Research Article

The Relative Efficiency of Some Plant Essential Oils against *Carpomya vesuviana* Costa, 1854 and *Carpomya incompleta* (Becker, 1903) (Diptera: Tephritidae) Infesting Jujube Fruits *Ziziphus mauritiana* Lam., 1789

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Abstract | Jujube (*Ziziphus mauritiana* Lam.) is a fruit crop of high economic importance in arid regions, but its production and quality are severely constrained by fruit fly infestations. Therefore, A field study was conducted to evaluate the efficacy of three plant essential oils: lavender (*Lavandula angustifolia* Mill., 1%), lemongrass (*Cymbopogon flexuosus* (Steud.) Wats., 0.5%), and cypress (*Cupressus sempervirens* L., 1%) in controlling two species of fruit flies, *Carpomya incompleta* (Becker) and *Carpomya vesuviana* Costa, on the 'Armouti' cultivar. Two foliar sprays of the extracts were applied during the fruiting stage after observing initial symptoms of natural infestation. The relative efficacy of the oils in reducing fruit infestation was assessed 1, 3, 7, and 14 days post-application. The results demonstrated that both species co-exist in jujube orchards. Based on the adults emerged from infested fruits collected from the control treatment and incubated in the laboratory, *C. incompleta* was the dominant species, representing 72% of the total infestation, while *C. vesuviana* accounted for 28%. These findings underscore the necessity of considering both species when developing integrated pest management (IPM) strategies. All essential oil treatments significantly reduced fruit infestation rates. Lavender oil showed the highest relative efficacy, achieving an 85.04% reduction one day after the first spray. The overall relative efficacy for the first and second sprays reached 64.60 and 67.73%, respectively. Lemongrass oil ranked second, with relative efficacy rates of 52.78 and 56.30% reduction for the first and second sprays, respectively. It is crucial to note that its concentration was adjusted to 0.5% to avoid phytotoxicity. Cypress oil exhibited the lowest relative efficacy as compared to the lavender and lemongrass oils, with a 48.11% reduction one day after the first spray and overall relative efficacy rates of 28.79 and 33.53% for the first and second sprays, respectively. Repeated applications were observed to enhance the overall efficacy of all tested extracts. In conclusion, these findings recommend the integration of plant essential oils, particularly lavender and lemongrass, into sustainable integrated pest management (IPM) programs as safe and eco-friendly alternatives to chemical insecticides.

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Introduction

Sidr trees (*Ziziphus* spp.), also known as Jujube, especially economic species like Indian Jujube (*Ziziphus mauritiana* Lam.), are vital horticultural crops in arid and semi-arid regions (Yadav *et al*., 2020). These trees have been cultivated for thousands of years across vast areas worldwide for their nutritious and delicious fruits. They are highly valued for their high nutritional content, utilization of by-products, medicinal uses, and remarkable adaptability to harsh environmental conditions (Liu *et al*., 2020; Hasan and Zainulabdeen, 2022; Al-Zaydi and Al-Jibouri, 2025; Jia *et al*., 2025).

With increasing interest in jujube cultivation as a source of income and food security, challenges to fruit production are escalating. One of the most prominent challenges is fruit flies, which negatively impact both the quality and quantity of the harvest (Ismail *et al*., 2023). In India, over 130 insect species have been identified as pests of jujube trees (Lakra and Singh, 1985). Among the many insect pests that affect jujube trees, the fruit fly species *C. vesuviana* Costa and *C. incompleta* (Becker) are among the most important pests that affect fruits and cause direct yield loss (Garrido-Jurado *et al*., 2022; Kavin *et al*., 2024).

These two pests are monophagous, meaning they specialize solely on jujube trees and cause significant reductions in the productivity and quality of jujube fruits. In Iraq, *C. incompleta* can lead to crop losses ranging from 80–100% in uncontrolled areas (Al-Masudey and Al-Yousuf, 2013). This species is widely distributed in Europe (e.g., France, Italy, Romania, Spain), Asia (including Iraq, Iran, Oman, Saudi Arabia, UAE, Yemen), and Africa (e.g., Egypt, Sudan, Morocco) (Zakari-Moussa *et al*., 2012; Ciceoi *et al*., 2017; Korneyev *et al*., 2017; Garrido-Jurado *et al*., 2022). As for *C. vesuviana*, it causes production losses of up to 80% in cases of severe infestation (Vadivelu, 2014) and is prevalent in vast regions including Italy, Georgia, Ukraine, Russia, Afghanistan, Azerbaijan, Cyprus, Iran, Iraq, UAE, Lebanon, Syria, Tajikistan, Turkmenistan, Uzbekistan, Cambodia, India, Pakistan, Bangladesh, China, Thailand, and Oman (Kapoor, 2002; Farrar *et al*., 2009; AlWahaibi and AlAnsar, 2024).

Females of both species lay their eggs inside the fruits, and the emerging larvae feed internally on the fruit's contents, creating tunnels filled with frass. This leads to fruit decay, and growth of secondary pathogens, this lead to an undesirable taste, fruit deformation, delayed development, or even premature fruit drop (White and Elson-Harris, 1992; Singh, 2008). The severity of damage increases as the season progresses, making these pests limiting factors for successful jujube cultivation, as a jujube tree rarely remains free from infestation (Lakra and Singh, 1984; Yadav *et al*., 2020).

In the local context of Iraq, the fruit fly *C. incompleta* attacks jujube fruits in Iraq during two generations per year, the first in November and the second in April, causing severe damage that necessitates control (Jabbar, 1996; Al-yousif *et al*., 2007). In contrast, despite the global prevalence of *C. vesuviana*, Jabbar (1996) indicated that this species has only one generation per year in Iraq. A recent study by Tahir (2023) in Basra Governorate reported no infestations by this species, while infestations by *C. incompleta* and *Bactrocera zonata* were recorded.

Due to these high infestation rates and the resulting significant losses in jujube crop quality and quantity, coupled with the environmental and health challenges associated with the excessive use of conventional chemical pesticides, which have led to resistance development and negative impacts on the environment, human health, and non-target organisms (Vadivelu, 2014; Zhao *et al*., 2020), there is an urgent need to develop effective and sustainable pest management strategies. Therefore, the search for safer and more effective alternative control methods, such as plant extracts, traps, biological control, cultural practices, and the development of resistant varieties, has become essential within integrated pest management programs (Ehler, 2006; Yunis, 2014; Aziz *et al*., 2014). essential oils have increasingly demonstrated significant potential as promising, safe, and effective alternatives to synthetic insecticides across various pest control programs (Majeed *et al*., 2018; Majeed *et al*., 2020; Akbar *et al*., 2021). Thus, this study aimed to test the field efficacy of certain plant essential oils to protect jujube fruits from infestation by jujube fruit flies, providing a safer alternative for the environment and humans.

Materials and Methods

The study was conducted in a 1.25 hectares jujube orchard located in the Radwaniya area of Baghdad Governorate, Iraq, during the season of 2024. Three plant essential oil extracts (*Lavandula angustifolia*, *Cymbopogon flexuosus*, and *Cupressus sempervirens*) were sprayed, using a manual backpack sprayer, in addition to a control treatment consisting of water with Tween 20. The application commenced in November of the same year, following the onset of infestation on jujube fruits. jujube trees of the 'Armouti' cultivar (*Ziziphus mauritiana* Lam.), aged 4-5 years with similar heights of approximately 2 meters, were selected for the study.

Identification of fruit fly species and their percentage

Infested fruits were collected from the replicates of the control treatment and placed in plastic containers filled with sterilized soil. The containers were covered with tulle fabric and kept in the laboratory at temperatures ranging from 25-30 °C until adult emergence for species identification. Emerged adults were preserved in test tubes containing 70% ethyl alcohol and sent to the Natural History Museum Research Center/University of Baghdad for morphological identification.

Method of plant oil extraction and concentrations used

During March and April of 2024, we collected the aerial parts of *C. flexuosus* (lemongrass) and *C. sempervirens* (cypress), along with flower buds of *L. angustifolia* (lavender), from the gardens of the University of Baghdad. After collection, plant parts were cleaned, washed with tap water, dried at room temperature, and stored under clean conditions until use.

Essential oils were separated from the dried leaves of lemongrass and cypress trees and lavender flower buds. Oils were extracted from 250 g of dried plant material using the hot water distillation method with a Cleavenger apparatus. Steam was passed through a condenser, and the condensed liquid was collected. The oil was separated from water using a separating funnel, and the extracted essential oil was stored in sealed specialized bottles at 4°C (Ali *et al*., 2020; Abed *et al*., 2022).

The concentrations used for the treatments included 1% lavender oil, 0.5% lemongrass oil (the concentration was adjusted from 1% to 0.5% after observing tissue burns on fruits during an initial preliminary spray before the main experiment), and 1% cypress oil, while the control treatment consisted solely of water mixed with the emulsifier Tween 20.

The dose of the emulsifier Tween 20 was fixed at 3 ml/L for all treatments, regardless of oil concentrations, to ensure reduced surface tension of water and improved adhesion on the plant, based on the study by Pavela and Novák (2024). The essential oil extracts were then diluted with water to achieve the desired concentration for each oil.

Preliminary experimental spray of oils

A preliminary experimental spray using a manual backpack sprayer on 4-5 years old fruiting jujube trees was conducted to test the plants' sensitivity to these concentrations. The spray revealed that lemongrass oil at 1% (10 ml/L) caused tissue burns on the fruits. Consequently, the concentration was reduced to 0.5% (5 ml/L), at which no burns were observed.

Experimental design of essential oils

Twelve 'Armouti' jujube trees were selected and divided into 3 groups (blocks), with 4 trees in each group. The trees were randomly sprayed with treatments including lavender oil, lemongrass oil, cypress oil, and the control treatment (water with Tween 20 only). This technique meant that each treatment was sprayed on 3 trees (replicates) randomly distributed within each block, following a Randomized Complete Block Design (RCBD). Trees were marked with distinct labels for each treatment. A 5-liter backpack sprayer was used to apply the essential oil extracts. Spraying was conducted to ensure complete coverage of all vegetative and fruiting parts of the trees.

Evaluation of essential oil efficacy

Infestation rates for all treatments were recorded by randomly collecting 25 fruits per tree from the four directions of the tree, specifically 5 fruits from each of the four sides, in addition to 5 fallen fruits. These were placed in nylon bags for laboratory examination.

The percentage of fruit infestation was determined by examining the fruits both externally and internally for oviposition puncture, presence of larvae, larval exit holes, partial fruit rot, and discoloration due to infestation.

Assessments were performed one day before spraying and 1, 3, 7, and 14 days after each spray, for both the first and second sprays, for each replicate. The relative efficacy of the extracts was calculated and then corrected using Henderson and Tilton's formula (Henderson and Tilton, 1955):

$$\% \text{ Reduction} = \left(1 - \frac{n \text{ in Co before} \times n \text{ in T after}}{n \text{ in Co after} \times n \text{ in T before}}\right) \times 100$$

Where: n = number of infested fruits, T = number of infested fruits in the treated group, Co = number of infested fruits in the control group.

Statistical analysis

Results were analyzed using an analysis of variance (ANOVA) according to the Randomized Complete Block Design (RCBD). Means of percentages were compared using the Least Significant Difference (L.S.D) at the 0.05 probability level, utilizing Genstat 15th Edition software (Payne *et al.*, 2012).

Results and Discussion

Identification of fruit fly species and their percentage

The morphological identification results from the Natural History Museum Research Center–University of Baghdad indicated the presence of two species of Jujube fruit flies in the submitted samples: *C. incompleta* and *C. vesuviana.*

Regarding the species composition within the untreated control group, the results revealed a clear dominance of *C. incompleta*, which accounted for 72% of the emerged adults, compared to 28% for *C. vesuviana*. This distribution indicates that *C. incompleta* was the predominant species in the study area during the trial period.

Relative efficacy of plant essential oils

Table 1 indicates that lavender oil was the most effective among the essential oils in the first spray, achieving a high efficacy of 85.04% after one day and an overall relative efficacy of 64.60%. This suggests its excellent immediate control capability. Lemongrass oil followed in second place with an average relative efficacy of 52.78%, while cypress oil was significantly less effective, at 28.79%. The efficacy of all oils decreased over time, starting at 70.59% one day after spraying and gradually dropping to 25.93% after 14 days. The overall average efficacy for the first spray was 48.72%, which was lower than that of the second spray's efficacy of 52.52% (Table 2). Statistical differences between the oils and time intervals were significant when compared to the L.S.D at the 0.05 level.

Table 2 shows that the second spray of essential oils led to a slight improvement in their efficacy compared to the first spray. Lavender oil maintained the highest level of efficacy at 67.73%, indicating the

Table 1: *Relative efficacy of different plant essential oils following the first spray application against fruit flies C. incompleta and C. vesuviana*

Essential oils	Period after treatment (day)				Average of Oils	Overall spray average
	1	3	7	14		
Lavender oil	(a)85. 04	(b)74. 53	(c)61.22	(d)37.62	(A)64.6	48.72
Lemongrass oil	(a)78. 62	(b)58. 19	(c)48.73	(d)25.56	(B)52.78	
Cypress oil	(a)48. 11	(b)32. 39	(c)20.03	(d)14.61	(C)28.79	
Average of period	(W)70. 59	(X)55 .04	(Y)43.32	(Z)25.93		
L.S.D at 0.05	Averages of period 4.136	Average of Oils 3.582	Oils × Period 7.164			

Table 2: *Relative efficacy of different plant essential oils following the second spray application against fruit flies C. incompleta and C. vesuviana*

Essential oils	Period after treatment (day)				Average of oils	Overall spray average
	1	3	7	14		
Lavender oil	(a)86.43	(b)77.98	(c)65.49	(d)41.01	(A)67.73	52.52
Lemongrass oil	(a)81.19	(b)62.67	(c)52.78	(d)28.55	(B)56.30	
Cypress oil	(a)54.32	(b)36.9	(c)23.41	(d)19.49	(C)33.53	
Average of period	(W)73.98	(X)59.18	(Y)47.23	(Z)29.68		
L.S.D at 0.05	Averages of period 5.068	Average of Oils 4.389	Oils × Period 8.778			

persistence of its positive effect. Lemongrass oil and cypress oil also showed slight improvements, with average efficacies of 56.30 and 33.53%, respectively. This evidence confirms that repeated applications of essential oils can increase their overall control efficacy. Furthermore, differences between the extracts and time intervals remained significant when compared to the L.S.D at the 0.05 level, indicating consistent differences in performance.

Identification of fruit fly species and their percentage

The results showed the presence of two types of fruit flies, *C. incompleta* and *C. vesuviana*, with the first type being more dominant than the second in the area where the study was conducted in Baghdad Governorate. This is consistent with the results of Al-Jboory and Hermize (2025a), who indicated the presence of both species in Iraq, specifically in Baghdad Governorate. The results did not align with what Tahr (2023) indicated in Basrah, Iraq, as she recorded the presence of the species *C. incompleta* and the peach fruit fly *B. zonata* but did not record the presence of the species *C. vesuviana* in her study, which involved a survey of the types of flies infecting jujube fruits in Basrah and the implementation of some control applications on them. The absence of the species *C. vesuviana* in Basrah Governorate and its presence in our study in Baghdad Governorate may be due to the differences in environmental conditions between the two regions.

Comparative efficacy of plant essential oils as eco-friendly alternatives for fruit fly management

Analysis of the results presented in Table 1 and Table 2 indicates that lavender oil exhibited superior efficacy compared to other tested oils in reducing infestation rates in jujube fruits. This can be attributed to lavender oil's possession of certain insecticidal properties, including contact mortality, repellency, and oviposition deterrence. Ouarhacha *et al*. (2022) highlighted the contact insecticidal effect of lavender oil, as well as its deterrent effect on adult female oviposition. Specifically, lavender oil extracted from *Lavandula coronopifolia* demonstrated these effects when tested against the Mediterranean fruit fly *Ceratitis capitata*, a major citrus pest belonging to the family Tephritidae, the same family as the Jujube fruit fly. Their study revealed that lavender oil caused a 75% mortality rate in adult insects when exposed to a concentration of 150 ml/gm after one day of testing. Furthermore, it significantly deterred adult females from ovipositing on fruits, achieving a 94% oviposition deterrence at a concentration of 55 ml/gm compared to the control treatment.

Similarly, results in Table 1 and Table 2 showed that lemongrass oil was effective in reducing the rates of infested jujube fruits. This efficacy may stem from lemongrass oil's contact insecticidal, repellent, and oviposition-deterrent effects on adult insects. Perwita *et al*. (2020) investigated the repellent and oviposition-deterrent properties of lemongrass oil against the fruit fly *Bactrocera carambolae*, another pest belonging to the Tephritidae family, under laboratory conditions. In their study, lemongrass oil was incorporated into an edible film composed of chitosan, polyethylene glycol, and carboxymethyl cellulose. This film, when tested on adult females, demonstrated a repellency effect and prevented oviposition on fruits with an efficacy of 85.412%.

Furthermore, Negm *et al*. (2022) highlighted the contact insecticidal effect of lemongrass oil on adult fruit flies in their study of the peach fruit fly *B. zonata*. Lemongrass oil alone, at LC25, resulted in a 13.33% mortality rate for male *B. zonata* and 3.33% for females after 24 hours of exposure. The study also noted that combining lemongrass oil with the bio-pesticide Spinosad significantly increased Spinosad's efficacy in adult mortality and enhanced its negative impacts on the insect's life parameters. This suggests that lemongrass oil can be utilized not only as a standalone biopesticide but also as a synergistic agent to boost the efficiency of other eco-friendly pesticides like Spinosad. This opens up new avenues for sustainable integrated pest management programs.

As for cypress oil, the results indicated it showed the lowest efficacy among the oils used in our study. Nevertheless, cypress oil demonstrated some effectiveness in reducing infestation rates due to its insect repellent properties. Augull *et al*. (2023) reported that cypress oil at 50,000 ppm had a repellent effect on adult *Vespa orientalis* wasps up to 45 meters when sprayed on honeybee hive entrances. Additionally, the researcher noted that cypress oil did not cause harm to bees when sprayed at the entrances of beehives. The low efficacy observed for cypress oil in our study might be attributed to the low concentration used.

The findings of this study confirms that repeated applications of essential oils can increase their overall control efficacy. Furthermore, differences between the extracts and time intervals remained significant when compared to the L.S.D at the 0.05 level, indicating consistent differences in performance.

The significant reduction in fruit fly infestation observed in this study aligns with recent findings by Al-Jboory and Hermize (2025b), who emphasized the increasing necessity of botanical pesticides in integrated pest management (IPM) programs in Iraq. Furthermore, the efficacy of the tested essential oils can be attributed to their complex chemical profiles, particularly the presence of bioactive constituents such as terpenes and phenolic compounds. This is supported by the recent work of Tabanca *et al.* (2025), who demonstrated that specific essential oil components α-thujone and α, β-thujone found in *Artemisia absinthium* L. exhibit significant toxicity and behavioral impacts on Tephritid fruit flies, including *Ceratitis capitata* and *Anastrepha suspensa*. Their findings underscore the potential of essential oils not only as repellents but also as toxic agents that can be effectively integrated into comprehensive sustainable pest management strategies under field conditions.

Conclusions and Recommendations

This research highlights the development and application of more effective and sustainable pest control methods with reduced environmental impact compared to conventional chemical pesticides. These methods target the fruit flies, *C. incompleta* and *C. vesuviana*, which cause significant losses to Jujube tree production in Iraq. Our findings demonstrate the efficacy of lavender oil, lemongrass oil, and cypress oil as safe, effective, and natural alternatives. This, in turn, reduces sole reliance on traditional chemical pesticides for control. The observed increase in oil efficacy across all treatments after the second spray indicates the necessity of multiple applications in pest management programs. This approach ensures sustained protection of agricultural yields while safeguarding the environment and human health from harmful exposure. Furthermore, future studies are crucial to determine the optimal and most effective dosages for all essential oil extracts and to investigate their long-term effects on non-target organisms.

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Novelty Statement

This study represents the first investigation to evaluate the relative efficacy of essential oils from *Lavandula angustifolia* (lavender), *Cymbopogon flexuosus* (lemongrass), and *Cupressus sempervirens* (cypress) against the fruit flies, *C. incompleta* and *C. vesuviana*, on Jujube tree fruits under field conditions in Iraq. The results provide helpful information about incorporating the mentioned oils into integrated pest management programs, aiming to reduce reliance on conventional chemical pesticides and mitigate their environmental harm.

Author's Contribution

Eyas Yaseen Al-Jboory: Performed the experiment and recorded and analyzed the data and write-up of this manuscript.
Feryal Bahjat Hermize: Conceived the research idea, provided resources and supervised the project.

Generative AI and AI-assisted technology statement
The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

Conflict of interest
The authors have declared no conflict of interest regarding the submission and publication of this research work.

References

Abed, I.J., A.R. Hussein, G.A. Abdulhasan and A.N. Dubaish. 2022. Microbiological effect of lemongrass *Cymbopogon citratus* and spearmint *Mentha spicata* essential oils as preservatives and flavor additives in yogurt. Iraqi J. Sci., 63(7): 2839-2849. https://doi.org/10.24996/ijs.2022.63.7.8

Akbar, M.S., F. Sajjad, M. Afzal, M. Luqman, M.A.

Riaz and M.Z. Majeed. 2021. Field evaluation of promising botanical extracts, plant essential oils and differential chemistry insecticides against subterranean termites *Odontotermes obesus* (Isoptera: Termitidae). Sar. J. Agric., 37(1): 120-127. http://dx.doi.org/10.17582/journal.sja/2021/37.1.120.127

Ali, H.B., I.J. Abed, R.S. Augul and H.Y. Fadhil. 2020. Insecticidal activity of *Eucalyptus* sp. volatile oil against backswimmer insect *Anisops sardea*. Iraqi J. Agric. Sci., 51(1): 470-482. https://doi.org/10.36103/ijas.v51i1.946

Al-Jboory, E.Y. and F.B. Hermize. 2025a. Morphological and molecular study of two species of *Carpomya* Costa, 1854 (Diptera, Tephritidae) infesting Sidr fruits in Baghdad, Iraq. *Bull.* Iraq Nat. Hist. Mus., 18(4): 917-928. https://doi.org/10.26842/binhm.7.2025.18.4.0917

Al-Jboory, E.Y. and F.B. Hermize. 2025b. Evaluation of the relative efficiency of some insecticidal performance in controlling Ziziphus fruit flies, *Carpomya incompleta* (Becker) and *C. vesuviana* Costa (Diptera: Tephritidae). IOP Conf. Ser.: Earth Environ. Sci., 1549(1): 012174. IOP Publishing. https://doi.org/10.1088/1755-1315/1549/1/012174

Al-Masudey, A.D. and A.A. Al-Yousuf. 2013. Effect of jujube fruit cultivars on chemical control of jujube fruit fly *Carpomya incompleta*. Kufa J. Agric. Sci., 5(1): 111-124.

AlWahaibi, A.K. and S.M. AlAnsari. 2024. Fruit flies fauna, bio-ecology, economic importance and management with an overview of the current state of knowledge in the Sultanate of Oman and the Arabian Peninsula. J. Agric. Mar. Sci., 29(1): 15-55. https://doi.org/10.53541/jams.vol29iss1pp15-55

Al-yousif, A. and M.Z. Al-Miahy. 2007. Effect of calcium on Jujube *Ziziphus* sp. fruit growth and their resistance to jujube fruit fly *Carpomyia incompleta*. J. Kerbala Univ., 3(2): 106-113.

Al-Zaydi, R.A. and A.I. Al-Jibouri. 2025. Diagonal growth curve for (*Ziziphus spina christi*) growing in governorate Anbar. Iraqi J. Agric. Sci., 56(2): 850-857. https://doi.org/10.36103/bw4j0y71

Augul, R.S., H.H. Al-Saffar and I.J. Abed. 2023. Evaluation the Effect of some Plant Extracts in Controlling the Oriental Hornet *Vespa orientalis* Linnaeus, 1771 Near the Apiaries. p. 012016. In: *IOP Conference Series:* Earth Environ. Sci., Vol. 1213, No. 1. IOP Publishing. https://doi.org/10.1088/1755-1315/1213/1/012016

Aziz, F., S. Al-Janabi and R. Na'ama. 2014. Laboratory studies on the effects of the entomopathogenic fungus *Beauveria bassiana* (Bals.) Vuill, on the Homaira insect, *Batrachedra amydraula* (Lepidoptera: Cosmopterygidae). Iraqi J. Sci., 55(2B): 643-648. https://ijs.uobaghdad.edu.iq/index.php/eijs/article/view/11744

Ciceoi, R., I. Dobrin, E.Ş. Mardare, E.D. Dicianu and F. Stănică. 2017. Emerging pests of *Ziziphus jujuba* crop in Romania. Sci. Pap. Ser. B. Hortic., 61.

Ehler, L.E. 2006. Integrated pest management (IPM): definition, historical development and implementation, and the other IPM. Pest Mgt. Sci., 62(9): 787-789.

Farrar, N., R. Golestaneh, H. Askari and M.H. Assareh. 2009. Studies on parasitism of *Fopius carpomyie* (Silvestri) (Hymenoptera: Braconidae), an egg-pupal parasitoid of Ber (Konar) fruit fly, *Carpomyia vesuviana* Costa (Diptera: Tephritidae), in Bushehr - Iran. p. 431-438. In: *Acta Horticulturae*. Vol. 840. Int. Soc. Hortic. Sci., https://doi.org/10.17660/ActaHortic.2009.840.61

Garrido-Jurado, I., E. Quesada-Moraga and M. Yousef-Yousef. 2022. *Zizyphus* fruit fly (*Carpomya incompleta* (Becker), Diptera: Tephritidae) is expanding its range in Europe. Span. J. Agric. Res., 20(4): e10SC02. https://doi.org/10.5424/sjar/2022204-18961

Hasan, H.R. and J.A. Zainulabdeen. 2022. Screening, extraction, and quantification of melatonin in waste of some plants. Iraqi J. Sci., 1874-1884. https://doi.org/10.24996/ijs.2022.63.5.2

Henderson, C.F. and E.W. Tilton. 1955. Tests with acaricides against the brown wheat mite. J. Econ. Entomol., 48(2): 157-161.

Ismail, M., A.B.M. Raza, Z. Qasim, M.Z. Majeed. 2023. Field evaluation of different pest management strategies against citrus fruit fly, *Bactrocera dorsalis* Hendel. Punjab University J. Zool., 38(1): 59-64.

Jabbar, A.S. 1996. Study of the life and ecology of jujube fruit flies and their behavior in Basrah. PhD thesis, University of Basrah, Basrah, Iraq. (In Arabic).

Jia, F., B. Wang, H. Ma, C. Bai and Y. Zhang. 2025. Research progress on extraction, separation, structure, and biological activities of polysaccharides from jujube fruit (*Ziziphus jujuba* Mill.): a review. Front. Chem., 13: 1581947. https://doi.org/10.3389/fchem.2025.1581947

Kapoor, V.C. 2002. Fruit fly pests and their present status in India. p. 23-33. In: Proceedings of the 6th International Symposium on Fruit Flies of Economic Importance, Stellenbosch, South Africa. Isteg Scientific.

Kavin, P., B. Usharani, P.D. Kamalajayanthi, K. Suresh, S. Sandeep, K.N. Richard and M.L. Mini. 2024. Advanced approaches for managing ber fruit fly (*Carpomyia vesuviana* Costa) in Indian jujube (*Ziziphus mauritiana* Lamk.) orchards. Plant Sci. Today., 11: 5479. https://doi.org/10.14719/pst.5479

Korneyev, V.A., R.I. Mishustin and S.V. Korneyev. 2017. The Carpomyini fruit flies (Diptera: Tephritidae) of Europe, Caucasus, and Middle East: new records of pests, with improved keys. Zoodivers., 51(6): 453.

Lakra, R.K. and Z. Singh. 1984. Calendar of losses due to ber fruit fly, *Carpomyia vesuviana* Costa (Diptera: Tephritidae) in different *Zizyphus* spp. Haryana. Ind. J. Entomol., 46: 261-264.

Lakra, R.K. and Z.S. Zile Singh. 1985. Seasonal fluctuations in incidence of ber fruitfly *Carpomyia vesuviana* Costa (Diptera: Tephritidae) under agro-climatic conditions of Hisar. Haryana Agric. Univ. J. Res., 15(1): 42-50.

Liu, M., J. Wang, L. Wang, P. Liu, J. Zhao, Z. Zhao, S. Yao, F. Stănică, Z. Liu, L. Wang, *et al*. 2020. The historical and current research progress on jujube–a superfruit for the future. Hortic. Res., 7. https://doi.org/10.1038/s41438-020-00346-5

Majeed, M.Z., M.S. Akbar, M. Afzal, M. Mustaqeem, M. Luqman, I. Asghar and M.A. Riaz. 2020. Comparative bioefficacy of indigenous phytoextracts against subterranean termites *Odontotermes obesus* Ramb. (Isoptera: Termitidae). Punjab Univ. J. Zool., 35(2): 229-238. https://doi.org/10.17582/journal.pujz/2020.35.2.229.238

Majeed, M.Z., M.I. Nawaz, R.R. Khan, U. Farooq and C.S. Ma. 2018. Insecticidal effects of acetone, ethanol and aqueous extracts of *Azadirachta indica* (A. Juss), *Citrus aurantium* (L.), *Citrus sinensis* (L.) and *Eucalyptus camaldulensis* (Dehnh.) against mealybugs (Hemiptera: Pseudococcidae). Trop. Subtrop. Agroecosyst., 21(3): 421-440.

Negm, A.A.K.H., D.A.E. Elsayed, A.M. El Shafei, A.M.Z. Mosallam and S.A.M. Maamoun. 2022. Synergistic activity of lemongrass and sesame oils on spinosad: A new approach to control the peach fruit fly; *Bactrocera zonata* (Saunders, 1841), referring to their effect on the adult biological and protein aspects. Pol. J. Entom., 91(2): 84-93. https://doi.org/10.5604/01.3001.0015.9179.

Ouarhach, A., L. Ait Said, H. Aboussaid, I. Ghalbane, S. El Messoussi and A. Romane. 2022. Evaluation of insecticidal activity of *Lavandula coronopifolia* essential oil against the Mediterranean fruit fly *Ceratitis capitata* Wiedemann (Diptera: Tephritidae). S. Afr. J. Bot., 149: 748-753. https://doi.org/10.1016/j.sajb.2022.05.026

Pavela, R. and M. Novák. 2024. Insecticidal activity of some major essential oil components against *Metopolophium dirhodum* and its predators. Plant., 13(13): 1863. https://doi.org/10.3390/plants13131863

Payne, R.W., S.J. Welham and S.A. Harding. 2012. A Guide to REML in Genstat® for WindowsTM. 15th ed. VSN International, Oxford, UK.

Perwita, M.C.S., T.D. Wahyuningsih, E. Astuti and D. Pranowo. 2020. Synthesis edible film chitosan/polyethylene glycol/carboxymethylcellulose with lemongrass oils as insect ovipositing repellent. Key Eng. Mater., 840: 142-148. https://doi.org/10.4028/www.scientific.net/KEM.840.142

Singh, S. 2008. Management of Ber fruit fly, *Carpomyia vesuviana* Costa (Diptera: Tephritidae) through cultural and chemical methods. M.Sc. thesis, CCS Haryana Agricultural University, Hisar, India.

Tabanca, N., K.R. Cloonan, X. Yang, A. Baldemir Kılıc and B. Demirci. 2025. Chemical variability for authenticated and commercial *Artemisia absinthium* L. essential oils with thujones on tephritid fruit flies: Mediterranean fruit fly *Ceratitis capitata* (Wiedemann) and Caribbean fruit fly *Anastrepha suspensa* (Loew). Front. Plant Sci., 16: 1674428. https://doi.

org/10.3389/fpls.2025.1674428

Tahir, H.M. 2023. Monitoring of fruit fly populations and management on jujube tree fruits in Basrah Governorate. M.Sc. thesis, University of Basrah, Basrah, Iraq. (In Arabic).

Vadivelu, K. 2014. Biology and management of ber fruit fly, *Carpomyia vesuviana* Costa (Diptera: Tephritidae): A review. Afr. J. Agric. Res., 9(16): 1310-1317.

White, I.M. and M.M. Elson-Harris. 1992. Fruit flies of economic importance: their identification and bionomics. CAB International, Wallingford, UK.

Yadav, J., R.K. Gaur, Y. Kumar, N. Kumari, S.S. Yadav, M. Khan and S. Yadav. 2020. Evaluation of antixenotic and allelochemical traits of ber (*Ziziphus mauritiana* Lamk.) fruits as source of host plant resistance against fruit fly (*Carpomyia vesuviana* Costa) (Diptera: Tephritidae) in semi-arid region of India. Phytoparasitica., 48(4): 607-620.

Yunis, M.I. 2014. Effect of orange peel (*Citrus sinensis*) (L) extracts and powder on confused flour beetle *Tribolium confusum* (Coleoptera: Tenebrionidae). Iraqi J. Sci., 55(3B): 1164-1169.

Zakari-Moussa, O., A. Ratnadass, J.F. Vayssières, A. Nikiema, D. Fatondji, H. Salha, K. Aboubacar, P. Ryckewaert and D. Pasternak. 2012. GF-120 effects on fruit fly species (Diptera: Tephritidae) in Sahelian agroforestry-based horticultural cropping systems. Fruit., 67(5): 333-339. https://doi.org/10.1051/fruits/2012025

Zhao, Y., J. Yang, J. Ren, Y. Hou, Z. Han, J. Xiao and Y. Li. 2020. Exposure level of neonicotinoid insecticides in the food chain and the evaluation of their human health impact and environmental risk: An overview. Sustain., 12(18): 7523. https://doi.org/10.3390/su12187523