spotted spider mite, with 87.23% in contrast, flower extract gave a higher mortality rate of 76.13%. In contrast, the commercial chemical pesticide resulted in a mortality rate of 86.96%; the mortality rate in the control treatment was 5.63%.

Conclusions

Insect population dynamics are essential for crop protection and for designing control strategies based on economic thresholds. Monitoring whitefly abundance and its temporal distribution helps in assessing infestation levels and understanding environmental influences. The study confirmed the superior efficacy of the ethanolic extract of *L. camara* in controlling the tested pests, supporting its potential integration into IPM programs. Future efforts should focus on enhancing extraction methods to increase active compound concentration, improve formulation stability, prolong field effectiveness, and reduce application frequency and dosage.

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Novelty Statement

This study uniquely integrates climatic factors with pest population dynamics under field conditions while evaluating the field efficacy of ethanolic *Lantana camara* extract against *Bemisia tabaci* and *Tetranychus urticae* on cucumber. It demonstrates the potential of *L. camara* extract as an eco-friendly alternative to chemical pesticides within IPM programs, highlighting its residual effectiveness and influence on different pest life stages in open-field environments.

Generative AI and AI-Assisted technology statement

The authors affirm that generative artificial intelligence (AI) and AI-assisted technologies were utilized solely to support language refinement, grammatical correction, and formatting improvements during the manuscript preparation process. These tools were not used to generate, analyze, or interpret any scientific data, nor to create any part of the original research content, results, or conclusions. The authors take full responsibility for the accuracy, originality, and integrity of all scientific content presented in this manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this research.

References

Ahmed, F.M. and H.I. Al-khazraji. 2024. Seasonal abundance of aphids on apple cultivars and their chemical control. IOP Conf. Series: Earth Environ. Sci., 1371: 032002. https://doi.org/10.1088/1755-1315/1371/3/032002

Ahmed, R.F. and H.I. Ali. 2009. Effects of some insect growth regulators and bio insecticide (abamectin) in reproductive potential of the cotton leaf worm. Iraqi J. Agric. Sciences, 40(3): 98-107.

Akinkunmi, O.Y. 2020. Bioecology of *Epilachna chrysomelina* Fabricius (Coleoptera: Coccinellidae) on five vegetable hosts in a rain forest transition location of Nigeria and control with botanicals. Ph.D Dissertation, Federal University of Agriculture Abeokuta, Nigeria.

Al-Jobori, K.M. and Z.A. Esmaeel. 2011. Antimicrobial effect of *Dodonaea viscosa* Jacq. extracts against some pathogenic microorganisms. Iraqi Journal of Sciences, 52(4): 425-439.

Al-Jourany, R.S. and H.I. Al-khazraji. 2021. Effect of plant extract of *Withania somnifera* (L.) dunal. on some biological performance of cotton leaf worm (*Spodoptera littoralis* Boisd.). Arab J. Plant Protect., 39(1): 22-28.

Al-khazraji, H.I., R.F. Ahmed and R.S. Al-jourany. 2016. Effect of feeding treatment with some extracts of black pepper on some biological aspects of cotton leaf worm. Iraqi J. Agric. Sci., 47(3): 856-864. https://doi.org/10.36103/ijas.v47i3.578

Al-Naemi, K.T., H.K. Al-Jbuori and H.I. Ali. 2012. Population density and percent of infestation by the eriophyid mite *Aceria ficus* (cotte) (acariformes: eriophyidae) on fig and its control by plant extract. Iraqi J. Agric. Sci., 43(5): 69-76.

Alwan, M.G., W.H.A. Alqatrani, I.A. Jihad, Q.R. Lahhob, M. Mudhafar, H.A. Alsailawi, and M.A. Zaidan. 2025. Development and in vivo evaluation of recom-binant multi-epitope vaccine (ABOR) with chitin microparticles as adjuvant against brucella abortus. J. Anim. Health Prod., 13(s1): 89–97. https://doi.org/https://dx.doi.org/10.17582/journal.jahp/2025/13.s1.89.97

Ammar, M.I. and S.M. Abolmaaty. 2016. Effect of different colors of mulch on population density of pome pests infesting cucumber plants and on cucumber yield. Egypt. Acad. J. Biolog. Sci., 9(4): 153-162.

Ayalew, A.A. 2020. Insecticidal activity of *Lantana camara* extract oil on controlling maize grain weevils. Toxicol. Res. Applic., 4: 1-10. https://doi.org/10.1177/2397847320906491

Baidoo, P.K., E. Adu and S. Peprah. 2017. The role of ethanolic extracts of leaves and roots of *Lantana camara* (L.) in the management of pests of okra *Abelmoschus esculentus* (L.) Moench. Advan. Entomol., 5: 99-108. https://doi.org/10.4236/ae.2017.53010

Bakry, M.M.S., G.S. Mohamed, ZS. Abd-Elazeem and R.O.H. Allam. 2023. Monitoring of the whitefly populations on cucumber plants in a greenhouse in Luxor region of South Egypt. S VU-Int. J. Agric. Sci., 5(3): 27-40. https://doi.org/10.21608/svuijas.2023.224688.1299

Ferreira Rodrigues, R.H., L.B. Silva, M.C.F. Silva, J.W.B. Lopes, E. Araujo Lima, R. Sobreira Barbosa and L.F. Oliveira Almeida. 2022. Population fluctuation and distribution of *Bemisia tabaci* MEAM1 (Hemiptera: Aleyrodidae) in soybean crops. Front. Agron., 4: 958498. https://doi.org/10.3389/fagro.2022.958498

Ghisalberti, E.L. 2000. *Lantana camara* L. (Verbenaceae).Fitoterapia,71:467-486.https://doi.org/10.1016/S0367-326X(00)00202-1

Gonçalves, M.I.F. 1996. Variação do teor de 2-tridecanona em folíolos de tomateiro e sua relação com a resistência a duas espécies de ácaros do gênero Tetranychus. M.Sc. Dissertation, Universidade Federal de Lavras, Brazil.

Gorayeb, E.S., L.F.M. Watanabe, Y.A.B. Pereira, L.H. Dovigo, V.H. Bello, I.M. de Souza, G.C.D. Cruciol and E. Vicentin. 2021. Performance and preference of *Bemisia tabaci* on cucumbers. Crop Protect., 143: 105468. https://doi.org/10.1016/j.cropro.2020.105468

Hahmeed, G.A., M.A. Abdullah and S.A.K.

Elhadeeti. 2023. Population density of *Bemisia tabaci* on sweet pepper (Capsicum annuum) varieties in the greenhouse. IOP Conf. Series: Earth Environ. Sci., 1262: 032033.

Kataria, S.K., R.K. Pal, V. Kumar and P. Singh. 2019. Population dynamics of whitefly, Bemisia tabaci (Gennadius), as influenced by weather conditions infesting Bt cotton hybrid. J. Agrometeorol., 21(4): 504-509. https://doi.org/10.54386/jam.v21i4.288

Khater, H.F. 2012. Prospects of botanical biopesticides in insect pest management. Pharmacologia, 3: 641-656. https://doi.org/10.5567/pharmacologia.2012.641.656

Kumar, D., D. Prakash, V. Agrawal, S. Nebapure, A. Ranjan and T. Jindal. 2019. bio-efficacy of Indian weed plants *Lantana camara* on cotton mealy bug (*Phenacoccus solenopsis*). Plant Arch., 19(2): 820-823.

Kumar, M. and A. Gupta. 2016. Effect of weather variables on whitefly (*Bemisia tabaci* Gennadius) population in development of potato apical leaf curl virus disease. J. Agrometeorol., 18(2): 288-291. https://doi.org/10.54386/jam.v18i2.952

Liu, H., Z. Jiang, J. Zhou, X. Liu, Y. Zhang and D. Chu. 2023. Ecological factors associated with the distribution of *Bemisia tabaci* cryptic species and their facultative endosymbionts. Insect., 14: 252. https://doi.org/10.3390/insects14030252

Merlin, I., K. Davidson and M. Suganthy. 2023. Plant extracts for the management of two spider mite, *Tetranychus urticae* Koch on jasmine (*Jasminum sambac*). Pest Manag. Hortic. Ecosys., 29(1): 172-176. https://doi.org/10.59467/bi.2023.19.29

Mishra, A. 2014. Allelopathic properties of *Lantana camara*: a review article. Int. J. Innov. Res. Rev., 2(4): 32-52.

Moanaro, O. and J.S. Choudhary. 2018. Seasonal incidence of major sucking pests complex of capsicum in relation to weather parameters in Eastern Plateau and Hill region of India. J. Entomol. Zool. Stud., 6: 270-273.

Park, Y.L. and J.H. Lee. 2005. Impact of two spotted spider mites on growth and productivity of glasshouse cucumbers. J. Econ. Entomol., 98: 457-463.

Patil, B.J. 2009. Studies on plant extracts as insecticides against white flies *Bemisia tabaci* (Gen.) on tomato. Nature Environ. Pollution Technol., 8(3): 515-517.

Priyanka, N. and P.K. Joshi. 2013. A review of *Lantana camara* studies in India. Int. J. Scient. Res. Public., 3(10): 1-11.

Qessaoui, R., R. Bouharroud, A. Amarraque, A. Ajerra, M. El Hassan, B. Chebli, M. Dadi, R. Elaini, F. El Filali and A.S. Walters. 2017. Ecological applications of Pseudomonas as a biopesticide to control two-spotted mite *Tetranychus urticae*. J. Plant Prot. Res., 57: 409-416. https://doi.org/10.1515/jppr-2017-0055

Rajashekar, Y., K.V. Ravindra and N. Bakthavatsalam. 2012. Leaves of *Lantana camara* Linn. (Verbenaceae) as a potential insecticide for the management of three species of stored grain insect pests. J. Food Sci. Technol., 51(11): 3494-3499.

Shweet, A.R. and H.I. Al-khazraji. 2024. Efficacy of the coragen insecticides in controlling the corn stem borer *Sesamia cretica* on *Zea mays*. Earth Environ. Sci: IOP Conf. Serie., 1371: 032005.

Solanki, R.D. and S. Jha. 2018. Population dynamics and biology of whitefly (*Bemisia tabaci* Gennadius) on sunflower. J. Pharmacogn. Phytochem., 7: 3055-3058.

Srimongholchai, W., P. Vichitbandha and T. Pung. 2013. Toxic effects of leaf and flower crude extracts from *Lantana camara* on *Tetranychus urticae*. Asian J. Chemis., 25(9): 4881-4884.

Talib, A.L., R.Y. Rashid, I.A. Jihad, Q.R. Lahhob, M. Mudhafar, H.A. Alsailawi, and A.A. Ayada. 2025. Genetic diversity and evolutionary patterns of avian influenza viruses in poultry and their implications for disease control and vaccine development. J. Anim. Health Prod., 13(s1): 460–469. https://doi.org/https://dx.doi.org/10.17582/journal.jahp/2025/13.s1.460.469

Whalon, M.E., D.M. Sanchez, R.M. Hollingworth and L. Daynslager. 2012. Arthropod pesticide resistance database. Available from: http://www.pesticide resistance.org