تأثـــــير تبخير وسمية بعض الزيـــــــوت العطريـــــــة على الذبابــــة البيضاء

رشا عبد الكريم الدرســــــي ـ كلية التربيــــة ـ جامعة درنة

الملخص :

هدفت الدراسة الحالية إلى مكافحة الذبابة البيضاء من خــــلال برامج مكافحة الآفات المتكاملة الناجحة الآمنة بما يكفي للإنسان والبيئة، عن طريق استخدام بعض الزيوت العطرية كبدائل لمبيدات الآفات، تم فحص ثلاثة زيوت عطرية (البردقوش والنعناع البلدي والريحان البلدي) مستخلصة من العائلة الشفوية لمعرفة سمية التبخير ضد الذبابة البيضاء في ظـــروف معملية خلال الفترة من أكتوبر 2021. لتحديد سمية التبخير، تم اختبار الذباب الأبيض البالغ في أوعية زجاجية محكمة الإغلاق تحتوي على زيت عطري على ورق ترشــــيح. تم تسجيل معدلات الوفيات بعد التعرض لمدة 24 ، 48 ، 72 ساعة بتركيزات مختلفة (1.5 ، 3 ، 5 جزء في المليون) من جميع الزيوت العطرية. كان لزيت البردقوش أقوى مفعول تبخير بين الزيوت المختبرة ، حيث بلغ معدل الوفيات 57.33٪ ، 64.00٪ ، 72.00٪ ، بتركيز 1.5 جزء في المليون ، 66.67٪ ، 74.67٪ ، 83.33٪ بتركيز 3 جزء في المليون و 76.67٪ و 85.33٪ و 95.33٪ بتركيز 5 جزء في المليون على التوالي. كان معدل الوفيات في الكنترول 0.0٪ بعد 24 و 48 و 72 ساعة من التعرض على التوالي ، يليها زيت النعناع البلدي مما تسبب في معدلات وفيات تراوحت بين 57.33٪ و 64.00٪ و 72.00٪ بتركيز 1.5 جزء في المليون، 66.67٪ ، 74.67٪ ، 83.33٪ بتركيز 3 جزء في المليون و 76.67٪ و 85.33٪ و 95.33٪ بتركيز 5 جزء في المليون على التوالي. احتل الزيت العطري لنبات الريحان المرتبة الثالثة في أعلى مستويات السمية حيث سجلت معدل وفيات بلغت 52.00٪ و 58.00٪ و 65.33٪ بتركيز 1.5 جزء في المليون و 62.00٪ و 69.33٪ و 78.00٪ بتركيز 3 جزء في المليون و 72.67٪. و 81.33٪ و 90.67٪ بتركيز 5 جزء في المليون على التوالي. كان معدل الوفيات في الكنترول 0.0٪ بعد 24 و 48 و 72 ساعة من التعرض على التوالي من التعرض للزيوت العطرية الثلاثة. تم زيادة معدل وفيات البالغين بالتزامن مع زيادة تركيز الزيوت المختبرة. الخلاصة : تم

الاستنتاج بأن الزيوت المختبرة يمكن استخدامها كبدائل للمبيدات في برنامج المكافحة المتكاملة للآفات.

Effect of fumigation and toxicity of some essential oils on whitefly (*Bemisia tabaci*)

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ABSTRACT

The present study aimed to control *Bemisia tabaci* through suitable successful Integrated Pest Management programs (IPMs) safe enough to man and environment, by inserting some plant oils as alternatives or synergists for pesticides. Three essential oils (*Marjoram Origanum*, *Mentha spicata* and *Ocimum basilicum*) extracted from Lamiaceae family were examined for their contact and fumigant toxicity against *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) under laboratory conditions during Oct. 2021. To determine fumigant toxicity, adult whiteflies were tested in airtight glass jars containing essential oil on filter paper. Mortality rates were recorded after 24, 48, and 72 h of exposure, at different concentrations (1.5, 3 and 5 ppm) of all essential oils . Essential oil from *Marjoram Origanum* plants was the strongest fumigant action among the tested oils, with mortality rates of 57.33%, 64.00%, and 72.00%, at concentration of 1.5 ppm, 66.67%, 74.67%, and 83.33%, at concentration of 3 ppm and 76.67%, 85.33%, and 95.33%, at concentration of 5 ppm, respectively. Mortality rates in the control were 0.0% at three ranged from 24, 48, and 72 h of exposure respectively, followed by essential oil of *Mentha spicata* causing mortality rates ranging from 57.33%, 64.00%, and 72.00%, at concentration of 1.5 ppm, 66.67%, 74.67%, and 83.33%, at concentration of 3 ppm and 76.67%, 85.33%, and 95.33%, at concentration of 5 ppm, respectively. essential oil of *Ocimum basilicum* had the third highest toxicity level which causing mortality rates of 52.00%, 58.00%, and 65.33%, at concentration of 1.5 ppm, 62.00%, 69.33%, and 78.00%, at concentration of 3 ppm and 72.67%, 81.33%, and 90.67%, at concentration of 5 ppm, respectively. Mortality rates in the control were 0.0% at three ranged from 24, 48, and 72 h of exposure with all three essential oils. The adult mortality was increased in conjunction with increasing dose of tested oils. Lethal concentrations (LC_{50}) of all plant extracts were also estimated with serial dilutions of the plant extracts. For aqueous extracts, those of *Marjoram origanum*, *Mentha spicata* and *Ocimum basilicum*, however, clear from the obtained results shown that *Marjoram origanum* oil was the most potent against whitefly adults with LC_{50} value of 0.538 ppm**,** followed by *Mentha spicata* oil with LC_{50} value of 0.580 ppm and *Ocimum basilicum* oil with LC50 values of 0.631 ppm**,** after 72 hr, of all three oils, respectively. Conclusion: It is concluded that the tested oils may use as insecticide alternatives in an integrated pest management program for the subject pest.

Keywords: Whitefly (*Bemisia tabaci*), Essential oils, Lamiaceae family.

INTRODUCTION

The whitefly (*Bemisia tabaci* Genn.) (Hemiptera: Aleyrodidae) is a widely distributed and highly harmful plant pest species. The management of *B. tabaci* has been typically carried out by chemical pesticides. In the last decade however, there has been an increasing interest in natural products, particularly those of plant origin, to control this pest species **(Cruz-Estrada *et al.*, 2013).** It is an important insect pest, causing severe damage to agricultural Crops **(Sadeh *et al.*, 2017)**.

The whitefly *Bemisia tabaci* is a cosmopolitan, broad-spectrum phloem-feeding insect that feeds on more than 900 plant hosts. *B. tabaci* is considered a species complex, containing over 35 different biotypes or cryptic species **(De Barro *et al.*, 2011 and Liu *et al.*, 2012)**.

The adaptation of *B. tabaci* to a specific host plant is considered biotype dependent **(Chiel *et al.*, 2007)**. Within the *B. tabaci* species complex, the Middle East-Asia Minor 1 species (MEAM1, previously known as the `B biotype') and the Mediterranean species (MED, previously known as the `Q biotype') are the two most frequently encountered in the last 20 years **(De Barro *et al.*, 2011, Liu *et al.*, 2012 and Firdaus *et al.*, 2013).**

Consequently, they have replaced most of the other indigenous whitefly species in many regions worldwide, including China, southern Africa and Asia **(Hu *et al.*, 2011).** Epidemics of begomoviruses are usually associated with whitefly outbreaks, which act as vectors of viruses from this group **(Czosnek and Ghanim 2002).** Therefore, limiting the invasive spread of whiteflies is essential in begomoviral disease control worldwide. The widespread utilization of synthetic pesticides poses hazards for both the environment and human health due to their toxicity and poor biodegradability **(Inbar and Gerling 2008).**

Therefore, farmers need alternative and safe agricultural methods, including the use of natural products, to achieve more sustainable production strategies. Recently, in plant protection, there has been a growing interest in botanical pesticides, which contain active ingredients composed of natural compounds such as essential oils (EOs) **(De Barro *et al.*, 2011 and Liu *et al.*, 2012)**.

Chemical insecticides have many harmful effects, including as foodborne residues and environmental contaminants, as well as side effects on natural enemies and serious risks for human health. The use of plant-derived essential oils (EOs) as effective bio-agents has become an essential component of integrated pest management **(Sayed *et al.*, 2022)**.

Essential oils (EOs) derived from medicinal and aromatic plants are considered safe substances for the environment and human health. Thus, they can be used as active substances for pest control **(Brown *et al.*, 1995)**. In this regard, many investigations have stated the potential of EOs as natural pesticides for integrated pest management (IPM) **(Inbar and Gerling 2008).** EOs derived from different plants exhibit unique medicinal and botanical activities that, upon suitable application, may not cause negative effects for animal and human health. The modes of action of EOs on pests include various methods, such as contact toxicity, repellent, antifeedant, fumigant, and growth-inhibiting activity **(Firdaus *et al.*, 2013)**. The main benefit of botanical pesticides is that they provide residue-free food and a safe environment. Moreover, they affect only target insects and do not have considerable negative effects on the beneficial insects such as pollinators and natural enemies **(Crowder *et al.*, 2010)**. Plant EOs is potentially valuable for pest control. They performed in different ways on various insect pests and can be applied to many crops or stored products **(Crowder *et al.*, 2010 and Delatte *et al.*, 2010).** EOs is secondary metabolites that play an important role in protecting plants from herbivores or pathogens **(Jiu *et al.*, 2007)**. EOs contain various volatiles, low-molecular-weight phenolics, and terpenes. The major families of plants from which EOs are extracted include Lamiaceae, Myrtaceae, Asteraceae and Lauraceae. EOs have insecticidal, repellent, and growth-reducing effects on various species of insects. They have been utilized viably to control preharvest and postharvest phytophagous insects **(Firdaus *et al.*, 2013)**.

Generally, they are composed of complex mixtures of phenols, monoterpenes, and sesquiterpenes, and they have demonstrated antifeedant, insecticidal, repellent, deterrent, and insect growth regulation effects **(Firdaus *et al.*, 2013 and Horowitz and Ishaaya 2014)**.

The Lamiaceae family includes approximately 220 genera and 3300 species. The genus Mentha also belongs to the Lamiaceae family and includes more than 25 species. *Mentha piperita* and *M. longifolia*, commonly known as peppermint and wild mint, respectively, are frequently cultivated in many countries for the production of EOs **(Czosnek and Ghanim 2002 and Yanishlieva *et al.*, 2006)**

This pest feeds on more than 1100 plant species belonging to various botanical families, 150 of which are important agricultural crops, including herbs from the family Lamiaceae **(Crowder *et al.*, 2010 and Horowitz and Ishaaya 2014).**

T. urticae feeds on plant tissue by piercing mesophyll cells and introducing a stylet between epidermal cells or through the stomata, injecting saliva to predigest the cell content and suck it up. Consequently, they cause biochemical and physiological changes in plant tissues, disrupt cell physiology, reduce photosynthesis and inject phytotoxic compounds. This results in the appearance of necrotic or yellowing spots and a darkening of the damaged plant organ, which usually turn yellow, gray and consequently fall off **(Yanishlieva *et al.*, 2006 and Sun *et al.*, 2013)**.

Herbivores feeding on plant tissues induce a broad range of defense responses, including the generation of reactive oxygen species (ROS) in cells. Oxidative stress usually results from excessive ROS production, which can cause severe oxidative damage to plants (**Regnault-Roger *et al.*, 2014).**

ROS comprise molecules such as superoxide, hydrogen peroxide, hydroxyl radicals, and singlet oxygen that play a prominent role in plant response to numerous stresses, including plant interactions with herbivores.

ROS may initiate destructive oxidative processes, such as chlorophyll bleaching, lipid peroxidation, protein oxidation, and nucleic acid damage, eventually leading to cell death **(Isman 2006).**
However, plants have antioxidant mechanisms to scavenge excess ROS and prevent cell damages (**Mahmoodi *et al.*, 2014 and Baldin *et al.***, **2014**).

Low molecular weight antioxidants (ascorbic acid, glutathione and tocopherols) and ROS-scavenging enzymes have the capacity to scavenge superoxides, hydroxyl radicals and singlet oxygen (**Deletre *et al.*, 2016 and Tosh and Brogan 2015).**These molecules are most commonly activated to protect stressed plant tissue against damage caused by overproduction of potentially harmful ROS **(Mena *et al.*, 2016).**

Generally, it seems that the greater the ROS balancing capacity, the higher the stress tolerance **(Mena *et al.*, 2016).** As documented, peroxidases catalyze oxidoreduction between H_2O_2 and various reductants, such as many phenolic compounds, they participate in the wall-building processes, such as suberization and lignifications, phenol oxidation, auxin catabolism and wound healing, as well as defense against the feeding of insects and mites **(Li *et al.*, 2014).** In turn, catalase directly converts H_2O_2 into N2o and O_2 **(Clavijo *et al.*, 2014).** While ROS molecules are necessary to orchestrate defense responses, their effect on plant-resistance/susceptibility to a particular herbivore is very specific and depends on plant-herbivore interaction **(Czosnek and Ghanim 2002).**

Therefore, the main objective of this research was to investigate effect of fumigation and toxicity of some essential oils on whitefly (*Bemisia tabaci*).

MATERIALS AND METHODS

A) Evaluation of the essential botanical oils against *Bemisia tabaci*

- **Essential oils tested used**

The tested botanical essential oils (EOs), their scientific names of plants they derived from, the used parts to extract oil from and their major constituents are listed **in Table (1).**

Table (1): The evaluated essential oils, the used plant parts and their major constituents

Essential Oil			The used part	Major constituents of the essential oil
Scientific Name	**Common Name**	**Family Name**		
Ocimum basilicum **L.**	**Sweet Basil**	**Lamiaceae**	**Leaves**	**Eugenol (75.1%)[1] Linalool (95%)[2]**
Marjoram Origanum **L.**	**Majorana**	**Lamiaceae**	**Leaves**	**4-Terpinenl (37.10 %) and p-Cymene (12.05 %)[3]**
Mentha spicata **L.**	**Spearmint**	**Lamiaceae**	**Leaves**	**Carvone (40.8% ± 1.23%) and limonene (20.8% ± 1.12%)[4]**

1(Joshi, 2013), 2(Dambolena *et al.*, 2010), 3(Sarer *et al.*, 1982) and 4 (Snoussi *et al.*, 2015).

- **Sample preparation and essential oil extraction**

The leaves were collected were washed and dried. Firstly, 100g of each sample were air dried at 25°C and submitted for 4 hours to steam-distillation using the Clevenger type-apparatus. The EOs of all dried samples (100g) was isolated by steam-distillation for 3 h, using a Clevenger-type apparatus according to the method recommended by the **British Pharmacopoeia (1988)**. The distillated essential oils (EO) were dried over anhydrous sodium sulphate and then stored in sealed glass vials at 4 to 5°C until use.

- **Bioassay (Fumigant Toxicity technique)**

Assay of the toxicity of botanical essential oils (EOs) were tested against *Bemisia tabaci* adults by using a modified fumigant toxicity assay as described by **Huang *et al*. (2000)**. A Whatman (#1) filter paper was treated with different concentrations of pure essential oil (a range of 1-300 µl/370 ml air). A piece of filter paper (2x2 cm for the concentrations of 1- 100 and 4x4 cm for the other ones of 150-300µl/370 ml air) was fixed in the center of the inner surface of a plastic lid of a 500ml glass jar. Each replicate (glass jar) implied 20 weevils. Mortality was assessed after 24, 48 and 72 hrs while the glass jar was still closed. There were three replicates of 50 *Bemisia tabaci* for each concentration and the untreated check (control). Mortality of treatments was adjusted according to **Abbott (1925)** formula if a proportion of control insects died during the experiment.

- **Statistical analysis**:

The toxicity data was analyzed using probit analysis to estimate the LC_{50} (Ldp line). Probit analysis was used to calculate LC_{50} (concentration causing 50% mortality) and fiducial limit (confidence intervals) for each evaluated essential oil that give a reasonable relation between dose and mortality (response) that could be used easily for probit analysis (**Finney, 1971)**. Toxicity Index (%) (based on LC_{50} after 72 hrs) was calculated according to **Sun (1950)**. Toxicity Index= LC_{50} of the most toxic oil /LC_{50} of the other compared oil. Meanwhile, the Ld-p lines of these essential oils were plotted. Meanwhile, All data were subjected to one-way analysis of variance (ANOVA) to compare the significance of differences between treatments. The least significant differences (L.S.D) were determined according to **Duncan (1955).**

RESULTS AND DISCUSSION

A) Laboratory experiments

- **Fumigant Toxicity**

The activity of the essential oils of *Marjoram origanum*, *Mentha spicata* and *Ocimum basilicum* were tested against adult of *B. tabaci*. The data indicate that all of the essential oils showed contact toxicity to *B. tabaci* during all experimental periods in the laboratory test.

Among the tested oils, *Marjoram origanum* oil had the highest toxicity level at 24, 48, and 72 h of exposure, at different concentrations (1.5, 3 and 5 ppm) causing mortality rates of 57.33%, 64.00%, and 72.00%, at concentration of 1.5 ppm, 66.67%, 74.67%, and 83.33%, at concentration of 3 ppm and 76.67%, 85.33%, and 95.33%, at concentration of 5 ppm, respectively. Mortality rates in the control were 0.0% at three ranged from 24, 48, and 72 h of exposure **(Table 2).**

Plant extracts are currently being studied as an ecologically friendly alternative to manage plant pests. Studies on botanical insecticides against *B. tabaci* have focused particularly on essential oils of different plants, such as

Thymus vulgaris, *Allium cepa*, *Allium sativum*, *Satureja hortensis*, *Achillea biebersteinii*, *Cinnamomum verum*, *Syzygium aromaticum*, *Alkanna strigosa*, *Ballota undulate*, *Galium longifolium*, *Lepidium sativum*, *Peganum harmala*, *Pimpinella anisum*, *Ruta chalepensi*s, *Retama raetam* and *Urtica pilulifera*, where 60-100% mortality has been reported **(Almazra'awi and Atteyyat, 2009, Ateyyat *et al.* 2009).**

Furthermore, natural enemies of *B. tabaci* suffer due to frequent pesticide applications **(Gonzalez-Zamora *et al.*, 2004),** which limits the ability of these natural enemies to manage heavy whitefly infestations. Thus, there is an urgent need to develop effective control alternatives that are environmentally friendly and harmless to humans and other non-target organisms. Plant essential oils have been shown to have potential for development as eco-friendly alternative to chemical insecticides, and they may offer advantages over conventional insecticides in terms of low mammalian toxicity, rapid degradation, and local availability **(Regnault-Roger *et al.*, 2012).** Several essential oils have been reported to have multiple modes of action like repellent, contact, fumigant, and fungicidal properties **(Isman 2000).**

In this respect, essential oil of *Mentha spicata* showed maintained at the second highest toxicity level at 24, 48, and 72 h of exposure at different concentrations (1.5, 3 and 5 ppm) causing mortality rates ranging from 57.33%, 64.00%, and 72.00%, at concentration of 1.5 ppm, 66.67%, 74.67%, and 83.33%, at concentration of 3 ppm and 76.67%, 85.33%, and 95.33%, at concentration of 5 ppm, respectively. Mortality rates in the control were 0.0% at three ranged from 24, 48, and 72 h of exposure **(Table 4).**

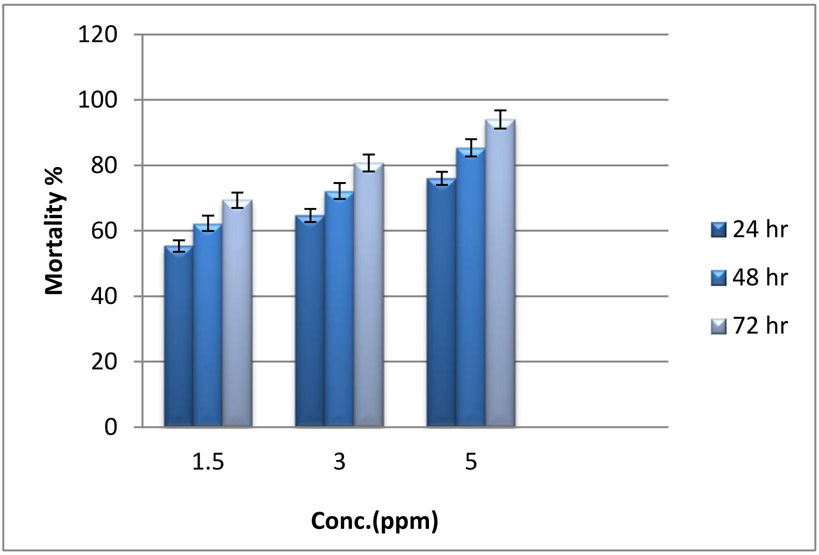
Also, essential oil of *Ocimum basilicum* had the third highest toxicity level at 24, 48, and 72 h of exposure at different concentrations (1.5, 3 and 5 ppm) causing mortality rates of 52.00%, 58.00%, and 65.33%, at concentration of 1.5 ppm, 62.00%, 69.33%, and 78.00%, at concentration of 3 ppm and 72.67%, 81.33%, and 90.67%, at concentration of 5 ppm, respectively. Mortality rates in the control were 0.0% at three ranged from 24, 48, and 72 h of exposure **(Table 6).**

Lethal concentrations (LC_{50}) of all plant extracts were also estimated with serial dilutions of the plant extracts. For aqueous extracts, those of

Marjoram origanum, *Mentha spicata* and *Ocimum basilicum*, however, clear from the obtained results shown that *Marjoram origanum* oil was the most potent against whitefly adults with LC_{50} value of 0.538 ppm **(Table 3),** followed by *Mentha spicata* oil with LC_{50} value of 0.580 ppm **(Table 5)** and *Ocimum basilicum* oil with LC50 values of 0.631 ppm **(Table 7),** after 72 hr, of all three oils, respectively.

Chemical analysis showed that fatty acids, terpene compounds, aromatic compounds and short-chain or middle-length -chain hydrocarbons were the major chemicals identified in these plants **(Li *et al.*, 2014**). The essential compounds of the volatile fraction were 2-hexenal and 3-hexen-1-ol. Terpenoids were the most abundant chemical compounds among the host plants and included α-pinene, β-myrcene, ocimene, limonene, β-phellandrene and β-caryophyllene. Consequently, the different host plants varied in their relative contents of various plant oils. For example, one of the chemicals, limonene, was a principal ingredient of the volatile component of celery while it appeared at very low concentrations in the other plants selected. Thereupon, while all the compounds were thought to attract *B. tabaci*, the presence of limonene at a very high concentration in celery suggested that it has a repelling action **(Li *et al.*, 2014**).

García-Mateos *et al.* (2007) reported that aqueous, methanolic and dicloromethane extracts of leaves caused 100% mortality on the whitefly



Trialeurodes vaporariorum. More recently, **Rosado-Aguilar *et al*. (2010)** showed that methanolic extracts of stem and leaves of *P. alliaceae* caused 100% mortality on the tick *B.microplus* larvae, and 91% inhibition of egg-laying on adults. Gas chromatography-mass spectrometry demonstrated that the chemical composition of the active fraction was mainly composed of dibenzyldisulfide and dibenzyltrisulfide, suggesting that these compounds might be responsible for the acaricidal activity of *P. alliaceae* stem extracts. This metabolite has been reported as an important component of the essential *Aedes albopictus* larvae with a LC_{50} value of 59.2 ppm **(Mathew and Thoppil, 2011).**

The use of biologically based compounds in plant extracts or essential oils may be an alternative to currently used insecticides to control insects. Moreover, essential oils have a broad spectrum of insecticidal activity due to the presence of several modes of action, including repellent and antifeedant activities, inhibition of molting and reduction in growth and fecundity **(Isman 2006 and Enan 2001).** Plant oils effect directly as repellents or even indirectly as antifeedant compounds or toxins, so, they may help to control B. tabaci by expulsion effect and consequently, by reducing virus transmission to the plants **(Baldin *et al.*, 2013).** Plant essential oils may also have minimal direct and/or indirect effects on natural enemies **(Bostanin *et al.*, 2005 and cloyd *et al.*, 2009)**. Essential oils and crude extracts of some plants have been evaluated for repellency and insecticidal activity against the sweet potato whitefly (*B. tabaci*) and some of them can be used as an alternative method of controlling this deleterious pest through suitable integrated pest management programs **(Gerling 1990 and Byrne and Bellowers 1991).**

Kim *et al.* (2011) who reported that some essential oils such as thyme and garlic resulted high suppression of *B. tabaci* population. The results of Yang et al.18 revealed that among the three tested oils, essential oil of T. vulgaris was the most effective, reducing the survival rate of eggs, nymphs and pupae of B. tabaci as compared with the control, also they found that egg hatchability was reduced ≈50% with essential oils from studies confirmed the effects of plant oils against B. tabaci immature stages, such as **Yarahmadi *et al.* (2013)** who showed that all concentrations of both essential oils Geranium and Artemisia were significantly suppressed all developmental stages of *B. tabaci*. **Himat (1999)** concluded that neem formulations proved to be effective in reducing the hatchability of the eggs of the whitefly *B. tabaci*.

There are many reports that supported the potency effect of thyme oils, **Barkman23**concluded that essential oils from T. vulgaris and its derivatives or their mixtures showed the strongest contact toxicity on adults of B. tabaci biotype Yang et al.18 reported that, among the tested oils, essential oil derived from *T. vulgaris* had the greatest contact toxicity against *B. tabaci*. **Aroiee *et al.* (2005)** showed that thyme (*T. vulgaris*) was the most effective essential oil against whitefly, *T. vaporariorum*. **Aslan *et al.* (2004)** found that essential oil vapors from *Thymus vulgaris* L. (Lamiaceae) had high toxicities against the adults of *B. tabaci*. The toxicity of garlic oil against B. tabaci, the present results agreed to a large extent with the findings of **Liu *et al*. (2014),** who evaluated the fumigant toxicity of essential oils of Chinese medicinal herbs against *B. tabaci*, they found that the two main constituent compounds of garlic essential oil, diallyl trisulfide and diallyl disulfide exhibited strong fumigant toxicity against the whitefly. **Nzanza and Mashela (2012)** showed that fermented plant extracts of neem and wild garlic, alone or in combination, have insecticidal properties to maintain lower population densities of whitefly.

The toxicity of cumin oil also reported by **Deletre *et al.* (2016)** reported that the cumin mixture and its derivatives, cuminaldehyde were toxic against *B. tabaci* and they found that cumin mixture limited the white y net-crossing rate by killing them.

Table (2): Fumigant activity of *Marjoram origanum* oil on *B. Tabaci* during 24, 48, and 72 h post-exposure periods.

Oil	Conc. ppm	Mortality %± SE		
		24 hr	48 hr	72 hr
Marjoram origanum	1.5	57.33±1.77[b]	64.00±1.12[b]	72.00±2.09[b]
	3	66.67±2.03[ab]	74.67±2.03a[b]	83.33±2.33[b]
	5	76.67±1.76[a]	85.33±1.86[a]	95.33±1.86[a]
Control		0.00±0.00[c]	0.00±0.00[c]	0.00±0.00[c]
$L.S.D_{(0.05)}$		5.78	6.61	6.63

Table (3): The LC_{50} values of *Marjoram origanum* oil fumigant on *B. Tabaci* after 24, 48 and 72 h post-exposure.

Oil	Exposure Time (hr)	LC_{50} ppm	Confidence Limits at 50% of probability		Slope ±Variance	X2
			Lower	Upper		
Marjoram origanum	**24**	**0.708**	**0.09**	**1.108**	**1.09±0.38**	**0.35**
	48	**0.573**	**0.124**	**0.901**	**1.37±0.40**	**0.58**
	72	**0.538**	**0.213**	**0.785**	**1.99±0.46**	**2.22**

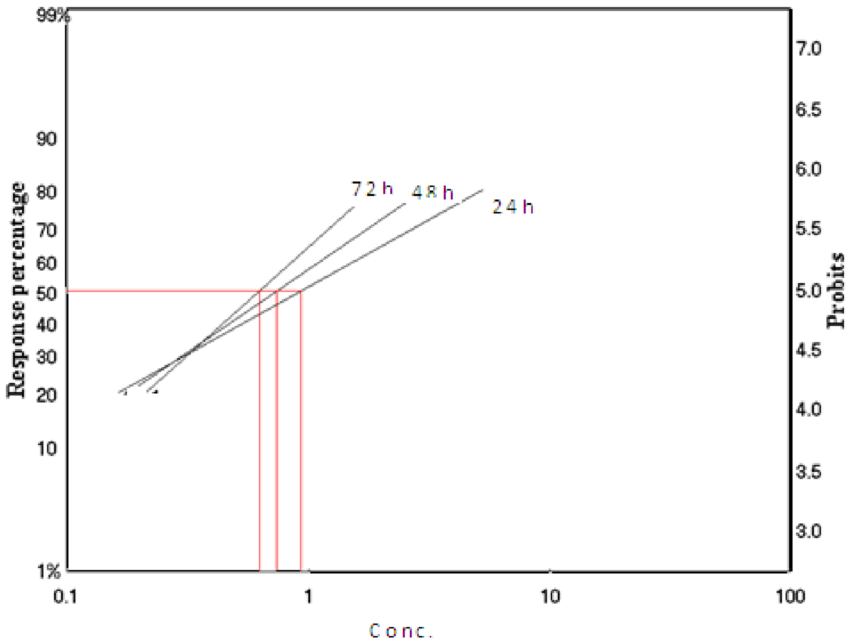
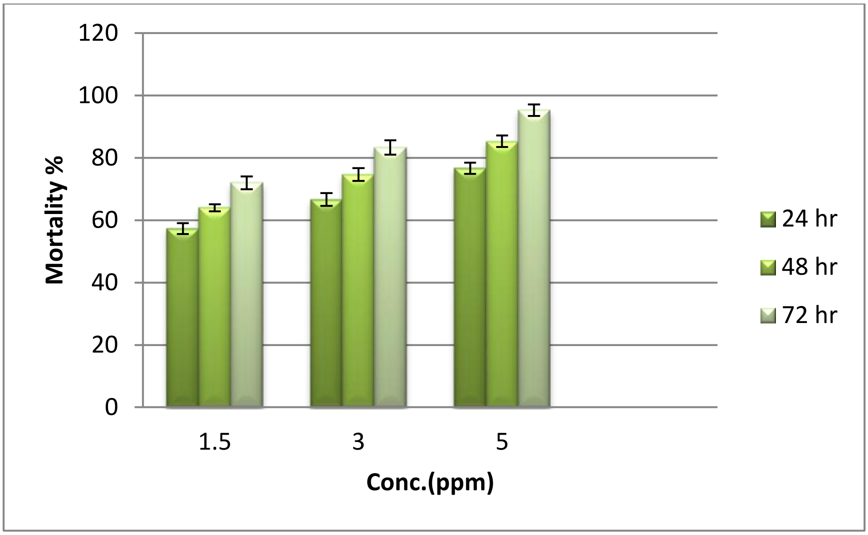


Fig. (1): Ld-P lines of *Marjoram origanum* oil fumigant against *B. Tabaci* after 24, 48and 72 hr.



Fig(2): Fumigant activity of *Marjoram origanum* oil on *B. Tabaci* during 24, 48 and 72 hr.

In this respect, essential oil of *Mentha spicata* showed maintained at the second highest toxicity level at 24, 48, and 72 h of exposure at different concentrations (1.5, 3 and 5 ppm) causing mortality rates ranging from 57.33%, 64.00%, and 72.00%, at concentration of 1.5 ppm, 66.67%, 74.67%, and 83.33%, at concentration of 3 ppm and 76.67%, 85.33%, and 95.33%, at concentration of 5 ppm, respectively. Mortality rates in the control were 0.0% at three ranged from 24, 48, and 72 h of exposure **(Table 2).**

Also, essential oil of *Ocimum basilicum* had the third highest toxicity level at 24, 48, and 72 h of exposure at different concentrations (1.5, 3 and 5 ppm) causing mortality rates of 52.00%, 58.00%, and 65.33%, at concentration of 1.5 ppm, 62.00%, 69.33%, and 78.00%, at concentration of 3 ppm and 72.67%, 81.33%, and 90.67%, at concentration of 5 ppm, respectively. Mortality rates in the control were 0.0% at three ranged from 24, 48, and 72 h of exposure **(Table 2).**

Chemical analysis showed that fatty acids, terpene compounds, aromatic compounds and short-chain or middle-length -chain hydrocarbons were the major chemicals identified in these plants **(Li *et al.*, 2014**). The essential compounds of the volatile fraction were 2-hexenal and 3-hexen-1-ol. Terpenoids were the most abundant chemical compounds among the host plants and included α-pinene, β-myrcene, ocimene, limonene, β-phellandrene and β-caryophyllene. Consequently, the different host plants varied in their relative contents of various plant oils. For example, one of the chemicals,

Oil	**Conc. ppm**	**Mortality %± SE**		
		24 hr	**48 hr**	**72 hr**
Mentha spicata	1.5	55.33±1.77[b]	62.00±2.09[b]	69.33±2.34[b]
	3	64.67±2.03[ab]	72.00±2.31[b]	80.67±2.60[b]
	5	76.00±2.31[a]	85.33±2.61[a]	94.00±2.81[a]
Control	0	0.00±0.00[c]	0.00±0.00[c]	0.00±0.00[c]
L.S.D		**5.78**	**6.61**	**6.63**

limonene, was a principal ingredient of the volatile component of celery while it appeared at very low concentrations in the other plants selected. Thereupon, while all the compounds were thought to attract *B. tabaci,* the presence of limonene at a very high concentration in celery suggested that it has a repelling action **(Li *et al.*, 2014**).

Table (4): Fumigant activity of *Mentha sicata* oil on whitefly (*Bemisia tabaci*) during 24, 48 and 72 h postexposure per

Table (5): The LC_{50} values of *Mentha sicata* oil fumigant on whitefly (*Bemisia tabaci*) after 24, 48 and 72 h post-exposure.

Oil	**Exposure Time (h)**	**LC_{50} ppm**	**Confidence Limits at 50% of probability**		**Slope ±Variance**	**X2**
			Lower	**Upper**		
Mentha spicata	**24**	0.805	0.169	1.192	1.14±0.38	0.54
	48	0.654	0.199	0.97	1.44±0.39	1.26
	72	0.58	0.242	0.832	1.92±0.44	2.39

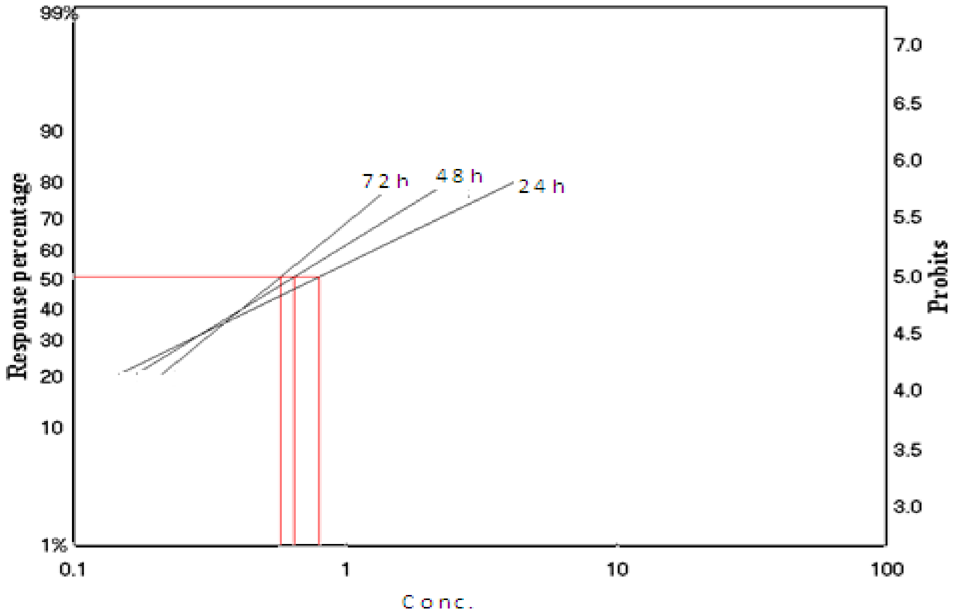


Fig. (3): Ld-P lines of *Mentha spicata* oil fumigant against *B. Tabaci* after 24, 48and 72 hr.

Fig(4): Fumigant activity of *Mentha spicata* oil on *B. Tabaci* during 24, 48, and 72 hr.

Table (6): Fumigant activity of *Ocimum basilicum* oil on *B. Tabaci* during 24, 48, and 72 h post-exposure periods.

Oil	**Conc. ppm**	**Mortality %± SE**		
		24 hr	**48 hr**	**72 hr**
Ocimum basilicum	1.5	52.00±1.73[b]	58.00±1.73[b]	65.33±2.02[b]
	3	62.00±1.73[a]	69.33±2.03[b]	78.00±2.31[ab]
	5	72.67±2.03[a]	81.33±2.34[a]	90.67±2.61[a]
Control		0.00±0.00[c]	0.00±0.00[c]	0.00±0.00[c]
L.S.D		**5.78**	**6.61**	**6.63**

Table (7): The LC_{50} values of *Ocimum basilicum* oil fumigant on *B. Tabaci* after 24, 48 and 72 h post-exposure.

Oil	Exposure Time (h)	LC_{50} ppm	Confidence Limits at 50% of probability		Slope ±Variance	X2
			Lower	Upper		
Ocimum basilicum	24	0.942	0.246	1.342	1.12±0.38	0.34
	48	0.746	0.242	1.078	1.37±0.39	0.62
	72	0.631	0.264	0.898	1.76±0.42	1.27

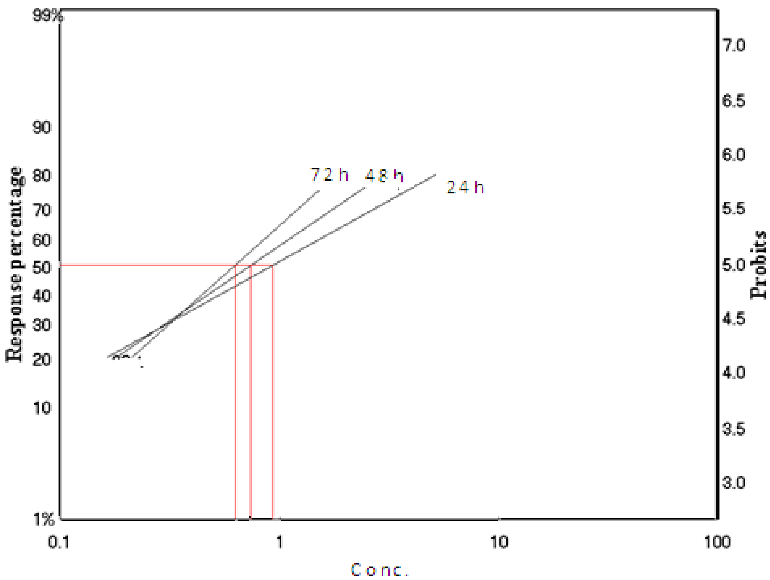
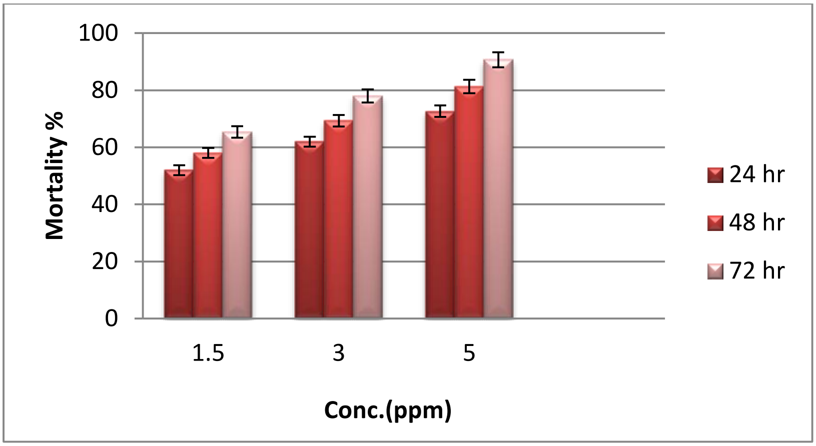


Fig. (3): Ld-P lines of *Ocimum basilicum* oil fumigant against *B. Tabaci* after 24, 48and 72 hr.



Fig(4): Fumigant activity of *Ocimum basilicum* oil on *B. Tabaci* during 24, 48, and 72 hr.

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