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Article

Influence of Certain Agrochemicals, Oils and Foliar Fertilizers Against Citrus Leaf miner, *Phyllocnistis citrella* Stainton (Lepidoptera:Gracillariidae) on Lime Trees

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Abstract

Field trials were conducted on a private farm cultivated with lime trees, *Citrus aurantifolia* Frank, 4 years old, in Kom Hamada, Behaira governorate. The influence of certain insecticides, oils, and foliar fertilizers was studied against citrus leafminer *Phyllocnistis citrella* on lime trees. The insecticides included abamectin, spinetoram, thiocyclam, azadirachtin, lambda-cyhalothrin, and profenofos; two oils (mineral and vegetable oils); and two foliar fertilizers (calcium nitrate and potassium nitrate). The results indicated that abamectin consistently showed the highest efficacy in eliminating the citrus leaf miner, on lime trees. This effectiveness was observed over five consecutive administrations conducted during the 2021 growing season. The treatment with abamectin exhibited the highest level of efficacy among the several treatments that were evaluated. It yielded reduction percentages of 79.60%, 85.90%, 81.20%, 89.40%, and 92.10%, respectively, and a grand reduction of 85.64%. The application of mineral oil came in the second order and resulted in a decrease in infestation levels by 64.90%, 63.10%, 65.70%, 70.90%, and 70.50% after five consecutive applications, with a grand reduction of 67.03%. Meanwhile, the treatments of vegetable oil, spinetoram, and lambda-cyhalothrin produced medium-significant reductions in infestation (̰50%), revealing grand reductions of 52.50, 52.04, and 49.92%, respectively, among the five consecutive applications. Based on the results of our research, it is evident that abamectin as well as mineral oil remain viable and advantageous options for effectively controlling the citrus leaf miner infestation in juvenile lime trees.

Key words: *Citrus aurantifolia*, *Phyllocnistis citrella,* Abamectin, Spinetoram, Azadirachtin, Profenofos, Thiocyclam, Lambda-cyhalothrin, Mineral oil.

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1. Introduction

Benzhair lemon is known in Egypt as municipal lemon, Benzhair, Rashidi, or salty. Their trees are large but not high, and the branching is not organized. Many of spines and leaves are small, densely packed, pale green in colour with a non-pointed tip; the leaf neck is short with wings; and the fruit has a thin pale-yellow peel at full maturity, completely adherent to the lobes.

In Egypt, the area of sour lime is 38,643 feddan, production/feddan is 9.991 tonnes and total production is 312,110 tonnes (according to the **Ministry of Agriculture and Land Reclamation, Agricultural Statistics 2018/19**). One lemon tree produces an average of 7 to 10 kg in the first five years, after which the production gradually doubles to reach 25 kg, and Egyptian's production of lemons is about thirty thousand tonnes annually.

The origin of the citrus leaf miner*Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) is probably in Southeast Asia (**Abdel-Rhman, 2009**), but coincided with or was related to the recent invasion of the same pest in other countries in the Mediterranean region (Spain, Italy, Cyprus, Turkey, Greece, Tunisia, Morocco, Egypt, etc.) and with the spectacular invasion and establishment of the pest in Florida and other southeastern states of the USA.

The damage to the leaf surface after an attack by the leaf miner is manifested by a reduction in the vigour of both summer and fall flushes. Loss of vigor is manifested by a lower length and diameter of young shoots (**Kharrat and Jerraya, 2006**).

Citrus is considered the main fruit crop in Egypt, and citrus trees were infested by a citrus leaf tunnel-making insect (CLM) beginning in the second half of 1994 in Sharqiya governorate. The infection spreads inside very quickly until it included citrus gardens and nurseries in all of Egypt **(Abdel-Aziz, 1995).**The presence of this insect is associated with the presence of modern succulent growths, which are constantly present in nurseries. Therefore, this insect is considered a nursery pest in the first place, although it infests all citrus varieties.

The larva is the causative phase of the damage; as soon as the eggs hatch, the larva comes out and begins to enter directly under the surface of the epidermis, making a tunnel, feeding on the walls of plant cells, and cellular juice resulting from breaking the cell walls and infected leaves. It has a bright silver colour as a result of the reflection of light from the winding tunnels, as clearly shown on the market. At the end of the fourth larval life, the larva refrains from feeding and begins to make a chamber inside which it turns into a virgin, where it is active in making a set of silk threads connecting the edge of the leaf with its surface, creating an excommunication chamber **(Jesus *et al*, 2006).**

Damavandian and Moosavi (2014) indicated that there is more *P. citrella* damage in orchards under the pressure of synthetic pesticides than in orchards in which the synthetic pesticides were eliminated for years. **Sarada *et al*. (2014)** reported that the utilization of biological control is the most favorable approach for achieving long-term control of the citrus leaf miner. The citrus leaf miner (CLM) has exhibited a historical trend of acquiring resistance to pesticides, hence posing challenges in attaining long-term and effective pest management strategies. Bio-pesticides have emerged as a viable and advantageous substitute for traditional insecticides in the context of integrated pest management. They provide a secure and efficient means of managing pests.

The main objective of this study was to assess the efficacy of specific insecticides, oils, and nutrients in managing citrus leaf miners, with the aim of determining the most appropriate option for integration into an Integrated Pest Management (IPM) strategy for controlling citrus leaf miners.

2. MATERIALS AND METHODS

2.1. Experimental design:

The field trials were conducted on a private farm cultivated with lime trees, *Citrus aurantifolia* Frank,four years old, in Kom Hamada, Beheira governorate, during the seasons 2020/2021.The experimental area was thirty-three trees, which were divided into three plots; each plot had eleven trees, and the experimental design was a randomized complete block design (RCBD) with three replicates. The distance between the blocks was set at five meters to prevent the pesticides from drifting.

During the season 2020/2021, lime trees were treated with five applications for each of the tested compounds on 1st September 2020 and 2021 with ten-day intervals using their recommended doses against the leafminer, *Phyllocnistis citrella*, to calculate the reduction percentage.

2.2. Treatments used

The effects of six insecticides, two oils, and two foliar nutrients were studied in tested season to evaluate the best and most effective treatments against the assigned leaf miner, *P. citrella* Stainton. The evaluated chemicals were used by their application rates per feddan as follows:

1. Abamectin **(Vertemic 1.8% EC) ®:** 100 cc /Feddan

2. Azadirachtin **(Achock 0.15% EC) ®:** 400 cc /Feddan

3. Lambda-Cyhalothrin **(Halothrin Chema 2.5% EC) ®:** 250 cc /Feddan

4. Spinotram **(Radiant® 12% SC) ®:** 100 cc/Feddan

5. Profenofos **(cord 72% EC) ®:** 750cc/Feddan

6. Thiocyclamhydrogen oxalate **(Evisect S 50%SP) ®:** 125 g/100 Liter

7. KZ oil **(KZ oil) ®:** 1.5 L/100 Liter

8. Vegetable oil **(Extra oil) ®:** 1.5 L/100 Liter

9. Calcium nitrate **(Dam cab) ®:** 250cc/100 Liter

10. Potassium nitrate **(Dam k) ®:** 250 cc/100 Liter

2.3. Sampling technique

For sampling of the leafminer**,** from randomized three trees, samples of ten leaves were collected from each tree before spraying and after one, two, three, five, and seven days after spraying.

Samples were checked by direct eye for the number of insect larvae inside the tunnels they made between the upper and lower leaf surfaces. The infestation percentages were calculated weekly after one, two, three, five, and seven days post-spraying taking into account the calculation of the infestation reduction.

2.4. Calculation of the infestation reduction

Pre- and post-treatment applications after one, two, three, five, and seven days, the reduction percentages of infestation were calculated according to the **Henderson and Tilton (1955)** equation as follows:

$$\text{Reduction \%} = \left[1 - \frac{A}{B} \times \frac{C}{D}\right] \times 100$$

Where:

A: % infested leaves in treatment after spraying.

B: % infested leaves in treatment before spraying.

C: % infested leaves in the untreated check before spraying.

D: % infested leaves in the untreated check after spraying.

2.5. Statistical analysis

Data were subjected to the analysis of variance ANOVA using the F test following the randomized complete block design (RCBD), with three replications for each treatment. The least significant differences (L.S.D.) at the 0.05 ≤ level were determined by **Steel and Torrie (1981)** to compare the average numbers of the inspected insects at different intervals.

3. RESULTS AND DISCUSSION

The citrus leaf miner (CLM), *P. citrella*, spread rapidly throughout the infestation of lemon trees in many parts of Egypt. Ultimately, a variety of pest management tactics have to been employed to manage the CLM, including cultural, chemical, and biological control.

The IPM program must prove to be effective and selective against the studied insect pests as a target. Therefore, the agrochemicals must meet the demand for controlling the pest and increasing the yield through the reduction of the pest population and its infestation.

3.1. **Efficacy of certian insecticides, oils and fertilizers on citrus leafminer, *P. citrella*infesting lemon trees**

The efficacy of six insecticides (abamectin, spinetoram, thiocyclam, azadirachtin, lambda-cyhalothrin, and profenofos), two oils (mineral and vegetable oils), and two foliar fertilizers (calcium nitrate and potassium nitrate) were evaluated. The evaluation of certain insecticides, oils, and foliar fertilizers against this insect pest is part of an integrated pest management programme. The effect of the tested compounds was evaluated on lime tree-leaves containing alive larvae.

The results in **Table 1 and Figures 1 up to5** refer to the mean numbers of citrus leaf miner larvae per 10 leaves after one, two, three, four, and five sprays with the assigned treatments on citrus leaf miner during the 2020/2021 season. Generally, the highest larval numbers of citrus leaf miner were recorded at untreated check, which continued to stable around nine larvae per ten leaves throughout the five inspection intervals. All treatments significantly varied in their effect on the mean number of citrus leaf miner. Meanwhile, in the experimental treatments, it was observed that as intervals increased, there was a drop in the average number of citrus leaf miner larvae. Moreover, the reduction percentages resulted from the treatments being significantly differentiated according to the treatment and their sequential application (**Table 2**).

3.2. The 1st application

Based on the empirical data presented in **Table 1, Figure 1**, and the computed outcomes outlined in **Table 2**, it is evident that the treatments involving abamectin and mineral oil exhibited the lowest average counts of citrus leaf miner larvae. Specifically, the abamectin treatment yielded an average of 1.86 larvae per 10 leaves, while the mineral oil treatment resulted in an average of 3.33 larvae per 10 leaves. These findings correspond to reduction percentages of 79.60% and 64.90%, respectively. The mean numbers of larvae per 10 leaves obtained from the application of lambda-cyhalothrin, vegetable oil, and spinetoram were 4.99, 4.99, and 5.20, respectively. Additionally, the corresponding decrease percentages were found to be 45.30%, 45.30%, and 41.70%, respectively. In contrast, the treatment of calcium nitrate exhibited the largest mean number of larvae per 10 leaves (6.60), followed by thiocyclam (6.66), potassium nitrate (6.46), and azadirachtin (7.80). These treatments showed the least significant reduction percentages, with values of 27.80%, 27.00% 27.70%, and 13.80%, respectively.

3.3. The 2nd application

In relation to the effectiveness of the agrochemicals under examination following the second application, the data presented in **Tables 1 and 2**, as well as **Figure 2**, indicate that the treatments resulting in the highest levels of efficacy were abamectin and mineral oil. These treatments resulted in the lowest significant average larval counts of only 1.66 and 3.66 larvae per 10 leaves, respectively, in contrast to the count of 9.66 larvae per 10 leaves observed in the untreated control. In the present study, it was observed that the application of abamectin and mineral oil resulted in a significant reduction in the infestation of citrus leaf miner. Specifically, abamectin exhibited a reduction rate of 85.90%, while mineral oil shown a reduction rate of 63.10%.

In addition, the agrochemicals spinetoram, lambda-cyhalothrin, vegetable oil, and calcium nitrate exhibited average values of 5.00, 5.00, 5.33, and 6.00 larvae per 10 leaves, respectively. These results indicate a reduction in infestation rates of 53.33%, 47.50%, 46.80%, and 41.80%, respectively. In contrast, the treatments that exhibited the lowest levels of efficiency were thiocyclam, profenofos, potassium nitrate, and azadirachtin. These treatments resulted in mean numbers of 6.33, 6.66, 6.66, and 8.33 larvae per 10 leaves, respectively. Additionally, the computed infestation reductions for these treatments were 34.00%, 34.80%, 39.70%, and 16.00%, respectively.

3.4. The 3rd application

Regarding the results of the third application shown in **Tables 1 and 2** as well as **Figure 3**, abamectin and mineral oil were the most effective on citrus leaf miner. However, abamectin remained the most effective treatment, showing the lowest mean number of larvae (1.93 per 10 leaves) and the highest reduction in infestation (81.20%). Mineral oil followed it, showing 3.53 larvae per 10 leaves and a 65.70% decrease in infestation. The treatments with vegetable oil, lambda-cyhalothrin, spinetoram, thiocyclam, and profenofos have moderate effects. The average number of larvae per 10 leaves was 4.39, 4.73, 4.79, 4.39, and 5.66, showing infestation reductions of 53.20, 50.30, 49.60, 43.00, and 42.00%, respectively. Calcium nitrate, potassium nitrate, and azadirachtin, on the other hand, were the least effective treatments. They showed the most infestations, with 5.45, 6.06, and 7.72 larvae per 10 leaves, respectively, compared to the untreated control, which showed reductions of 41.90, 36.30, and 19.60%, respectively.

3.5. The 4th application

For the fourth application, the results showed that abamectin and mineral oil were still the best treatments to get rid of the citrus leaf miner, which cause leaf mines in lemon trees. The rate of larvae per 10 leaves decreased significantly to only 0.99 and 2.73 in abamectin and mineral oil, respectively, representing the highest significant reductions of infestation percentages, which amounted to 89.40 and 70.90%, respectively. However, spinetoram, vegetable oil, thiocyclam, and lambda-cyhalothrin revealed moderate efficacy, giving means numbers of 4.13, 4.13, 4.66, and 4.79 larvae per 10 leaves, which correspond to 56.00, 56.00, 50.40, and 48.90% reductions, respectively. Conversely, the weakest effective treatments were potassium nitrate, profenofos, calcium nitrate, and azadirachtin, which slightly decreased the infested leaves to 5.19, 5.39, 5.66, and 6.73 larvae per 10 leaves, indicating weak percentage reductions of 44.70, 42.60, 39.70, and 28.40%, respectively (**Tables 1, 2 and Figure 4**).

3.6. The 5th application

In relation to the fifth application, it was observed that abamectin and mineral oil treatments remained consistently efficacious. The application of abamectin and mineral oil led to the most significant reductions in infestation rates, with values of 0.72 and 2.73 larvae per 10 leaves, corresponding to infestation reductions of 92.10% and 70.50%, respectively (**Tables 1, 2 and Figure 5**).

The treatments of vegetable oil, spinetoram, lambda-cyhalothrin, thiocyclam, and calcium nitrate produced the medium significant reductions in infestation rates, which were 3.59, 3.72, 3.59, 4.19, and 4.53 larvae per 10 leaves; the corresponding infestation reductions were 61.20, 59.70, 57.60, 54.70, and 51.10%, respectively.

In contrast, the treatments that had the lowest efficacy in managing the citrus leaf miner were potassium nitrate, profenofos, and azadirachtin. These treatments exhibited infestation rates of 4.79, 5.52, and 6.06 larvae per 10 leaves, respectively, compared to the infestation rate of 9.26 larvae per 10 leaves observed in the untreated check group. The aforementioned treatments demonstrated infestation reductions of 48.20%, 40.30%, and 34.50% correspondingly.

Table (1). Effect of certain insecticides, two oils, and two foliar fertilizers on larvae of citrus leaf miner *P. citrella* infested lemon trees in season 2021

Treatments	Mean number of larvae /10 leaves throughout 5 applications					
	pre	1st	2nd	3rd	4th	5th
Abamectin	9.9	1.86	1.66	1.93	0.99	0.72
Spinetoram	9.7	5.20	5.00	4.79	4.13	3.72
Thiocyclam	9.9	6.66	6.33	4.39	4.66	4.19
Azadirachtin	9.8	7.80	8.33	7.72	6.73	6.06
Lambda-Cyhaalothrin	9.9	4.99	5.00	4.73	4.79	3.93
Profenofos	9.9	6.33	6.66	5.66	5.39	5.52
Mineral oil	10.3	3.33	3.66	3.53	2.73	2.73
Vegetable oil	9.9	4.99	5.33	4.39	4.13	3.59
Calcium nitrate	9.9	6.60	6.00	5.45	5.66	4.53
Potassium nitrate	9.7	6.46	6.66	6.06	5.19	4.79
Untreated check	10	9.20	9.66	9.73	9.39	9.26
LSD 0.05	-	0.256	0.322	0.340	0.306	0.337

Table (2). **Reduction% of citrus leaf miner *P. citrella* infested lemon trees throughout five Consecutive applications of different treatments in season 2021.**

Treatments	% Infestation reduction throughout 5 applications					% Grand Reduction
	1st	2nd	3rd	4th	5th	
Abamectin	79.60	85.90	81.20	89.40	92.10	85.64
Spinetoram	41.70	53.20	49.60	56.00	59.70	52.04
Thiocyclam	27.00	34.00	43.30	50.40	54.70	41.82
Azadirachtin	13.80	16.00	19.60	28.40	34.50	22.46
Lambda-	45.30	47.50	50.30	48.90	57.60	49.92
Profenofos	30.60	34.80	42.00	42.60	40.30	38.06
Mineral oil	64.90	63.10	65.70	70.90	70.50	67.03
Vegetable oil	45.30	46.80	53.20	56.00	61.20	52.50
Calcium nitrate	27.80	41.80	41.90	39.70	51.10	40.46
Potassium nitrate	27.70	39.70	36.30	44.70	48.20	39.32

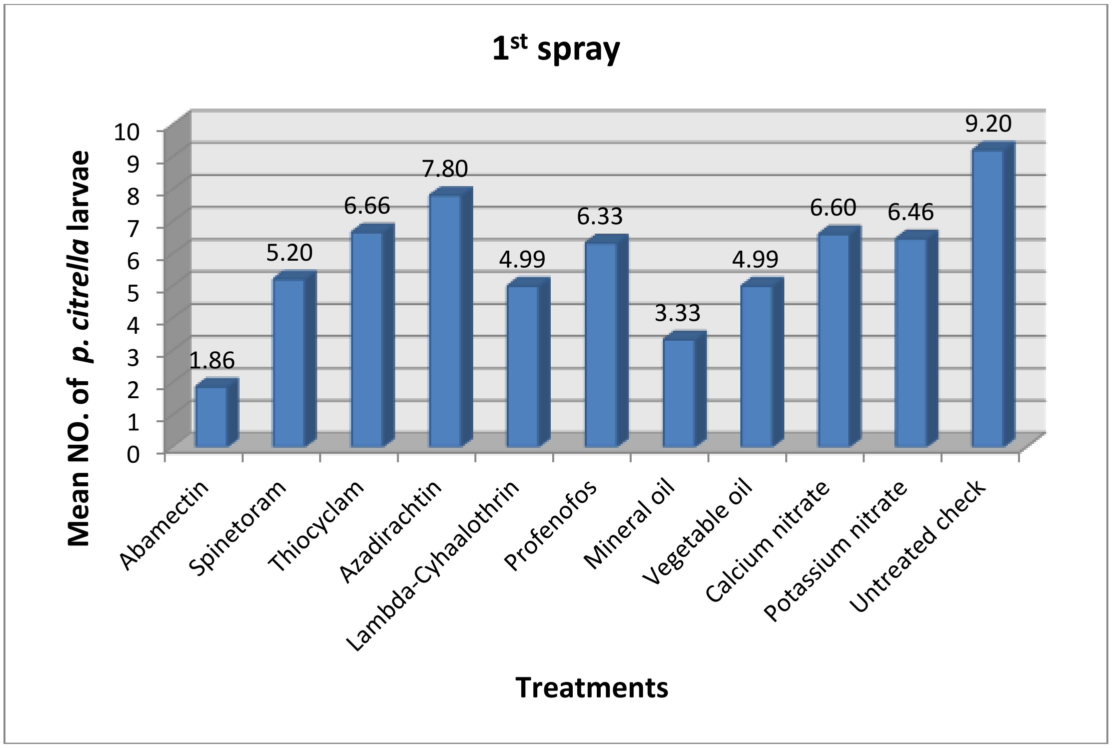

Fig. (1). General mean number of inspected citrus leaf miners, *P. citrilla* infesting lemon trees on 2021 season (1st spray).

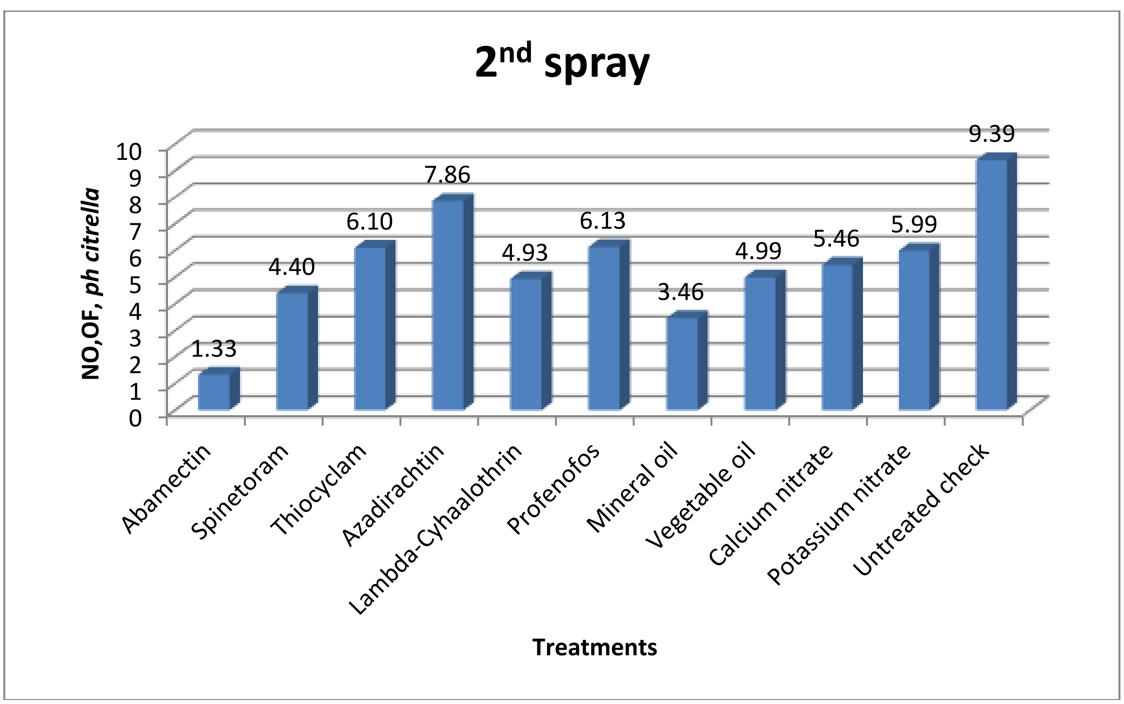

Fig. (2). General mean number of inspected citrus leaf miners, *P. citrilla* infesting lemon trees on 2021 season (2nd spray).

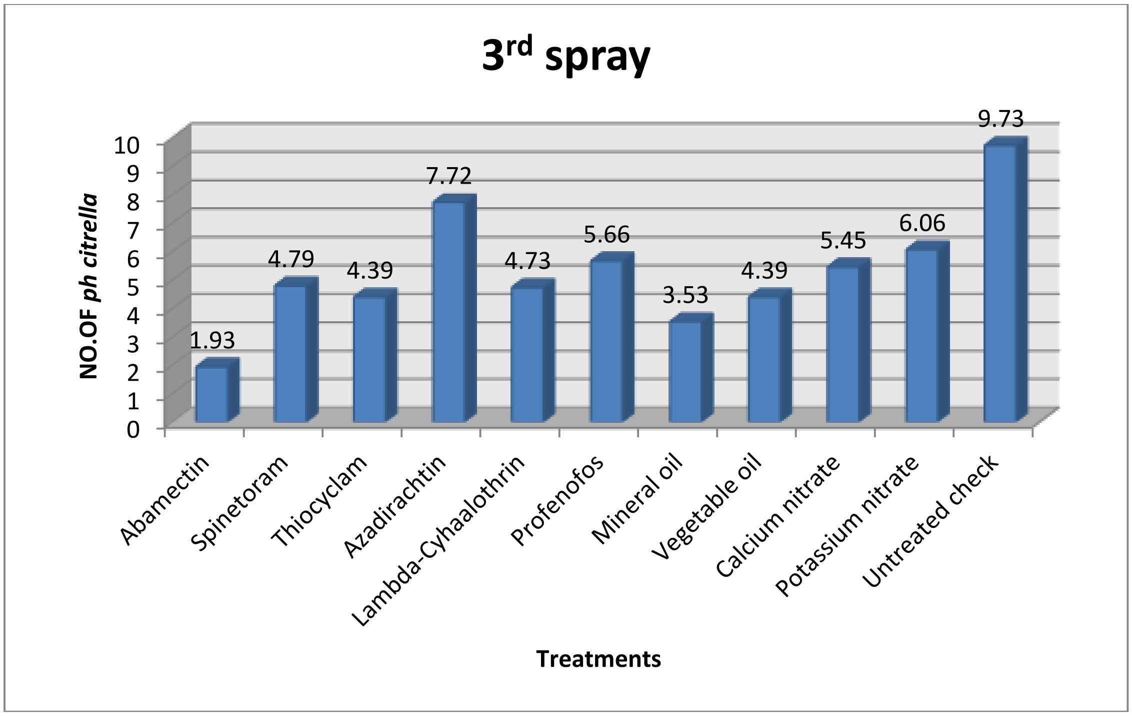

Fig. (3). General mean number of inspected citrus leaf miners, *P. citrilla* infesting lemon trees on 2021 season (3rd spray).

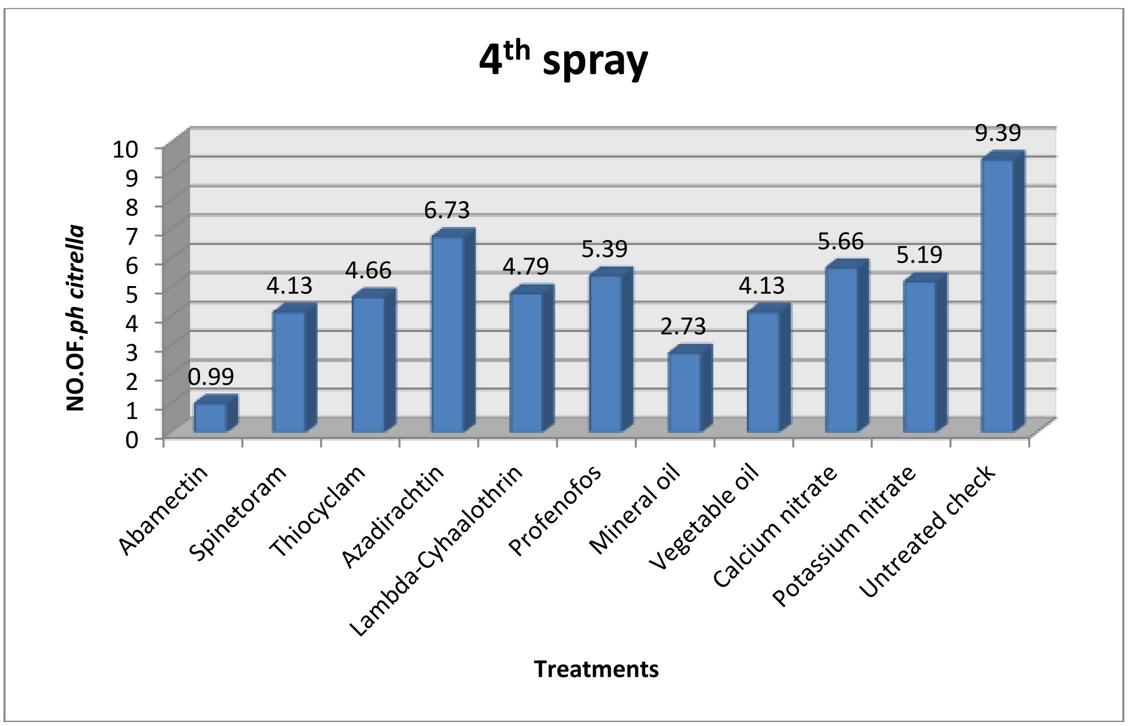

Fig. (4). General mean number of inspected citrus leaf miners, *P. citrilla* infesting lemon trees on 2021 season (4th spray).

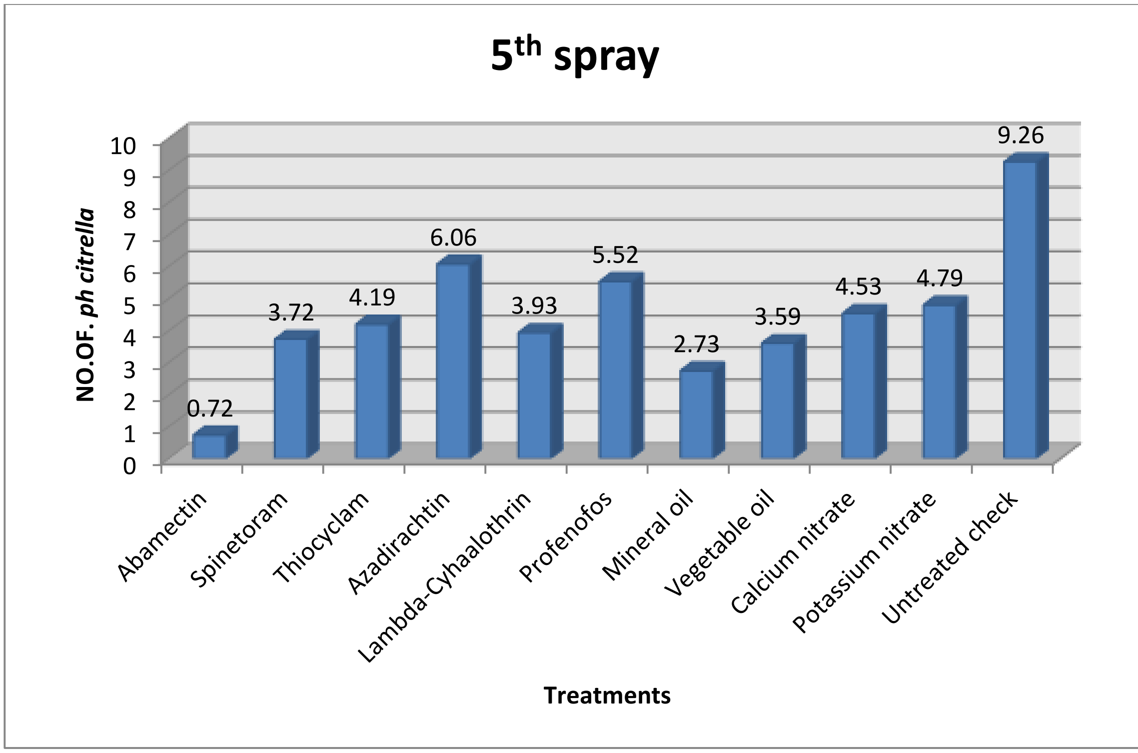

Fig. (5). General mean number of inspected citrus leaf miners, *P. citrilla* infesting lemon trees on 2021 season (5th spray).

In conclusion, the findings indicated that abamectin consistently showed the highest efficacy in eliminating *Phyllocnistis citrella*, the citrus leaf miner, on lime trees. This effectiveness was observed over five consecutive administrations conducted during the 2021 growing season. The treatment with abamectin exhibited the highest level of efficacy among the several treatments that were evaluated. It yielded reduction percentages of 79.60%, 85.90%, 81.20%, 89.40%, and 92.10%, respectively, and a grand reduction of 85.64%. The application of mineral oil came in the second order and resulted in a decrease in infestation levels by 64.90%, 63.10%, 65.70%, 70.90%, and 70.50% after five consecutive applications, with a grand reduction of 67.03%.

Meanwhile, the treatments of vegetable oil, spinetoram, and lambda-cyhalothrin produced medium-significant reductions in infestation (ξ50%), revealing grand reductions of 52.50, 52.04, and 49.92%, respectively, among the five consecutive applications.

However, the treatments with the lowest efficacy in managing the citrus leaf miner were thiocyclam, calcium nitrate, potassium nitrate, profenofos, and azadirachtin. These treatments exhibited grand infestation reductions of 41.82, 40.46, 39.32, 38.06, and 22.46%, respectively.

The above demonstrated results were in agreement with those mentioned by earlier investigators. **Sarada *et al*. (2014)** reported that the citrus leaf miner (CLM), *P. citrella*, is a potentially serious pest of citrus (oranges, mandarins, lemons, limes, grapefruit, and other varieties) and related *Rutaceae* (kumquat and calamondin) and ornamental plants almost worldwide. The management of this insect depends on chemical control and biological control, which are the two key tools. The complex of natural enemies attacking CLM causes up to 90 percent mortality in larvae and pupae. Effective chemical control of CLM is difficult because the larva is protected by leaf cuticles and the pupa is protected by rolled leaf margins. **Garcia-Mari *et al.* (2002)** reported thatmining by leaf miner *P. citrella* was observed in 45% of the new leaf area in the Valencia region of eastern Spain in the spring. Only 5–15% of the yearly new leaf area of mature trees was injured by *P. citrella* in Mediterranean regions.

Patil *et al*. (2013) studied the efficacy of abamectin, spinosad, novaluron, diafenthiuron, triazophos, and acephate for the control of citrus leaf miner (*Phyllocnistis citrella*) on acid lime. The results demonstrated that on the third, seventh, and fourteenth days following application, all insecticidal treatments substantially reported decreased infestation. The common insecticides used for the control of the citrus leaf miner (CLM) on young trees are sprayed 4 to 5 times at 5- to 10-day intervals during the flush developing period. Recently, CLM has become resistant to pyrethroids in some regions (**Ujiye, 2000)**.

Damavandian and Moosavi (2014)demonstrated that abamectin plus mineral spray oil at a rate of 0.02% plus 0.50% in water, respectively, provided the highest level of control and reduced the population of larvae up to 85%. Ina field experiment, **Raga *et al*. (2001)** found that only abamectin and petroleum oil (PO) significantly reduced the populations of citrus leaf miner larvae by 93.9% and larvae and pupae by 95.0%, five days after the second administration. **Rae et al. (1996)** compared three petroleum spray oils and abamectin plus oil against citrus leaf miner. The leaf miner was completely controlled with abamectin plus petroleum spray oil. Using two laboratory bioassays, **Arshad *et al*. (2019)** found that abamectin appears to provide superior efficiency for citrus leaf miner larvae than *Azadirachta indica*. **Damavandian (2016)** showed that mineral oil may be a good substitute for synthetic pesticides in citrus crops.

Finally, the efficacy of chemical control methods for managing the citrus leaf miner may be limited due to the protective nature of the larvae within their mines and the pupae within their pupal chambers. Nevertheless, the application of chemicals is only required for the new growth, and often, there is no need for the chemicals to penetrate the tree canopy. It is not advisable to use broad spectrum insecticides, such as organophosphates, carbamates, and pyrethroids for controlling leaf miners. Specially, these pesticides have the potential to negatively impact not just the natural enemies of leaf miners, but also those of insect-pests.

Based on the results of our research and subsequent discussions, it is evident that microorganism-derived substances, such as abamectin and mineral oil, remain a viable and advantageous option for effectively controlling the citrus leaf miner infestation in juvenile lime trees.

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بعض المبيدات الحشرية، الزيوت والأسمدة الورقية ضد صانعات أنفاق الموالح على أشجار الليمون

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الملخص العربي

أجريت التجارب الحقلية في مزرعة خاصة بمنطقة كوم حمادة محافظة البحيرة على أشجار الليمون عمر أربع سنوات خلال الموسم 2021/2020 لتقييم أداء بعض المبيدات الحشرية، الزيوت والأسمدة الورقية ضد صانعات أنفاق الموالح ضمن برنامج المكافحة المتكاملة للآفات. تضمنت المبيدات الحشرية 6 مبيدات كيماوية (أبامكتين، سبنتورام، ثيوسكلام، أزديراخين، لمبادا سيهالوثرين، وبرفينوفوس و عدد 2 من الزيوت (زيت معدني و زيت نباتى) و عدد 2 من الأسمدة الورقية (نترات كالسيوم و ونترات بوتاسيوم). أوضحت النتائج أن الأبامكتين أظهر باستمرار أعلى فعالية في القضاء على حشرة صانعات أنفاق أوراق الموالح بين العديد من المعاملات التي تم تقييمها على أشجار الليمون. وقد لوحظت هذه الفعالية على مدى خمس معاملات متتالية أجريت خلال موسم النمو لعام 2021 والتي أعطت نسب خفض لمستويات الاصابة تقدر بـ 79.60%، 85.90%، 81.20%، 89.40% و 92.10٪ على التوالي، وانخفاض كبير بنسبة 85.64٪. جاءت معاملة الزيت المعدني في المرتبة الثانية وأدت إلى انخفاض مستويات الإصابة بمقدار 64.90%، 63.10%، 65.70%، 70.90% و 70.50٪ بعد خمس تطبيقات متتالية، مع انخفاض كبير بنسبة 67.03٪. وفي الوقت نفسه أعطت،معاملة الزيت النباتي والسبينيتورام و لمبادا سيهالوثرين انخفاض في متوسط مستويات الإصابة يقدر بـ (50٪ تقريباً) والتى بلغت 52.50، 52.04 و 49.92٪ على التوالي، من خلال المعاملة خمس مرات متتالية. وقد لخصت نتائجنا إلى أن الأبامكتين وكذلك الزيت المعدني تظل معاملات قابلة للتطبيق وحيثيه للتحكم بشكل فعال في حشرة صانعات أنفاق أوراق الموالح في أشجار الليمون الصغيرة.