Investigating the Impact of Abamectin on Dust Mite, *Oligonychus afrasiaticus* Density and Anatomical Features of Date Fruits *cv.* Halawi

N. Aldosary[1*], Y.N. Kalaf[1], A.S.A. Abdullah[1], A.H. Radhi[2] and M.A. Al-Darwish[1]
(1) Date Palm Research Centre, University of Basrah, Basra, Iraq;
(2) Department of Plant Protection, College of Agriculture, University of Basrah, Basra, Iraq.
*Email address of the corresponding author: nasserh_1977@yahoo.com

Abstract

Aldosary, N., Y.N. Kalaf, A.S.A. Abdullah, A.H. Radhi and M.A. Al-Darwish. 2024. Investigating the Impact of Abamectin on Dust Mite, *Oligonychus afrasiaticus* Density and Anatomical Features of Date Fruits *cv.* Halawi. Arab Journal of Plant Protection, 42(4): 511-517. https://doi.org/10.22268/AJPP-001269

The high nutritional value and economic importance of date fruits are compromised by severe damage caused by pests such as the dust mite *Oligonychus afrasiaticus*. To control this pest, chemicals such as Abamectin are commonly used, although this may cause changes in the anatomical characteristics of date fruits. This study aimed to investigate the effect of Abamectin on the density of dust mites and the anatomical features of *cv.* Halawi dates. Date fruits were sprayed with Abamectin (1.8% EC) in five concentrations (0.0, 0.25, 0.50, 0.75 and 1.0 ml/L) during the Hababuk stage, and dust mite density and several anatomical characteristics of the fruits were evaluated. The results obtained showed a decrease in dust mite population density with increasing Abamectin concentration and a significant impact on certain anatomical features of date fruits. The highest thickness of the exocarp, cuticle, epidermis, hypodermis, stoncells, outer mesocarp, and inner mesocarp, as well as the number of pith cells were observed at the concentration of 1.0 ml/L. However, a reduction in the tannin layer was detected at higher concentrations. Positive correlations were found between Abamectin concentration and the thickness of certain fruit components, as well as the number of pith cells, whereas a negative correlation was found with dust mite population density. The study concluded that Abamectin application directly reduces dust mite density and improves the anatomical characteristics of date fruits.

Keywords: Abamectin, date palm, dust mite, pest density, anatomical characteristics.

Introduction

The date palm tree, *Phoenix dactylifera* L. is one of the oldest and most important cultivated species, being an economically significant fruit tree that is cultivated in tropical and subtropical regions of South West Asia and North Africa. In addition, it can be grown in Australia, Mexico, South America, South Africa, and the United States (Al-Alawi *et al.*, 2017). The date palm belongs to the family of Arecaeae and encompasses more than 200 genera and around 5000 species (Jonoobi *et al.*, 2019). The importance of the date palm lies in its fruits having high nutritional and economic value due to being rich in carbohydrates, fibers, proteins, minerals and vitamins (Al-Alawi *et al.*, 2017). Therefore, date palm fruits and their products have contributed to one of the elements of global food security for more than 5000 years (FAOSTAT, 2018). It was also mentioned by Al-Alawi *et al.* (2017) that color, taste, moisture and the absence of damage, such as cracks, defects and surface blemishes that are caused by pests, are among the important quality characteristics of date palm fruits to provide high nutritional and economic value. Therefore, control operations are directed to reduce the incidence of these pests (El Bouhssini & Faleiro, 2018; Haldhar *et al.*, 2015).

Oligonychus afrasiaticus is considered one of the economically important pests of date fruits, and can cause a reduction in the quality and quantity of these fruits (Ben Chaaban *et al.*, 2011; Elhalawany *et al.*, 2020). This pest causes economic damage to date palm production in Iraq, reaching up to 90% of total production in arid, sandy, and windy climates (Al-Jboory & Al-Suaide, 2010; El-Shafie, 2022). The damage occurs directly by feeding on date fruits and indirectly by spider webbing produced by the mite, which leads to the deformity of fruits, changes in their nutritional, morphological, and anatomical characteristics (Ben Chaaban *et al.*, 2011; Elhalawany *et al.*, 2020; El-Shafie, 2022). In addition, the spider webbing blocks light and air exchange, which affects metabolic processes in fruits (Elhalawany *et al.*, 2020), resulting in a decrease in yield and quality. Therefore, various methods have been used to reduce the damage caused by this pest (Arbabi *et al.*, 2017).

Despite the availability of multiple methods to combat this pest, chemical control of date palm mites is one of the most widely used methods to reduce its impact (Alhewairini *et al.*, 2021; El-Shafie, 2022), because it is rapid, economically feasible and easily applicable in comparison to other available methods (Al-Dosary, 2010; Ali & Fhaid, 2019). One of the main insecticides used in controlling this pest is Abamectin which belongs to the Avermectin family. Abamectin is a new and effective insecticide against a wide range of phytophagous pests. Its mode of action relies on its ability to disrupt the nerve system, thereby allowing Abamectin to kill resistant insects to other insecticides. It does not accumulate in the environment and has low toxicity to non-targeted animals; thus, it is widely used for mites, insects and nematode control (Al-Dosary, 2010; Alhewairini & Al-Azzazy, 2019). Numerous studies have reported the high efficacy of Abamectin in controlling date palm mites in different parts of the world (Al-Dosary, 2010; Palevsky *et*

https://doi.org/10.22268/AJPP-001269

al., 2004). However, studies have pointed out the effect of chemical insecticides on some plant attributes related to growth and anatomical changes in plant tissues (Giménez–Moolhuyzen *et al.,* 2020; Lichtenstein *et al.,* 1962; Sangiorgio *et al.,* 2022).

Although Abamectin is widely used as an insecticide to control dust mites, its effects on the anatomical characteristics of date palm fruits and its interaction with dust mite infestation are not well understood. Thus, the current study aimed to investigate the effect of Abamectin on the population density of *O. afrasiaticus* dust mites and some anatomical characteristics of the date palm fruits *cv.* Halawi.

Materials and Methods

Field experiment

This study was conducted between mid-April and early June 2022 in an orchard with a history of *O. afrasiaticus* infestation located in Basra, Iraq. Twenty date palms *cv.* Halawi of similar age were divided into five groups. Each group of four trees was sprayed two times using one of the following concentrations (0.0, 0.25, 0.50, 0.75 and 1 ml/L) (0= control treatment) of Abamectin 1.8% EC (Emulsifiable concentrate) (Cropstar Chemical Industry Co., Ltd. China), diluted with distilled water. Spraying was carried out on the fruit group of palm trees in the Hababok stage. The first application was sprayed four weeks after mid-March, whereas the second spraying was applied six weeks after the first one, using a 20-liter backpack sprayer with constant pressure. Ten strands were randomly collected from each treatment two weeks after the second spraying, and the samples were placed in airtight plastic containers to determine the density of *O. afrasiaticus*. Five fruits were randomly selected from each strand, and the *O. afrasiaticus* (all moving stages) were counted under a microscope (SD30, Olympus, Japan) in the laboratory (Alhewairini *et al.,* 2021). The remaining fruit samples were stored in a refrigerator at 5±3°C until used for the anatomical study.

Anatomical studies

The anatomical charactaristics included exocarp thickness, cuticle thickness, epidermis thickness, hypodermis thickness, stoncells thickness, outer mesocarp thickness, inner mesocarp thickness, pith cells number, tannin's layer thickness and vascular bundles number. The paraffin wax embedding method for date palm fruits described by Sakr *et al.* (2010) was followed. Five fruits from each bunch for each treatment were randomly selected. The samples were fixed with F.A.A. (5 ml formaldehyde, 5 ml HCl glacial, and 90 ml of 70% ethyl alcohol) for 24-48 hours, then washed one time with distilled water and twice with 70% ethyl alcohol for one hour and 18 hours, respectively, to eliminate the effects of the fixative. Subsequently, the samples were subjected to an ascending series of ethyl alcohol concentrations (70, 80, 90 and 95%) for one hour each and then placed in absolute ethyl alcohol (100%) overnight to remove all traces of water. Afterwards, the samples were dehydrated with mixtures of 3:1 and 1:1 (v/v) of absolute ethyl alcohol and xylene, then dipped in xylene alone for half an hour each. The samples were then transferred to a 1:1 (v/v) mixture of xylene and paraffin wax and placed in an oven at 60°C for 4 hours. The samples were then immersed in pure paraffin wax and placed in an oven at 60°C overnight. Next, the samples were embedded in special containers containing paraffin wax and oriented accordingly before being placed at room temperature for solidification and stored in the refrigerator. The paraffin wax embedded samples were then cut with a Rotatory Microtomn at a thickness range of 7-12 µm. The sections were transferred to a water bath at 45°C for staining and then picked up by glass slides coated with Albumin Myer and placed on a fisher slide warmer at 45°C. The samples were stained with fast green and safranine and mounted with Canada balsam before covering them with a coverslip. The slides were then viewed under an Olympus compound light microscope, using an Ocular Micrometer to complete the measurements after calibration with the Stage Micrometer.

Statistical analysis

The experiment was conducted according to the randomized complete block design (RCBD), and the results were analysed using ANOVA table, with the means compared by a least significant difference (LSD) test at a probability level of 0.05. The simple linear correlation was applied to find out the relationship between the anatomical changes in date palm fruits and the concentration of the insecticide on one hand, and the population density of dust mites on the other hand. The Statistical Analysis System (SAS) was used to analyse the data, and the results were presented as means ± standard deviation.

Results

Effect of Abamectin on the dust mite population density

A significant decrease in dust mite population density was observed with increasing Abamectin concentrations (Figure 1). The concentration of 1 ml/L produced the lowest density of 6.25 mites/fruit, compared to the control treatment (concentration 0 ml/L), which produced a higher density of 42.00 mites/fruit.

Effect of Abamectin on anatomical characteristics of date palm fruits

Abamectin treatment significantly affected certain anatomical characteristics of date palm *cv.* Halawi fruits (Figure 2). As the concentration increased, the thickness of the exocarp, cuticle, epidermis, hypodermis, and stone cells also increased, reaching their peak values of 106.50, 5.43, 9.60, 33.15, and 66.10 µm at 1 ml/L of Abamectin, respectively. These values were significantly higher than the control treatment (0.0 ml/L), which showed the lowest thicknesses of 67.00, 2.45, 4.93, 17.55, and 46.70 µm, respectively.

Furthermore, Abamectin positively affected the thickness of the outer mesocarp, tannin layer, and inner mesocarp. The 1 ml/L Abamectin concentration yielded the highest thicknesses of 877.50 and 2680.00 µm for the outer mesocarp and the inner mesocarp, respectively (Figure 2). Notably, this concentration also provided the lowest thickness of the tannin layer at 220.00 µm, which was

statistically significant from the other concentrations used. In contrast, the control treatment produced the lowest thickness of the outer mesocarp and inner mesocarp (491.25 and 1650.00 µm, respectively) and the highest thickness of the tannin layer (532.50 µm).

In addition, the control treatment provided the lowest amount of pith cells and the most significant number of vesicular bundles (871.50 and 28.05, respectively) (Figure 3). In comparison, 1 ml/L Abamectin concentration yielded the highest amount of pith cells and the lowest number of vesicular bundles (1050.00 and 15.60, respectively) (Figure 4). Overall, the results of this study suggest that Abamectin affected the anatomy of date palm fruits cv. Halawi.

Simple correlation analysis (Table 1) showed a positive relationship ($p < 0.0001$) between Abamectin concentrations and all of the thickness of each of exocarp cuticle layer, epidermis, hypodermis, stone cells, outer mesocarp, inner mesocarp layer and the number of pith cells. However, the results obtained showed a negative correlation ($p < 0.0001$) between the density of the dust mite on date palm fruits with the same characteristics above. In addition, a negative correlation ($p < 0.0001$) was found between Abamectin concentrations and both the tannin layer thickness and the number of vascular bundles. The correlation was also negative ($p < 0.0001$) between the dust mite density and the same characteristics mentioned above.

Discussion

The current study findings revealed a positive correlation between Abamectin concentrations and a negative relationship between the dust mite density with the thickness of exocarp, cuticle, epidermis, hypodermis, stoncells, outer mesocarp, inner mesocarp and pith cells. At the same time, there was a negative correlation between Abamectin concentrations and a positive relationship between the density of the dust mite with vascular bundles and tannin layer. This could be attributed to the positive impact of Abamectin on reducing the density of the dust mites on date fruit and consequently reducing the damage resulting from dust mites feeding, similar to what has been reported earlier (El-Shafie, 2022; Rajput *et al.*, 2016; Salman, 2019). Abamectin is one of the effective pesticides for combating dust mites (Salman, 2019), as it affects all mite stages (egg, larvae and adults) at different levels (Alhewairini & Al-Azzazy, 2019; Salman, 2019). Generally, Abamectin affects the targeted mite nervous system by blocking the gamma aminobutyric acid (GABA) neurotransmitter flow between the nerve endings of the mites. Also, it inhibits the binding of acetylcholine to nicotinic acetylcholine receptors on the nerve cells, leading to severe agitation and eventually complete paralysis of the mites and thus their death (Saber *et al.*, 2018; Vojoudi *et al.*, 2011).

The efficacy of Abamectin in mitigating mite infestation on fruit crops was observed to have a positive effect on the anatomical characteristics of date palms. Specifically, increased concentrations of Abamectin were correlated with a reduction of the damage caused to plant tissues by mites' stylet penetration. This is due to the stylet's ability to puncture cells, as well as extract plant sap and secrete a deleterious viscous substance onto the plant's vascular system, which impairs its ability to photosynthesize and, consequently, adversely affects its growth rate and morphology (Tehri, 2014).

The damage caused to plant tissues from mite feeding is primarily determined by the length of the stylets used to access the feeding sites (Bensoussan *et al.*, 2016; El-Shafie, 2022; Reyes-Zepeda *et al.*, 2022). Dust mite's web has been shown to have a deleterious effect on the growth, shape and colour of date palm fruits via interference with the cuticle, preventing light, gas and moisture exchange, which in turn hinders metabolic processes in the fruit (Elhalawany *et al.*, 2020). This study discovered that the exocarp layers and outer mesocarp of the date palm fruit were the most affected by the damage caused by mite feeding and the construction of mite web on the fruit. Furthermore, results indicated a negative correlation between dust mite density and thickness of the tannin layer, which was inversely proportional to the concentration of Abamectin. The tannin layer is significant in plants for the generation of tannins, which are substances that increase in plants under stress as a defensive response to external changes (Kernaghan *et al.*, 2022). Agrochemical damage is one of these external stresses (Moon *et al.*, 2022), which may be attributed to the role of tannins in providing protection from various pest infestations. Many studies revealed an increase in tannin levels, leading to an augmented thickness of the tannin layer in plants affected by pests (Steenbergen *et al.*, 2018).

It can be concluded from this study that Abamectin indirectly affected the anatomical characteristics of date palm fruits through its direct impact on the density of date palm dust mites. It was found that as the concentration of Abamectin increased, the density of dust mites on date palm fruits decreased, resulting in an increased exocarp, outer mesocarp and inner mesocarp layers thickness and decreased tannin layer thickness. This led to improved fruit anatomical characteristics.

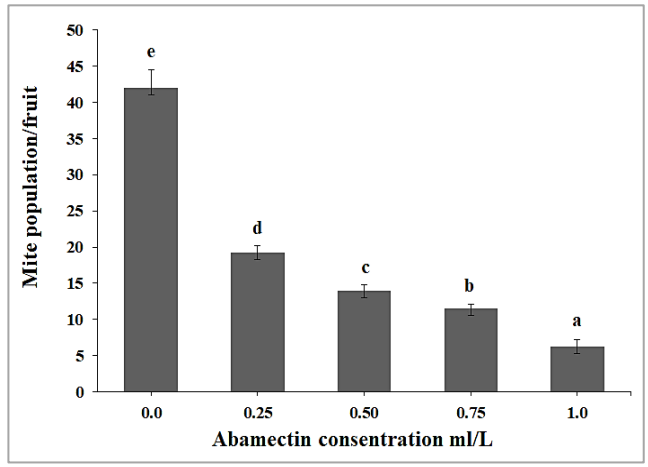

Figure 1. Effect of Abamectin on dust mite density, error bars are the standard deviation (n=50). Values marked with the same letters are not significantly different at P=0.05.

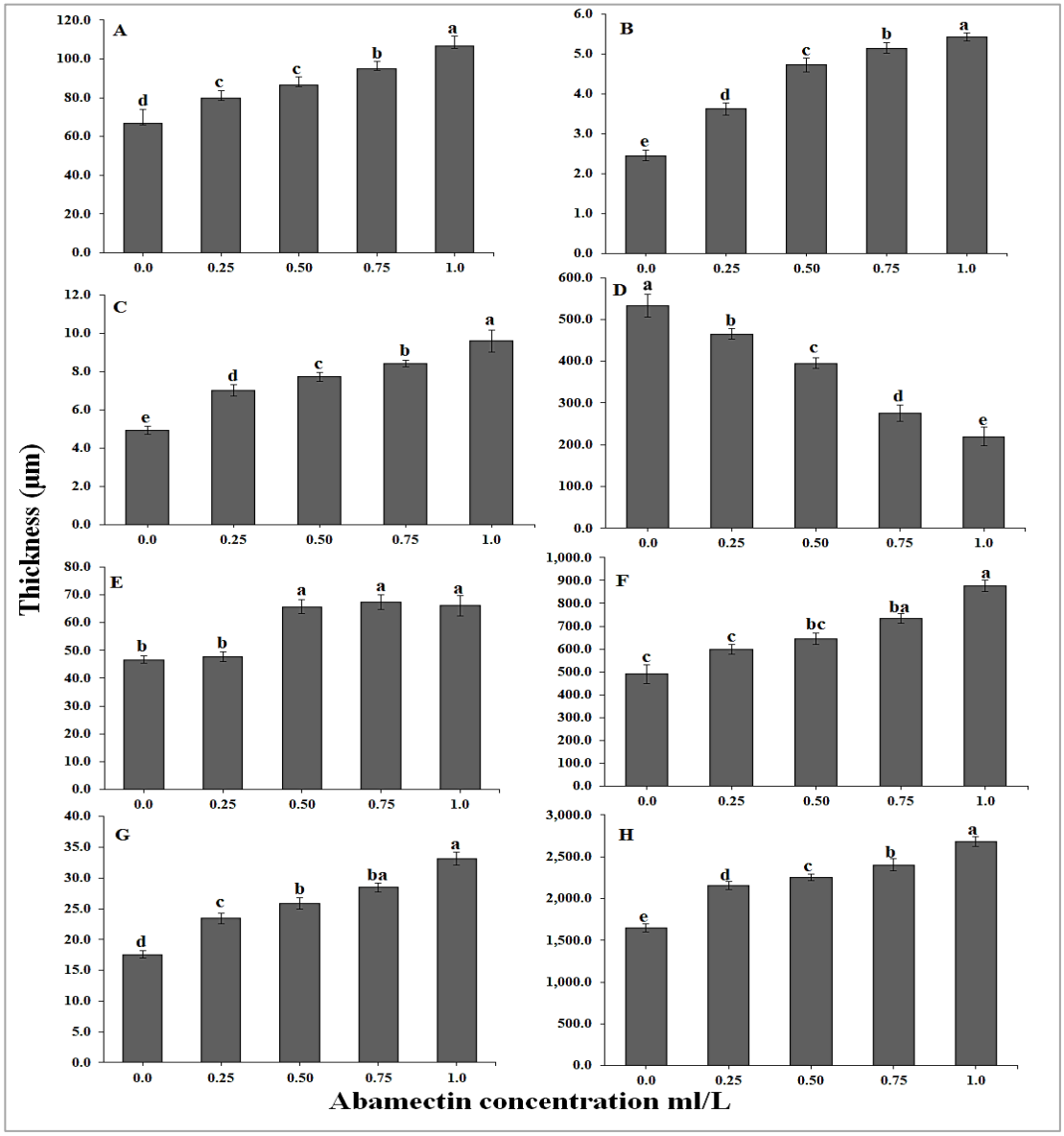

Figure 2. Effect of Abamectin on the thickness of A: exocarp, B: cuticle, C: epidermis, D: hypodermis, E: stoncells, F: outer mesocarp, G: tannins layer, H: inner mesocarp of date palm fruits, *cv*. Halawi. Error bars represent the standard deviasion (n=10). Values marked with the same letters are not significantly different at P=0.05.

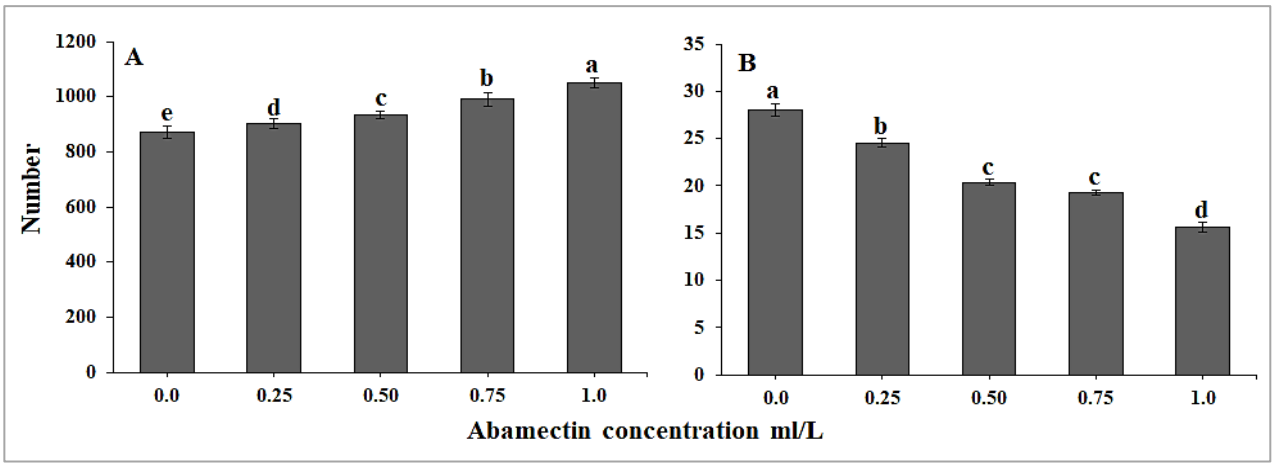

Figure 3. Effect of Abamectin on the number of A: pith cells, B: vVascular bundles of date palm fruits, *cv*. Halawi. Error bars represent the standard deviation (n=10). Values marked with the same letters are not significantly different at P=0.05.

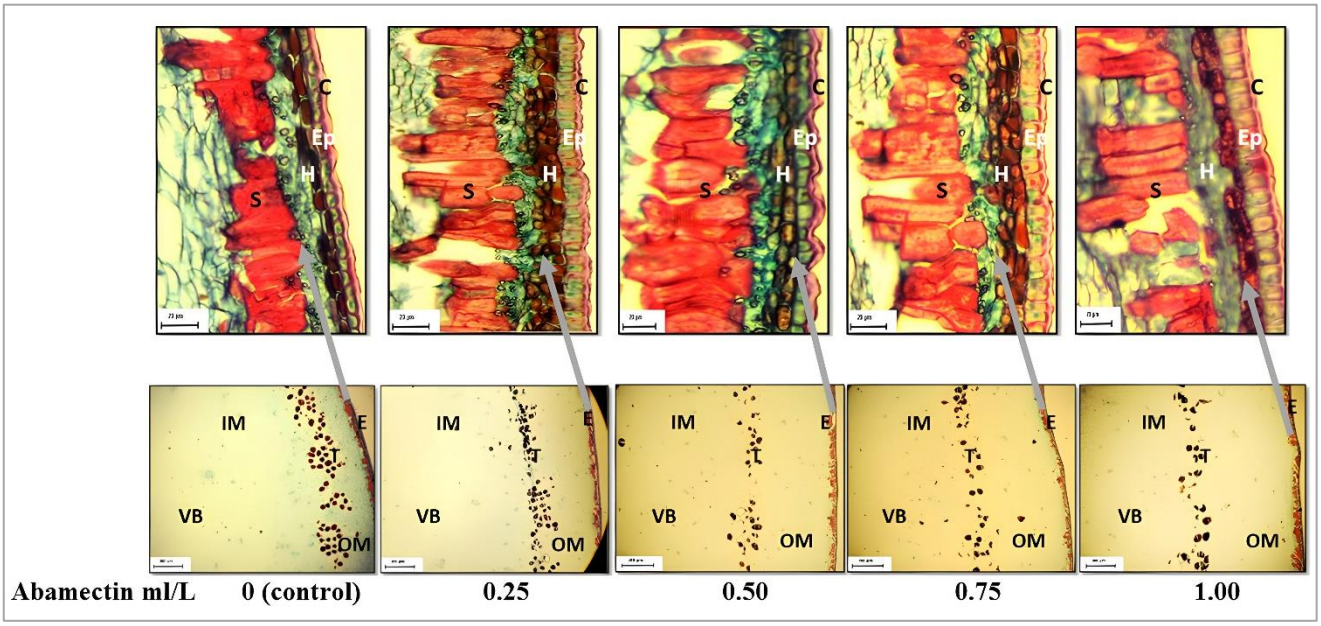

Figure 4. Cross section of date palm fruits, *cv.* Halawi, treated with different concentrations of Abamectin. C= Cuticle, Ep= Epidermis, H= Hypodermis, S= Stoncells, E= Exocarp, OM= Outer mesocarp, T= Tannins, IM= Inner mesocarp, VB= Vascular bundles.

Table 1. The simple linear correlation between dust mite population and the concentrations of Abamecin with some anatomical characteristics of the date palm fruits, *cv.* Halawi.

	Treatments			
	Concentrations of Abamecin		**Dust mite population**	
Anatomical characteristics	**ml/L**	***P* value***	**mite/fruit**	***P* value***
Exocarp thickness	0.95	<.0001	-0.87	<.0001
Cuticle thickness	0.95	<.0001	-0.94	<.0001
Epidermis thickness	0.96	<.0001	-0.95	<.0001
Hypodermis thickness	0.87	<.0001	-0.77	<.0001
Stoncells thickness	0.83	<.0001	-0.77	<.0001
Outer mesocarp thickness	0.78	<.0001	-0.74	<.0001
Inner mesocarp thickness	0.94	<.0001	-0.95	<.0001
Number Pith cells	0.96	<.0001	-0.81	<.0001
Tannins layer thickness	-0.98	<.0001	0.86	<.0001
Number Vascular bundles	-0.98	<.0001	0.92	<.0001

* The significance of correlation at p≤0.01

الملخص

الدوسري، ناصري حميد، يحيى نوري خلف، عبد الصمد عبود عبد الله، علاء حسن راضي ومحمد عبد الباسط درويش. 2024. تأثير الرش بمبيد الأبامكتين على الكثافة العددية لحَلَم الغبار (*Oligonychus afrasiaticus*) وبعض الصفات التشريحية لثمار نخيل التمر صنف الحلاوي. مجلة وقاية النبات العربية، 42(4): 511–517. https://doi.org/10.22268/AJPP-001269

تصاب ثمار نخيل التمر بالعديد من الآفات، ومن أهمها حَلَمَ الغبار (*Oligonychus afrasiaticus*) الذي قد يسبب أضراراً اقتصادية ويقلل من القيمة الغذائية للثمار، ما لم تتمّ مكافحته. لذلك استخدم مبيد الأبامكتين بشكل واسع لتقليل ضرر هذه الآفة، إلّا أن هذه المعاملة قد تؤثر على الثمار وبخاصةٍ عند استخدام هذا المركب بتراكيز عالية. هدفت هذه الدراسة إلى التحقق من تأثير الأبامكتين على الكثافة العددية لحَلَم الغبار والصفات التشريحية لثمار التمر صنف الحلاوي. رشّت ثمار التمر بخمسة تراكيز (0، 0.25، 0.50، 0.75 و 1 مل/ليتر) من الأبامكتين خلال مرحلة الحبابوك، وحسبت الكثافة العددية لحلم الغبار، ودرست بعض الصفات التشريحية للثمار. أظهرت النتائج انخفاضاً في الكثافة العددية لحَلَم الغبار مع زيادة تركيز الأبامكتين، ووجد أنّ له تأثير ملحوظ في بعض الصفات التشريحية لثمار التمر. إذ سجلت أعلى سماكة للغطاء الخارجي والبشرة والطبقة الخارجية وطبقة البشرة الداخلية وخلايا القشرة الخارجية والداخلية وعدد الخلايا الحجرية عند تركيز 1 مل/ليتر.

بينما سجلت أقل سماكة للطبقة التانينية عند هذا التركيز كما وجدت علاقة ارتباط إيجابية بين تركيز الأبامكتين وسماكة بعض مكونات الثمار، بالإضافة إلى عدد الخلايا الحجرية، في حين وُجِدَت علاقة سلبية مع الكثافة العددية لحلم الغبار. من خلال هذه النتائج، أثبتت الدراسة الحالية أن لمبيد الأبامكتين تأثير غير مباشر في بعض الصفات التشريحية لثمار نخيل التمر من خلال التأثير المباشر على الكثافة العددية لحَلَم الغبار.

كلمات مفتاحية: أبامكتين، نخلة التمر، حَلَم الغبار، الكثافة العددية، الصفات التشريحية.

عناوين الباحثين: ناصر حميد الدوسري[1*]، يحيى نوري خلف[1]، عبد الصمد عبود عبد الله[1]، علاء حسن راضي[2] ومحمد عبد الباسط درويش[1]. (1) مركز أبحاث النخيل، جامعة البصرة، البصرة، العراق؛ (2) قسم وقاية النبات، كلية الزراعة، جامعة البصرة، البصرة، العراق. *البريد الإلكتروني للباحث المراسل: nasserh_1977@yahoo.com

References

Al-Alawi, R.A., J.H. Al-Mashiqri, J.S. Al-Nadabi, B.I. Al-Shihi and Y. Baqi. 2017. Date palm tree (*Phoenix dactylifera* L.): natural products and therapeutic options. Frontiers in Plant Science, 8:845. https://doi.org/10.3389/fpls.2017.00845

Al-Dosary, N.H. 2010. Evaluation of the efficiency of some insecticides and stick color traps to protect date palm fruits from infestation with dust mite *Oligonychus afrasiaticus* (Mcgregor) and lesser date moth *Batrachedra amydraula* (Merck). Basrah Journal of Agricultural Sciences, 23(1):1-21.

Alhewairini, S.S. and M.M. Al-Azzazy. 2019. Toxicity evaluation of Abamectin against the date palm mite, *Oligonychus afrasiaticus* (McGregor) (Acari: Tetranychidae). Journal of Food, Agriculture and Environment, 17(1):30-35. https://doi.org/10.1234/4.2019.5549

Alhewairini, S.S., M.M. Al-Azzazy, S.B.A. Ghani and M.A. Al-Deghairi. 2021. A new strategy for controlling the date palm mite, *Oligonychus afrasiaticus* (McGregor) and *Eutetranychus palmatus attiah* (Acari: Tetranychidae) using cinnamaldehyde. Pakistan Journal of Agricultural Sciences, 58(2):783-789. https://doi.org/10.21162/PAKJAS/21.149

Ali, H.M. and K.A. Fhaid. 2019. Field efficacy of pesticides against dust mite *Oligonychus afrasiaticus* (McGregor) (Acari: Tetranchidae) on date palm, Hillawi cultivar. Basrah Journal of Agricultural Sciences, 32(2):160-168. https://doi.org/10.37077/25200860.2019.206

Al-Jboory, I.J. and T.M. Al-Suaide. 2010. Effect of temperature on the life history of the old-world date mite, *Oligonychus afrasiaticus* (Acari: Tetranychidae). Pp. 361-363. *In:* Trends in Acarology. M.W. Sabelis and J. Bruin (eds.). Springer, Amsterdam, Dordrecht, the Netherlands. https://doi.org/10.1007/978-90-481-9837-5

Arbabi, M., M. Latifian, M. Askari, M. T. Fasihi, M. R. Damghani, N.G. Zadeh and H. Rezai. 2017. Evaluation of different treatments in the control of *Oligonychus afrasiaticus* in date palm orchards of Iran. Persian Journal of Acarology, 6(2):125-135. https://doi.org/10.22073/pja.v6i2.17599

Ben Chaaban, S., B. Chermiti and S. Kreiter. 2011. Comparative demography of the spider mite, *Oligonychus afrasiaticus*, on four date palm varieties in southwestern Tunisia. Journal of Insect Science, 11(1):1-12. https://doi.org/10.1673/031.011.13601

Bensoussan, N., M. E. Santamaria, V. Zhurov, I. Diaz., M. Grbić and V. Grbić. 2016. Plant-herbivore interaction: dissection of the cellular pattern of Tetranychus urticae feeding on the host plant. Frontiers in Plant Science, 7:1105. https://doi.org/10.3389/fpls.2016.01105

El Bouhssini, M and J.R. Faleiro. 2018. Date Palm Pests and Diseases: Integrated Management Guide. International Center for Agricultural Research in the Dry Areas (ICARDA), Beirut, Lebanon. 233pp.

Elhalawany, A.S., N.F. Ahmad and A. Amer. 2020. Biological aspects of date palm dust mite, *Oligonychus afrasiaticus* (McGregor) (Acari: Tetranychidae) on fronds of three date palm cultivars. Egyptian Academic Journal of Biological Sciences. (A.Entomology), 13(1), 89-98. https://doi.org/10.21608/eajbsa.2020.74534

El-Shafie, H.A. 2022. The old world date palm mite *Oligonychus afrasiaticus* (McGregor 1939) (Acari: Tetranychidae), a major fruit pest: biology, ecology, and management. CABI Reviews, 17:020. https://doi.org/10.1079/cabireviews202217020

FAO STAT. 2018. http://www.fao.org/faostat/en/#data/QC

Giménez–Moolhuyzen, M., J. van der Blom, P. Lorenzo–Mínguez, T. Cabello and E. Crisol–Martínez. 2020. Photosynthesis inhibiting effects of pesticides on sweet pepper leaves. Insects, 11(2):69. https://doi.org/10.3390/insects11020069

Haldhar, S.M., V. Karuppaiah, C.M. Muralidharan and S.K. Sharma. 2015. Insect-pests of date palm and their management. Pp. 405-421. *In:* Insect Pests Management of Fruit Crops. A.K. Pandey and P. Mall (eds.). Biotech Books, New delhi, India.

Jonoobi, M., M. Shafie, Y. Shirmohammadli, A. Ashori, H.Z. Hosseinabadi and T. Mekonnen. 2019. A review on date palm tree: properties, characterization and its potential applications. Journal of Renewable Materials, 7(11):1055-1075. https://doi.org/10.32604/jrm.2019.08188

Kernaghan, G., A. Griffin, J. Gailey and A. Hussain. 2022. Tannin tolerance and resistance in dark septate endophytes. Rhizosphere, 23:100574. https://doi.org/10.1016/j.rhisph.2022.100574

Lichtenstein, E. P., W. F. Millington and G. T. Cowley. 1962. Insecticide effects on plant growth, effect of various insecticides on growth and respiration of plants. Journal of Agricultural and Food Chemistry, 10(3):251-256. https://doi.org/10.1021/jf60121a024

Moon, T.T., I.J. Maliha, A.A. M. Khan, M. Chakraborty, M.S. Uddin, M.R. Amin and T. Islam. 2022. CRISPR-Cas genome editing for insect pest stress management in crop plants. Stresses, 2(4):493-514. https://doi.org/10.3390/stresses2040034

Palevsky, E., O. Ucko, S. Peles, S. Yablonski and U. Gerson. 2004. Evaluation of control measures for Oligonychus afrasiaticus infesting date palm cultivars in the southern Arava Valley of Israel. Crop Protection, 23(5):387-392. https://doi.org/10.1016/j.cropro.2003.09.008

Rajput, L.B., S.A. H. Shah, S. Rajput, N.A. Wahocho and M.M. Khan. 2016. Efficacy of different acaricides against the date spider mite (*Oligonychus afrasiaticus* Meg) under field condition. The Entomological Society Of Karachi (Pakistan), 31(1):91-99.

Reyes-Zepeda, F., R.T.Q. Heinz-Castro, F.E. Olazaran-Santibañez, S. Ordaz-Silva, J.G. Pedro-Méndez and J.C. Chacón-Hernández. 2022. Evaluation of ethanolic powdered extract of *Magnolia tamaulipana* Vazquez against *Oligonychus punicae* Hirst (Trombidiformes: Tetranychidae). Plants, 11(13):1711. https://doi.org/10.3390/plants11131711

Saber, M., Z. Ahmadi and G. Mahdavinia. 2018. Sublethal effects of spirodiclofen, abamectin and pyridaben on life-history traits and life-table parameters of two-spotted spider mite, *Tetranychus urticae* (Acari: Tetranychidae). Experimental and Applied Acarology, 75(1):55-67. https://doi.org/10.1007/s10493-018-0226-2

Sakr, M.M., I.A. Zeid, A.E. Hassan, A.G.I.O. Baz and W.M. Hassan. 2010. Identification of some date palm (*Phoenix dactylifera*) cultivars by fruit characters) cultivars by fruit characters. Indian Journal of Science and Technology, 3(3):338-343. https://doi.org/10.17485/ijst/2010/v3i3/29712

Salman, A.M. 2019. Toxicity of some acaricides against *Oligonychus afrasiaticus* (McGregor) (Acari: Tetranychidae) under laboratory conditions in the new Valley, Egypt. Assiut Journal of Agricultural Sciences, 50(1):75-80. https://doi.org/10.21608/ajas.2019.33460

Sangiorgio, D., F. Spinelli and E. Vandelle. 2022. The unseen effect of pesticides: The impact on phytobiota structure and functions. Frontiers in Agronomy, 4:936032. https://doi.org/10.3389/fagro.2022.936032

Steenbergen, M., A. Abd-el-Haliem, P. Bleeker, M. Dicke, R. Escobar-Bravo, G. Cheng, M.A. Haring, M.R. Kant, I. Kappers, P.G.L. Klinkhamer, K.A. Leiss, S. Legarrea, M. Macel, S. Mouden, C.M.J. Pieterse, S.J. Sarde, R.C. Schuurink, M. De Vos, S.C.M. Van Wees and C. Broekgaarden. 2018. Thrips advisor: exploiting thrips-induced defences to combat pests on crops. Journal of Experimental Botany, 69(8):1837-1848. https://doi.org/10.1093/jxb/ery060

Tehri, K. 2014. A review on reproductive strategies in two spotted spider mite, *Tetranychus urticae* Koch 1836 (Acari: Tetranychidae). Journal of Entomology and Zoology Studies, 2(5):35-39.

Vojoudi, S., M. Saber, M.J. Hejazi and R. Talaei-Hassanloui. 2011. Toxicity of chlorpyrifos, spinosad and Abamectin on cotton bollworm, Helicoverpa armigera and their sublethal effects on fecundity and longevity. Bulletin of Insectology, 64(2):189-193.

Received: August 3, 2023; Accepted: October 24, 2023

تاريخ الاستلام: 2023/8/3؛ تاريخ الموافقة على النشر: 2023/10/24