



Efficacy of a single root drench application of thiamethoxam for the management of dubas bug and white date scale on date palms

Mokhtar Abdulsattar Arif¹ · Salvatore Guarino²

Received: 25 August 2025 / Accepted: 3 April 2026 / Published online: 16 April 2026
© The Author(s) 2026, modified publication 2026

Abstract

Date palms (*Phoenix dactylifera*) are a vital crop in the Middle East, particularly in Iraq, where infestations by the dubas bug (*Ommatissus lybicus*) and the white date scale (*Parlatoria blanchardi*) significantly threaten yield and fruit quality. This study assessed the efficacy of a single soil drench application of thiamethoxam (Actara 240 SC) for controlling these pests in two cultivars, Barhi and Brem, under field conditions. Treatments resulted in a substantial and sustained reduction in pest populations compared to untreated controls over a 120-day period. Residue analysis using gas chromatography demonstrated systemic absorption and gradual dissipation of thiamethoxam in leaves and fruits, with residues declining below detection limits by 120 days after treatment. The temporal correlation between residue decline and pest suppression underscores the prolonged protective effect of root drenching. These findings support the use of a single root drench as an effective, long-lasting, and potentially more sustainable pest management strategy that reduces the need for repeated foliar applications, thereby lowering labor and chemical inputs.

Keywords *Phoenix dactylifera* · Neonicotinoid insecticide · Integrated pest management (IPM) · Pesticide residues

Introduction

Date palms (*Phoenix dactylifera* L.) are a cornerstone crop in the Middle East, underpinning both the cultural heritage and agricultural economies of the region, and playing a particularly vital role in Iraq (Khierallah et al., 2015). However, growers face persistent challenges from key insect pests, notably the dubas bug, *Ommatissus lybicus* de Bergevin (Hemiptera: Tropicodidae) (Mokhtar and Al Nabhani, 2010; Al-Kindi et al., 2017) and the white date scale, *Parlatoria blanchardi* Targioni Tozzetti (Hemiptera: Diaspididae), which together pose significant threats to date palm health and productivity (Al Antary et al., 2015; Awadalla et al., 2023).

The dubas bug is a major endemic pest across Iraq and neighboring countries, frequently causing substantial yield

losses and compromising fruit quality. Direct feeding by nymphs and adults not only weakens the trees but also leads to fruit of lower sugar content and reduced size. Additionally, honeydew excreted by dubas bugs fosters the growth of sooty mold, further deteriorating fruit marketability (Al-Nabhani et al., 2023). Infestations can result in yield reductions exceeding 50% in affected areas, making the dubas bug a focus of integrated pest management strategies.

Similarly, *Parlatoria blanchardi* is widely recognized as a destructive pest in date palm plantations throughout the Middle East (Ouameur et al., 2025). The white date scale adversely impacts photosynthetic pigments (chlorophyll a, chlorophyll b, and carotenoids) as well as leaflet area, moisture content, dry weight, and wax proportion, leading to yield reductions of 30–50 kg per palm (Idris et al., 2006). Losses can sometimes exceed 85–90%, depending on several factors such as varietal tolerance, infestation severity, and orchard management (Ahmed, 2013). The prevalence and economic impact of these pests are exacerbated by factors including regional climate, palm density, cultivar, and the movement of infested plant material.

Together, dubas bug and white date scale represent persistent obstacles to sustainable date palm cultivation in Iraq and the wider region, necessitating ongoing research and the

✉ Salvatore Guarino
salvatore.guarino@cnr.it

¹ Plant Protection Directorate, Ministry of Agriculture, Abu-Ghraib, Baghdad 10081, Iraq

² Institute of Biosciences and BioResources (IBBR), National Research Council of Italy, Via Ugo La Malfa 153, Palermo 90146, Italy

implementation of effective monitoring and integrated pest management approaches.

The most commonly used insecticides to control dubas bug and white date scale are organophosphates (e.g., diazinon, dimethoate), pyrethroids (e.g., deltamethrin), and botanical insecticides such as azadirachtin (Al-Rawahi et al., 2018; Ouameur et al., 2025). These are used in the Middle East, including Iraq and Oman, mainly through foliar sprays or aerial applications (Ali and Hama 2016; Blumberg et al., 2008).

Negative effects determined by their use include environmental contamination, harm to non-target organisms (including beneficial insects), resistance development among pest populations, and potential human health risks from residues (Guarino et al., 2013; Martinez et al., 2013). To mitigate these, low impact methods (e.g. root drenching) and reduced application frequency are recommended in promoting an effective integrated pest management for these pests.

Drenching provides prolonged, whole-plant protection, reduces environmental contamination and spray drift, and improves control of hidden pests compared to foliar sprays. Neonicotinoids such as thiamethoxam, which are highly effective against sucking pests, are particularly suitable for soil drenching applications, as their polar chemical structure and high water solubility facilitate absorption through the root zone and systemic distribution within the plant (Arbabtafti et al., 2014; Goulson, 2013). However, due to their non-target risk, high specificity, and flexible application methods, such insecticides must be carefully managed within resistance management programs to preserve their long-term effectiveness (Jeschke and Nauen, 2008). Minimizing the number of applications is important to reduce environmental impact, also in consideration of possible risk for pollinators related with the use of this insecticide (Obregon et al., 2022; Jiang et al., 2018), delay pest resistance, and lower costs, supporting sustainable pest management (Nauen and Denholm, 2005a). It should be noted that thiamethoxam, like other neonicotinoids, is currently subject to severe restrictions in several regions, including a full ban on outdoor uses in the European Union, due to concerns about pollinator safety, environmental persistence, and residue risks; therefore, its use in date palm management must be carefully evaluated within an integrated pest management framework and in compliance with national regulations.

Our objective was to evaluate/demonstrate the efficacy of a single thiamethoxam application by root drenching for the control of dubas bug and white date scale on palms. This method allows the insecticide to be systemically absorbed and distributed throughout plant tissues, ensuring extended protection with one treatment. However,

studies investigating the persistence of thiamethoxam following treatment, especially in palm tissues from application through to fruit harvest, remain limited (Chihouai-Meridja et al., 2020). To address this gap, this study was conducted to evaluate the residual presence of the pesticide within the plant system, to assess its effectiveness against target pests in order to determine the optimal pre-harvest interval required to ensure food safety and compliance with established residue limits. By relying on a single drench, we aim to minimize repeated field applications, reduce labor and operational costs, and limit environmental and non-target exposure. Demonstrating the effectiveness of this approach also supports integrated pest management by lowering the risk of resistance development. Contextually, in consideration that monitoring the concentration of insecticide within treated palms is essential to assess its persistence and efficacy over time, we conducted gas chromatography analyses to quantify thiamethoxam residual amounts throughout the study.

Materials and methods

Field selection and experimental design

A field experiment was conducted in a private date palm orchard in West Baghdad Province, Iraq. The orchard was planted with two cultivars, Barhi and Brem, with trees of comparable age and approximately 8 m in height. The site was known for recurrent infestations of the white date scale *P. blanchardi* and the dubas bug *O. lybicus*. Palm trees were considered infested if any signs of pest activity were present, including live adults or nymphs, honeydew and leaf yellowing caused by *O. lybicus*, or visible scale coverage by *P. blanchardi*. For the latter, all mobile stages of *P. blanchardi* were considered when assessing pest populations and also sessile scales that were inactive or covered by wax were also included if they showed signs of feeding. No minimum density threshold was required; a single detectable pest or diagnostic symptom was sufficient to classify a palm as infested. The insecticide used in this experiment was thiamethoxam (Actara 240 SC, Syngenta, Basel, Switzerland), applied by soil drenching. To carry out the treatment a circular trench was dug around the base of each palm, and a solution of 75 mL Actara (18 g of thiamethoxam) in 200 L water per tree was poured into the trench. The relatively large volume of solution was used to ensure adequate infiltration into the soil surrounding the root zone and to facilitate systemic uptake of thiamethoxam by the palm. Applications were performed after sunset to minimize evaporation and enhance uptake. The treatment was carried out on the 10th of April.

The experiment followed a factorial design with two factors: treatment (treated vs. untreated) and cultivar (Barhi vs. Brem). For each cultivar, five infested palms were treated, and five infested palms were left untreated as controls. The sample size was limited primarily by the restricted availability of naturally infested palms exhibiting comparable infestation levels and similar agronomic conditions within the study site. To reduce variability, we carefully selected trees of similar age, size, and infestation severity, and all selected palms were monitored concurrently under identical environmental conditions.

Insect infestation assessments

Populations of *O. lybicus* and *P. blanchardi* were monitored simultaneously on the same palms. Sampling was conducted before treatment and at 30, 60, 90, and 120 days after treatment (dat).

For *O. lybicus*, infestation levels were assessed by visual inspection and manual counting of mobile stages (nymphs and adults) on fixed leaflet positions (35–40 cm long × 2–3 cm width) from each palm.

For *P. blanchardi*, leaflets were collected at each sampling date, placed in labeled plastic bags, and transported to the laboratory under cooled conditions. Infestation density was quantified using a stereomicroscope by counting individuals in a standardized 1 cm² area per leaflet.

Determination of pesticide residues

Chemicals and standards

High-purity (>99%) analytical standard thiamethoxam was obtained from Dr. Ehrenstorfer (Germany). Acetonitrile and ultrapure water were purchased from Chemlab (Belgium), while sodium chloride (NaCl) and anhydrous magnesium sulfate (MgSO₄) were sourced from Romil (UK). QuEChERS extraction kits were provided by Agilent Technologies Inc. (USA).

Preparation of standards and calibration curves

Stock solutions of thiamethoxam were prepared in acetonitrile at concentrations of 1, 5, 10, and 15 mg/kg. Working standards were used for calibration and method validation (LOD and LOQ). Both stock and working solutions were stored at −18 °C. Calibration curves showed excellent linearity ($R^2 = 0.99$). Moreover, the recovery test of the analytical method was assessed, with results indicating 72% recovery from leaflet samples and 78% from fruit samples, demonstrating acceptable reliability and accuracy of the extraction and quantification procedures according European Commission's SANTE/11,312/2021 guidelines.

Sample collection and preparation

Leaflets and date fruits from Barhi and Brem palms cultivar were collected at each sampling interval. Leaflets were collected from the lower, middle, and upper crown levels, at north, east, south, and west positions, to ensure representative sampling of the entire tree canopy. Samples were placed in sterile polypropylene bags, sealed, and transported to the laboratory at 4 °C. For residue analysis, leaflets or fruits were collected separately during each sampling period, pooled to form a composite sample, washed, air-dried, and homogenized. Subsequently, 10 g portions of the homogenized tissue were processed following the European Commission's SANTE/11,312/2021 guidelines, ensuring reproducibility and compliance with standardized analytical procedures.

Extraction and Clean-up

A 10 g subsample was mixed with 10 mL acetonitrile containing 1% (v/v) acetic acid, shaken for 3 min, and incubated at 4 °C for 60 min. After addition of 2 g MgSO₄ and 0.5 g NaCl, the mixture was vortexed and centrifuged (4500 rpm, 15 min). The supernatant was purified using QuEChERS SPE kits, evaporated to dryness, reconstituted to 1 mL, and filtered (0.45 µm PTFE syringe filters).

Instrumental analysis

Thiamethoxam quantification was performed with a Shimadzu GC-2014 gas chromatograph (Kyoto, Japan) equipped with a flame ionization detector (FID). Separation was achieved using an Rxi-5Sil MS capillary column (60 m × 0.25 mm, 0.25 µm film thickness). The oven program was: 150 °C (1 min), ramped at 20 °C/min to 270 °C, hold for 20 min. Injector and detector temperatures were 260 °C and 290 °C, respectively. Nitrogen (99.9%) was used as carrier gas. All chemical analyses were conducted at the laboratories of the National Center for Pesticide Control, Plant Protection Directorate, Baghdad, Iraq.

Statistical analysis

The mean number of individuals of *O. lybicus* and *P. blanchardi* sampled in treated and control palms were compared by using an ANOVA using “treatment”, “days after treatment” and “palm cultivar” as source of variation. The interaction among “treatment” and “days after treatment” was also subjected to Tukey test to evaluate the effect of the treatment across time. Data were root square transformed before analysis to address heteroscedasticity (non-constant variance) and approximate normality. Statistical analyses were carried out using Statistica 10.0 for Windows (Statsoft 2001, Vigonza, PD, Italy).

Results

Omatissus lybicus

The effect of the treatment in treated and control palms is reported in Fig. 1. Overall, the insecticide treatment had a highly significant effect on *O. lybicus* populations, with treated palms showing markedly lower numbers of adults compared with the untreated controls ($F_{1,80} = 242.1$, $p < 0.001$). The number of individuals was significantly lower in treated palms compared with control palms at both 30, 60, 90 and 120 days after treatment ($p < 0.05$; ANOVA followed by Tukey test) (Fig. 1; SM1).

A significant effect of days after treatment was also detected ($F_{4,80} = 108.7$, $p < 0.001$), indicating that adult population densities varied substantially across the sampling period. Moreover, both the treatment $\times$ days after treatment interaction ($F_{4,80} = 21.7$, $p < 0.001$) and the cultivar $\times$ days after treatment interaction ($F_{4,80} = 9.2$, $p < 0.001$) were significant. These results demonstrate that population trends over time were not uniform: the reduction in adult numbers due to insecticide application was more pronounced at certain days after treatments. In contrast, cultivar alone did not significantly affect adult abundance ($F_{1,80} = 0.4$, $p = 0.518$), nor did the treatment $\times$ cultivar ($F_{1,80} = 0.8$, $p = 0.374$) or the three-way interaction ($F_{4,80} = 1.7$, $p = 0.169$). This indicates that both cultivars were equally susceptible to *O. lybicus*, and that the insecticide efficacy was consistent between them.

Parlatoria blanchardi

The effect of the treatment in treated and control palms is reported in Fig. 2. The insecticide treatment had a significant

effect on the number of *P. blanchardi* individuals, with treated palms showing consistently lower infestations compared with untreated controls ($F_{1,80} = 765.6$, $p < 0.001$). The number of individuals was significantly lower in treated palms compared with control palms at both 30, 60, 90 and 120 days after treatment ($p < 0.05$; ANOVA followed by Tukey test) (Fig. 2; SM1).

A highly significant effect of days after treatment was detected ($F_{4,80} = 38.10$, $p < 0.001$), reflecting clear temporal variation in the abundance of *P. blanchardi*. The treatment $\times$ days after treatment interaction was also significant ($F_{4,80} = 82.80$, $p < 0.001$), indicating that differences between treated and untreated palms varied across sampling times. However, the treatment $\times$ cultivar interaction was significant ($F_{1,80} = 11.7$, $p < 0.01$), demonstrating that the efficacy of the insecticide differed between the two cultivars, with the treatment for effective in Barhi cultivar in comparison with Brem.

Residual presence

Thiamethoxam residues showed a progressive decline over time in both fruits and leaves of the Barhi and Brem date palm cultivars (Table 1). In Barhi fruits, concentrations decreased from 1.16 ± 0.24 mg/kg at 30 days after treatment (dat) to 0.066 ± 0.02 mg/kg at 90 dat, becoming undetectable by 120 dat. A similar pattern was observed in the leaves, where residues dropped from 2.13 ± 0.52 mg/kg at 30 dat to 0.053 ± 0.02 mg/kg at 90 dat, with no detectable residues at 120 dat. In the Brem cultivar, fruit concentrations declined from 0.59 ± 0.10 mg/kg at 30 dat to 0.02 ± 0.005 mg/kg at 90 dat, also falling below the detection limit by 120 dat. Leaf residues in Brem followed the same trend, decreasing from 1.66 ± 0.14 mg/kg at 30 dat to 0.15 ± 0.02 mg/kg at 90 dat, but still being detectable at 120 dat (0.01 ± 0.001 mg/kg).

Fig. 1 Mean ($\pm$ SE) individuals of *Omatissus lybicus* before and after 30, 60, 90 and 120 days after treatment (dat) present in single leaflet (35–40 cm long $\times$ 2–3 cm width); ctrl=control. ** indicates $p < 0.01$; * indicates $p < 0.05$ (ANOVA followed by Tukey test)

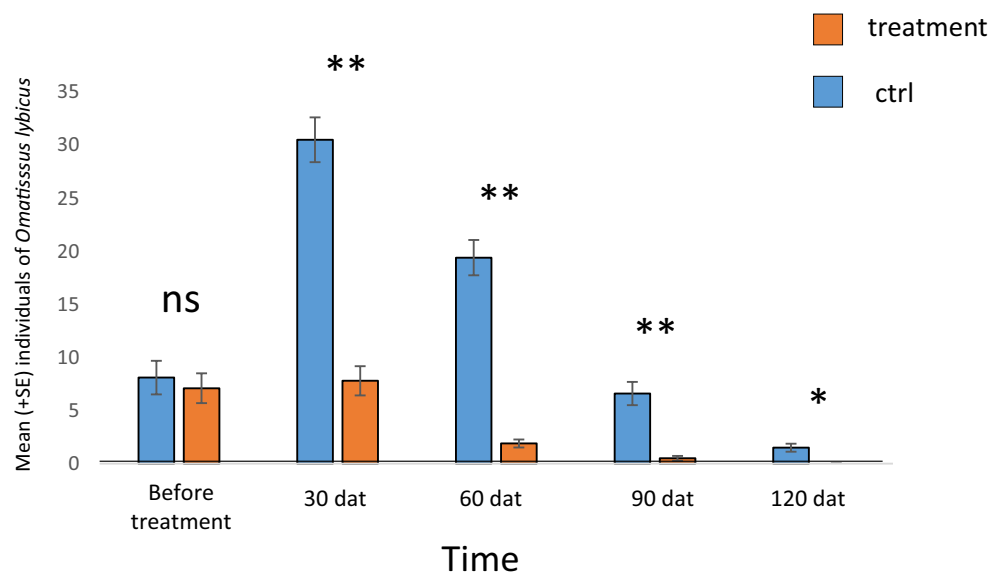


Fig. 2 Mean ($\pm$ SE) individuals of *Parlatoria blanchardi* before and after 30, 60, 90 and 120 days after treatment (dat) present in 1 cm² area per leaflet; ctrl=control. ** indicates $p<0.01$; * indicates $p<0.05$ (ANOVA followed by Tukey test)

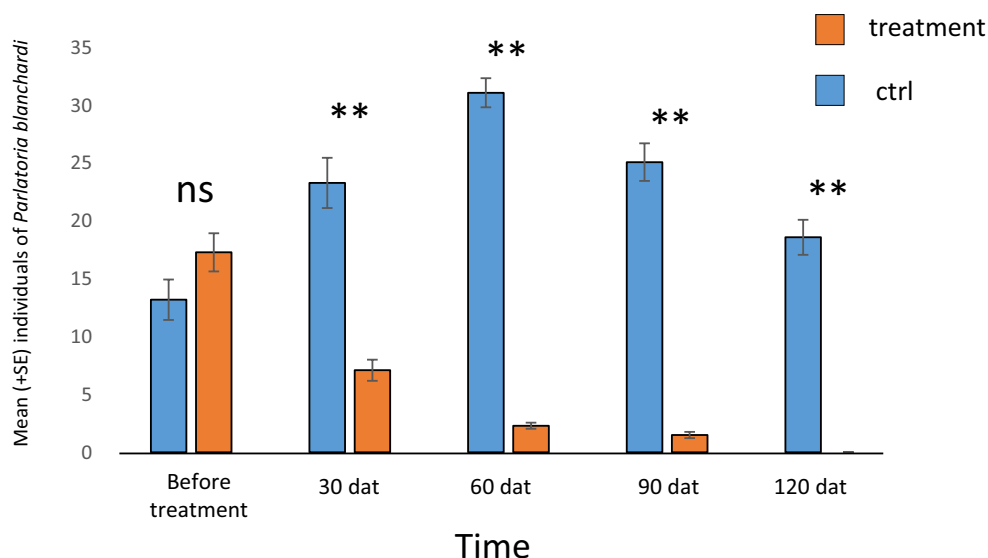


Table 1 Residue levels of thiamethoxam (mean $\pm$ SD) reported in mg/kg in fruits and leaves of Barhi and Brem date palm cultivars at 30, 60, 90, and 120 days after treatment (dat)

Cultivar	sample	30 dat	60 dat	90 dat	120 dat
Barhi	fruits	1.16 $\pm$ 0.24	0.75 $\pm$ 0.18	0.066 $\pm$ 0.02	nd
	leaves	2.13 $\pm$ 0.52	0.93 $\pm$ 0.21	0.053 $\pm$ 0.02	nd
Brem	fruits	0.59 $\pm$ 0.10	0.11 $\pm$ 0.02	0.02 $\pm$ 0.005	nd
	leaves	1.66 $\pm$ 0.14	0.76 $\pm$ 0.14	0.15 $\pm$ 0.02	0.01 $\pm$ 0.001

Discussion

The present study demonstrates that a single root drench application of thiamethoxam is highly effective in suppressing populations of both *O. lybicus* and *P. blanchardi* in date palms. Treated palms consistently showed significantly lower pest infestations compared to untreated controls across all assessment periods, confirming the systemic and long-lasting activity of the insecticide.

For *O. lybicus*, the treatment reduced mobile stages (adults and nymphs) abundance for up to 120 days after application, indicating that a single drench can provide extended protection over a large portion of the pest's seasonal cycle. The consistency of results across cultivars suggests that for this pest thiamethoxam efficacy is not cultivar-dependent, which increases its practical utility in mixed orchards. Overall, these findings clearly show that the insecticide significantly suppressed mobile stages populations of *O. lybicus* in treated palms compared to untreated controls, with temporal variation in efficacy likely linked to seasonal changes in population dynamics.

Similarly, *P. blanchardi* populations were markedly suppressed throughout the study. While the treatment $\times$ cultivar interaction was significant, with slightly higher efficacy in Barhi palms compared to Brem, the overall effect remained strong across both cultivars. The higher effectiveness of

thiamethoxam in the Barhi cultivar compared with Brem may be attributed to cultivar-specific traits, such as leaf morphology, canopy density, or physiological differences that affect systemic uptake and distribution of the insecticide. Although genetic differences between cultivars could contribute, this study did not directly assess genetic or biochemical traits. This also highlights the robustness of the soil drench method in achieving uniform pesticide distribution across varying host plant characteristics (Zhang and Li 2023; Al-Saedi et al., 2025).

Overall, these data are in accordance with past studies that encourage the use of systemic insecticides used by drenching for controlling piercing sucking pests (Mao et al., 2022). For example, a study about the control of the white mango scale *Aulacaspis tubercularis* (Hemiptera: Sternorrhyncha: Diaspididae) showed the effectiveness of thiamethoxam by drenching (Habtegebriel et al., 2020). The ability to control both sap-feeding pests with one treatment reduces labor and chemical inputs, aligning with integrated pest management principles aiming to minimize environmental impacts and pesticide residues (Nauen and Denholm, 2005b; Pimentel, 2005).

In addition, the fact that a single thiamethoxam soil drench effectively suppresses dubas bug and white date scale populations in date palms for up to 120 days post-application corroborates previous findings on systemic neonicotinoids (Smitley et al., 2015) and supports the feasibility of long-term pest control with reduced intervention frequency (Peshin and Zhang 2014).

Residual analyses further support the entomological findings, with detectable thiamethoxam residues in leaves and fruits up to 90 days after treatment, declining to non-detectable levels by 120 days. This persistence matches the period of effective pest suppression, confirming that the systemic distribution of thiamethoxam within the plant is the underlying mechanism

for long-term control. Importantly, the gradual decline of residues reduces the risk of exceeding safety thresholds in harvested fruits, aligning with food safety considerations.

However, further investigation is required to monitor thiamethoxam metabolites, particularly clothianidin, which may persist longer or pose additional toxicological risks (Gui et al. 2019; Chen et al., 2021).

From a management perspective, the results are particularly relevant for integrated pest management (IPM) programs. A single drench application minimizes the frequency of pesticide use, reducing labor and application costs, lowering risks of environmental contamination and exposure of non-target organisms as pollinators particularly sensitive to thiamethoxam (Li et al., 2023), and slowing the development of resistance. Compared with foliar sprays, root drenching also ensures more uniform systemic protection, including against hidden pest stages that are otherwise difficult to reach. Additionally, limiting treatments to a single application reduces selection pressure, potentially delaying resistance development (Gould et al., 2018).

A limitation of this study is that it was conducted in a single orchard, with a relatively small number of palms, which limits the generalization of the results across different environments, cultivars, and seasons. In addition, another risk lies in the environmental and regulatory context: thiamethoxam is subject to increasing restrictions worldwide due to its impact on pollinators and residue persistence, which may limit its long-term applicability as a sustainable solution. In fact, it should be also being pointed out that the even a single thiamethoxan treatment carried out by drenching can have negative consequences on pollinators, as showed by Stoner and Eitzer (2012). Therefore, future studies should consider larger multi-site trials, including alternative or complementary control measures, and assess the implications of integrating this approach into broader IPM strategies. In addition, we plan to evaluate reduced doses in future studies to determine the minimum effective concentration that maintains pest control while reducing chemical input.

The findings of this study encourage the adoption of single soil drench applications for effective pest management in date palm orchards. Future research should validate efficacy across diverse regions and cultivars and explore combining chemical and biological controls for improved sustainability.

Conclusion

This study demonstrated that a single root drench application of thiamethoxam effectively suppressed infestations of *O. lybicus* and *P. blanchardi* in date palms, with efficacy persisting for up to 120 days after treatment. Residual analyses confirmed systemic uptake and gradual decline of the insecticide within plant tissues, aligning with the observed duration of pest control and ensuring residues were not detectable by

harvest. The findings highlight the potential of a single drench treatment as a practical and sustainable alternative to repeated foliar sprays, reducing labor and input costs while minimizing risks to non-target organisms and the environment. Incorporating this approach into integrated pest management programs can improve long-term date palm protection while contributing to resistance management strategies.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s42690-026-01849-9>.

Author contributions Mokhtar Abdulsattar Arif conceived the idea and conducted the experiments while Salvatore Guarino performed the statistical analyses, generated graphs, curated the data. Both the authors wrote and revised the manuscript.

Funding Open access funding provided by Consiglio Nazionale Delle Ricerche (CNR) within the CRUI-CARE Agreement. this research did not receive any external funding.

Data availability No datasets were generated or analysed during the current study.

Declarations

Clinical trial number Not applicable.

Competing interests The authors declare no competing interests.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Ahmed MA, Abdelbagi AO, Elshafie HAF, Fageer EA, Abass IA (2013) Efficacy of imidacloprid (Confidor 200SL) and improved cultural practices in the control of the green date palm pit scale insect (*Asterolecanium phoenicis*) (Homoptera: Asterolecaniidae) in northern Sudan. *Sci Res Essays* 8:1752–1758
- Al Antary TM, Al-Khawaldeh MM, Ateyyat MA (2015) Economic importance and seasonal population trends of grey date scale *Parlatoria blanchardi* (Homoptera: Diaspididae) in Jordan Valley. *Braz J Biol Sci* 2:3
- Al-Kindi KM, Kwan P, Andrew N, Welch M (2017) Impact of environmental variables on dubas bug infestation rate: a case study from the Sultanate of Oman. *PLoS One* 12:e0178109. <https://doi.org/10.1371/journal.pone.0178109>
- Al-Nabhani SS, Velazhahan R, Hussain S, Al-Raqmi S, Al-Hashmi M, Al-Sadi AM (2023) Relationship between dubas bug (*Ommatissus*

- lybicus*) infestation and the development of fungal-induced leaf spots in date palms (*Phoenix dactylifera*). *Insects* 14:283. <https://doi.org/10.3390/insects14030283>
- Al-Rawahi FG, Al-Antary TM, Sadder MT (2018) Effect of three chemicals and neem insecticide against autumn populations of dubas bug, *Ommatissus lybicus* (Tropiduchidae: Homoptera) in Oman. *Fresenius Environ Bull* 27:8594–8599
- Al-Saedi GF, Al-Hamoud FM, Ali HM (2025) Impact of seasonal generations of dubas bug *Ommatissus binotatus* on oviposition and chlorophyll in three date palm *Phoenix dactylifera* L. cultivars. *Basrah J Date Palm Res* 24(1):117–27
- Ali ASA, Hama NN (2016) Integrated management for major date palm pests in Iraq. *Emir J Food Agric* 28:1. <https://doi.org/10.9755/ejfa.2016-01-032>
- Arbabsafti R, Sheikhiarjan A, Gharalari AH, Damghani R, Tajbakhsh MR, Arab Jafari KM (2014) Drenching efficacy of imidacloprid and thiamethoxam against dubas bug, *Ommatissus lybicus* (Hemiptera: Tropiduchidae). *Egypt Acad J Biol Sci F Toxicol Pest Control* 6:43–52
- Awadalla SS, Ata TE, Fathy DM, El-Shenawy HM (2023) Population of white date palm scale insect, *Parlatoria blanchardi* and mortality factors acting on their population at New Damietta District. *J Plant Prot Pathol* 14:287–291. <https://doi.org/10.2160/8/jppp.2023.235502.1177>
- Blumberg D (2008) Date palm arthropod pests and their management in Israel. *Phytoparasitica* 36:411–448. <https://doi.org/10.1007/BF03020290>
- Chen L, Li F, Jia C, Yu P, Zhao E, He M, Jing J (2021) Determination of thiamethoxam and its metabolite clothianidin residue and dissipation in cowpea by QuEChERS combining with ultrahigh-performance liquid chromatography–tandem mass spectrometry. *Environ Sci Pollut Res* 28(7):8844–8852. <https://doi.org/10.1007/s11356-020-11164-6>
- Chihaoui-Meridja S, Harbi A, Abbes K, Chaabane H, La Pergola A, Chermiti B, Suma P (2020) Systematicity, persistence and efficacy of selected insecticides used in endotherapy to control the red palm weevil *Rhynchophorus ferrugineus* (Olivier, 1790) on *Phoenix canariensis*. *Phytoparasitica* 48(1):75–85. <https://doi.org/10.1007/s12600-019-00776-5>
- European Commission's SANTE/11312/2021 https://food.ec.europa.eu/system/files/2023-11/pesticides_mrl_guidelines_wrkdoc_2021-11312.pdf
- Gould F, Brown ZS, Kuzma J (2018) Wicked evolution: can we address the sociobiological dilemma of pesticide resistance? *Science* 360:728–732. <https://doi.org/10.1126/science.aar3>
- Goulson D (2013) An overview of the environmental risks posed by neonicotinoid insecticides. *J Appl Ecol* 50:977–987. <https://doi.org/10.1111/1365-2664.12111>
- Guarino S, Peri E, Lo Bue P, Germanà MP, Colazza S, Anshelevich L, Ravid U, Soroker V (2013) Assessment of synthetic chemicals for disruption of *Rhynchophorus ferrugineus* response to attractant-baited traps in an urban environment. *Phytoparasitica* 41:79–88. <https://doi.org/10.1007/s12600-012-0266-9>
- Gui T, Jia GF, Xu J, Ge SJ, Long XF, Zhang YP, Hu DY (2019) Determination of the residue dynamics and dietary risk of thiamethoxam and its metabolite clothianidin in citrus and soil by LC-MS/MS. *J Environ Sci Health B* 54(4):326–335. <https://doi.org/10.1080/03601234.2019.1571361>
- Habtegebriel B, Melisie D, Kidane H, Daba T, Azerefegn F (2020) Control of the white mango scale *Aulacaspis tubercularis* (Hemiptera: Diaspididae) with systemic soil drenching insecticides and pruning on mature mangos in western Ethiopia. *Isr J Entomol* 50:65–73. <https://doi.org/10.5281/zenodo.3987792>
- Idris T, Ibrahim A, Taha A (2006) A study of the current status of date palms in the Northern State–Sudan: technical report. Sudan Univ Sci Technol, Minist Agric Agric Res Corp Univ Dongola
- Jeschke P, Nauen R (2008) Neonicotinoids—from zero to hero in insecticide chemistry. *Pest Manag Sci* 64:1084–1098. <https://doi.org/10.1002/ps.1631>
- Jiang J, Ma D, Zou N, Yu X, Zhang Z, Liu F, Mu W (2018) Concentrations of imidacloprid and thiamethoxam in pollen, nectar and leaves from seed-dressed cotton crops and their potential risk to honeybees (*Apis mellifera* L.). *Chemosphere* 201:159–167. <https://doi.org/10.1016/j.chemosphere.2018.02.168>
- Khierallah HS, Bader SM, Ibrahim KM, Al-Jboory IJ (2015) Date palm status and perspective in Iraq. *Date Palm Genet Resour Util: Vol 2: Asia and Europe*. Springer, Dordrecht, pp 97–152
- Li W, Lv L, Wang Y, Zhu YC (2023) Mixture effects of thiamethoxam and seven pesticides with different modes of action on honey bees (*Apis mellifera*). *Sci Rep* 13:2679. <https://doi.org/10.1038/s41598-023-29837-w>
- Mao L, Zhang L, Wang S, Zhang Y, Zhu L, Jiang H, Liu X (2022) Application of insecticides by soil drenching before seedling transplanting combined with anti-insect nets to control tobacco whitefly in tomato greenhouses. *Sci Rep* 12:15939. <https://doi.org/10.1038/s41598-022-20294-5>
- Martínez OL, Plata-Rueda A, Martínez LC (2013) Oil palm plantations as an agroecosystem: impact on integrated pest management and pesticide use. *Outlook Pest Manag* 24:225–229. https://doi.org/10.1564/v24_oct_10
- Mokhtar AM, Al Nabhani SS (2010) Temperature-dependent development of dubas bug, *Ommatissus lybicus* (Hemiptera: Tropiduchidae), an endemic pest of date palm, *Phoenix dactylifera*. *Eur J Entomol* 107:555–563. <https://doi.org/10.14411/eje.2010.076>
- Nauen R, Denholm I (2005a) Resistance of insect pests to neonicotinoid insecticides: current status and future prospects. *Arch Insect Biochem Physiol* 58:200–215. <https://doi.org/10.1002/arch.20043>
- Nauen R, Denholm I (2005b) Resistance of insect pests to neonicotinoid insecticides: current status and future prospects. *Arch Insect Biochem Physiol* 58(4):200–215
- Obregon D, Pederson G, Taylor A, Poveda K (2022) The pest control and pollinator protection dilemma: the case of thiamethoxam prophylactic applications in squash crops. *PLoS One* 17:e0267984. <https://doi.org/10.1371/journal.pone.0267984>
- Ouameur S, Bammou M, Essarioui A, Bouamri R, Bouhlali EDT (2025) Integrated pest management (IPM) for *Parlatoria blanchardi* on date palm: a review. *Vegetos* 1:1–13. <https://doi.org/10.1007/s42535-025-01444-2>
- Peshin R, Zhang W (2014) Integrated pest management and pesticide use. *Integrated Pest Manag: Pesticide Problems*, Vol 3. Springer, Dordrecht, pp 1–46
- Pimentel D (2005) Environmental and economic costs of the application of pesticides primarily in the United States. *Environ Dev Sustain* 7:229–252. <https://doi.org/10.1007/s10668-005-7314-2>
- Smitley DR, Herms DA, Davis TW (2015) Efficacy of soil-applied neonicotinoid insecticides for long-term protection against emerald ash borer (Coleoptera: Buprestidae). *J Econ Entomol* 108:2344–2353. <https://doi.org/10.1093/jee/tov205>
- Stoner KA, Eitzer BD (2012) Movement of soil-applied imidacloprid and thiamethoxam into nectar and pollen of squash (*Cucurbita pepo*). *PLoS One* 7:e39114. <https://doi.org/10.1371/journal.pone.0039114>
- Zhang X, Li Z. (2023) Generalizing routes of plant exposure to pesticides by plant uptake models to assess pesticide application efficiency. *Ecotoxicology and Environmental Safety*. 1:262:115145. <https://doi.org/10.1016/j.ecoenv.2023.115145>