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Assessment of Infestation Severity by Scale Insects and Citrus Leafminer and Evaluation of Cultivar Susceptibility in a Citrus Orchard in Qasr Ben Ghashir, Libya

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تقييم شدة الإصابة بالحشرات القشرية وصانعة أنفاق أوراق الحمضيات وتقييم حساسية الأصناف في بستان حمضيات بمنطقة قصر بن غشير، ليبيا

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Abstract:
Scale insects and the citrus leafminer are among the major pests affecting citrus productivity and fruit quality in Mediterranean environments, including Libya. This study aimed to evaluate the infestation severity of three scale insect species: California red scale (*Aonidiella aurantii*), black scale (*Chrysomphalus ficus*), and purple scale (*Lepidosaphes beckii*), in addition to the citrus leafminer (*Phyllocnistis citrella*), on six citrus cultivars (Fresh Lime, Kenyan local, Java, Lime, Kenyan American, and Abu Surra).
The study was conducted in an orchard located in Qasr Ben Ghashir (Jefara Plain). Samples were randomly collected by examining 100 leaves and 25 fruits per cultivar from five trees. Infestation percentages were calculated for leaves and fruits.
The results showed clear variation among cultivars in infestation levels. The Kenyan local and Fresh Lime cultivars recorded the highest infestation percentages with California red scale (36.8% and 36.6%, respectively), while Abu Surra exhibited complete resistance. The highest citrus leafminer infestation was recorded on Lime and Fresh Lime cultivars (48%).
These results reflect genetic differences in cultivar susceptibility and support the use of less susceptible cultivars within integrated pest management programs to reduce reliance on chemical pesticides.

Keywords: Citrus, Scale insects, Citrus leafminer, Integrated pest management, Libya.

الملخص
تُعدّ الحشرات القشرية وصانعة أنفاق أوراق الحمضيات من الآفات الرئيسة التي تؤثر في إنتاجية الحمضيات وجودة ثمارها في البيئات المتوسطية، بما في ذلك ليبيا. هدفت هذه الدراسة إلى تقييم شدة الإصابة بثلاثة أنواع من الحشرات القشرية: الحشرة القشرية الحمراء في كاليفورنيا(*Aonidiella aurantii*) ، والحشرة القشرية السوداء (*Chrysomphalus ficus*) والحشرة القشرية الأرجوانية(*Lepidosaphes beckii*) ، إضافة إلى صانعة أنفاق أوراق الحمضيات (*Phyllocnistis citrella*)، على ستة أصناف من الحمضيات (العصري، الكيني المحلي، الجافا، الحامض، الكيني الأمريكي، وأبو صرة).
أُجريت الدراسة في بستان يقع بمنطقة قصر بن غشير (سهل الجفارة). جُمعت العينات عشوائيًا من خلال فحص 100 ورقة و25 ثمرة لكل صنف من خمسة أشجار. وحُسبت نسب الإصابة على الأوراق والثمار.

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أظهرت النتائج وجود تباين واضح بين الأصناف في مستويات الإصابة. فقد سجل صنفا الكيني المحلي والعصري أعلى نسب إصابة بالحشرة القشرية الحمراء في كاليفورنيا (36.8% و36.6% على التوالي)، بينما أظهر صنف أبو صرة مقاومة كاملة. كما سُجلت أعلى نسبة إصابة بصانعة أنفاق أوراق الحمضيات في صنفي الحامض والعصري.(48%)
تعكس هذه النتائج وجود فروق وراثية في حساسية الأصناف للإصابة، وتدعم التوسع في استخدام الأصناف الأقل حساسية ضمن برامج الإدارة المتكاملة للآفات للحد من الاعتماد على المبيدات الكيميائية.

الكلمات المفتاحية :الحمضيات، الحشرات القشرية، صانعة أنفاق أوراق الحمضيات، الإدارة المتكاملة للآفات، ليبيا.

Introduction

Citrus represents one of the most important horticultural crops in Libya and constitutes a major component of agricultural production in the Jefara Plain, one of the country's principal citrus-growing regions. Beyond its economic value, citrus contributes to local food security, provides nutritionally rich fresh produce, and supports market activity. However, sustained production is challenged by several biotic stresses, particularly insect pests that adversely affect tree vigor, yield, and fruit quality.

Among the most damaging pests are scale insects (Hemiptera), which feed by extracting sap from leaves, branches, and fruits. Continuous feeding weakens trees, reduces photosynthetic efficiency, impairs vegetative growth, and may lead to fruit deformation and reduced market value. Under heavy infestations, branch dieback may occur due to prolonged sap depletion (Hussein et al., 2018). The most prevalent species in Mediterranean citrus orchards include California red scale (*Aonidiella aurantii*), black scale (*Chrysomphalus ficus*), and purple scale *(Lepidosaphes beckii*), whose severity varies depending on environmental conditions and host cultivar.

Citrus leafminer (*Phyllocnistis citrella*) represents an additional constraint, particularly affecting young foliage. Larval feeding results in serpentine mines within leaf tissues, reducing effective photosynthetic area and causing leaf curling and premature abscission. Severe early infestations may weaken trees and predispose them to secondary infections (Li et al., 2017).

Although chemical control remains common practice, excessive pesticide use has resulted in resistance development and ecological imbalance, including negative effects on natural enemies. These concerns underscore the importance of integrated pest management (IPM) strategies based on monitoring, economic thresholds, and the rational integration of cultural, biological, and chemical measures (Alhadad,2018). Within this framework, the selection of less susceptible cultivars represents a fundamental preventive approach (El-Sayed et al., 2019; Daane et al., 2023). Accordingly, the present study aimed to assess infestation severity of three scale insect species and citrus leafminer in a representative orchard in Qasr Ben Ghashir and to evaluate the relative susceptibility of six citrus cultivars in order to support cultivar-based IPM decisions(Alhadad,2022).

Materials and Methods

The study was conducted in a private citrus orchard located in Qasr Ben Ghashir, Jefara Plain, northwestern Libya, during the period from August to November 2010, which represents the peak biological activity of scale insects and citrus leafminer.

Six cultivars grown under uniform field conditions were included: Fresh Lime (*Citrus sinensis*), Kenyan local (*Citrus sinensis*), Java (*Citrus reticulata*), Lime (*Citrus aurantifolia*), Kenyan (*Citrus sinensis*), and Abu Surra (Citrus medica). Tree ages ranged between 5–12 years, and agricultural practices (irrigation, fertilization, and pruning) were kept uniform (Ibrahim & Khalif, 1997).

Sample Collection

A systematic random sampling method was adopted. Five trees were randomly selected from each cultivar. From each tree, 100 leaves and 25 fruits were collected from the four cardinal directions (north, south, east, west) and from different canopy heights to ensure balanced representation.
Samples were immediately transported to the laboratory in sealed plastic bags and maintained under cooled conditions to preserve insect integrity before microscopic examination (Ismail & Al-Maezi, 2003).

Examination and Identification

Leaves and fruits were examined using a stereomicroscope. Scale insect species were identified based on distinguishing morphological characteristics and confirmed by a plant protection specialist. The targeted species included California red scale, black scale, and purple scale.
For citrus leafminer, the number of leaves containing active larval mines per tree was recorded, and the presence of a fresh mine was considered evidence of active infestation.
Infestation Percentage Calculation
Infestation percentage (%) = (Number of infested samples ÷ Total examined samples) × 100

Statistical Analysis

Data were analyzed using one-way ANOVA to test differences among cultivars in infestation percentages, followed by LSD test at ($p \leq 0.05$). Statistical analyses were performed using SPSS version 25.

Results and Discussion

The results showed the presence of scale insects and citrus leafminer on the six studied cultivars, with clear significant differences in infestation levels.

California Red Scale (*Aonidiella aurantii*)

Marked differences in infestation severity were observed among the examined cultivars ($P \leq 0.05$) (Table 1). Infestation levels on leaves were highest in Kenyan local (36.8%) and Fresh Lime (36.6%), forming a distinct high-susceptibility group. In contrast, Abu Surra remained completely free of infestation. Fruit infestation followed a similar trend, with Fresh Lime recording the highest value (12.2%), while Kenyan American exhibited comparatively low infestation.(%4.6)
The clear cultivar-dependent pattern suggests inherent differences in host suitability, potentially linked to structural or biochemical traits influencing insect establishment.

Table 1. Mean infestation percentage of California red scale on leaves and fruits of six citrus cultivars.

Cultivar	Mean infestation on leaves (%)	Mean infestation on fruits (%)
Kenyan local	36.8 ± 1.5 a	10.0 ± 0.8 b
Fresh Lime	36.6 ± 1.7 a	12.2 ± 1.1 a
Java	18.8 ± 1.2 b	9.0 ± 0.7 b
Lime	11.2 ± 0.9 c	11.0 ± 0.9 ab
Kenyan American	7.8 ± 0.6 c	4.6 ± 0.7 c
Abu Surra	0.0 ± 0.0 d	0.0 ± 0.0 d

Means followed by different letters within each column differ significantly at $p \leq 0.05$ according to LSD test

Black Scale (Chrysomphalus ficus)

Infestation by black scale was limited to three cultivars (Table 2), indicating a narrower host range compared to California red scale. Fresh Lime exhibited the highest leaf infestation (14.0%), whereas Kenyan local recorded the highest fruit infestation (18.8%). Differences among cultivars were statistically significant ($P \leq 0.05$).

Such variation may reflect differences in sap composition, particularly sugar and amino acid profiles, which influence feeding preference. Abd El-Ghany et al. (2021) reported a tendency of this species to prefer cultivars with higher sugar content, supporting the observed pattern.

Table 2. Mean infestation percentage of black scale on leaves and fruits

Cultivar	Mean infestation on leaves (%)	Mean infestation on fruits (%)
Fresh Lime	14.0 ± 1.1 a	11.2 ± 0.9 b
Java	12.0 ± 0.9 a	11.0 ± 0.8 b
Kenyan local	12.8 ± 1.0 a	18.8 ± 1.4 a

Means followed by different letters within each column differ significantly at $p \leq 0.05$ according to LSD test.

This variation may be attributed to differences in plant sap chemical composition, particularly sugar and amino acid content, which influence feeding preference. Abd El-Ghany et al. (2021) reported that this species tends to prefer cultivars with higher sugar content, which may explain the higher infestation observed in certain cultivars.

Purple Scale (*Lepidosaphes beckii*)

Infestation levels were consistently higher on fruits than on leaves across all affected cultivars (Table 3), indicating that fruits provide a more favorable microenvironment for development. This may be associated with peel characteristics, surface exposure, and attachment suitability of sessile stages.

These observations align with (Daane et al., 2023), who noted increased fruit infestation under low humidity conditions, consistent with the climatic characteristics of the study area

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Table 3. Mean infestation percentage of purple scale on leaves and fruits

Cultivar	Mean infestation on leaves (%)	Mean infestation on fruits (%)
Fresh Lime	8.2 ± 0.7 a	16.4 ± 1.3 a
Kenyan local	6.8 ± 0.6 a	15.0 ± 1.2 a
Java	5.6 ± 0.5 b	13.3 ± 1.1 b

Means followed by different letters within each column differ significantly at $p \leq 0.05$ according to LSD test.

These findings are consistent with (Daane et al. ,2023), who indicated that infestation severity of this species increases on fruits under low humidity conditions, which correspond to the prevailing climatic conditions in the study area. Fruit surface characteristics may also facilitate attachment of the sessile developmental stages.

Citrus Leafminer (*Phyllocnistis citrella*)

Leafminer infestation varied substantially among cultivars (Table 4). Lime and Fresh Lime recorded the highest infestation percentages (48%), whereas Kenyan American exhibited the lowest level (18.4%). No fruit infestation was observed, confirming that damage is restricted to foliage.

Variation among cultivars may be associated with differences in phenolic compounds, essential oils, and structural leaf characteristics such as toughness and trichome density (Lucchi et al., 2021; Salama et al., 2024), which may influence oviposition and larval penetration.

Table 4. Mean infestation percentage of citrus leafminer on leaves of six citrus cultivars

Cultivar	Mean infestation on leaves (%)
Lime	48.0 ± 2.3 a
Fresh Lime	48.0 ± 2.6 a
Abu Surra	39.2 ± 1.9 b
Java	39.2 ± 1.7 c
Kenyan local	31.8 ± 1.3 c
Kenyan American	18.4 ± 0.9 d

Means followed by different letters differ significantly at $p \leq 0.05$ according to LSD test.

This variation may be associated with differences in leaf phenolic compounds and essential oil content, which may play an inhibitory role in feeding or oviposition (Salama et al., 2024). Physical traits such as leaf toughness and trichome density may also influence larval penetration ability and mine formation (Lucchi et al., 2021).

Evaluation of Cultivar Susceptibility

Based on the combined results, cultivars can be classified into three main categories:

Highly susceptible cultivars include Fresh Lime and Kenyan local, which showed high susceptibility to most of the studied pests.

Moderately susceptible cultivars include Java and Lime.

Low-susceptibility or relatively resistant cultivars include Kenyan American and Abu Surra, with the latter exhibiting almost complete resistance to California red scale.

These findings indicate a potential genetic basis for pest resistance in certain cultivars and emphasize the importance of incorporating such cultivars into integrated pest management programs. Selection of appropriate cultivars represents a strategic step that reduces dependence on chemical pesticides and supports sustainable citrus production in citrus-growing regions.

Conclusion

Significant differences in infestation severity of scale insects and citrus leafminer were recorded among the six evaluated citrus cultivars in Qasr Ben Ghashir. Fresh Lime and Kenyan local exhibited consistently high infestation levels, whereas Abu Surra and Kenyan American demonstrated relatively low susceptibility.

The observed variability indicates that cultivar-related traits play an important role in pest establishment and development. Incorporating less susceptible cultivars into production systems may contribute to reducing infestation pressure and limiting reliance on chemical control, thereby

enhancing the sustainability of citrus production in Mediterranean environments. Further studies are recommended to explore the biochemical and genetic mechanisms underlying resistance.

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References

1. Abd El-Ghany, N. M., Abd El-Wahab, H. E., & Ibrahim, S. S. (2021). Factors influencing host preference and fecundity of the black scale, Chrysomphalus ficus (Hemiptera: Diaspididae) on citrus. Egyptian Journal of Biological Pest Control, 31(1), 1–9.
2. .Daane, K. M., Almeida, R. P. P., & Bell, V. A. (2023). Ecology and management of armored scale insects in global citrus production. Annual Review of Entomology, 68, 229–250.
3. Hussein, A. F., El-Heneidy, A. H., & Awadalla, S. S. (2018). Impact of scale insects on citrus orchards in North Africa: Implications for integrated pest management. Journal of Applied Entomology, 142(7), 601–614.
4. El-Sayed, A. M., Suckling, D. M., Wearing, C. H., & Byers, J. A. (2019). Biological control of citrus pests in the Mediterranean region: Successes and challenges. Biological Control, 136, 104–112.
5. Alhadad, A. (2018). Effects Of Pesticides On Human Health
6. Li, X., Zhang, Y., & Wu, Q. (2017). Population dynamics and control strategies of citrus leafminer (Phyllocnistis citrella) in citrus orchards. Pest Management Science, 73(3), 589–597.
7. Lucchi, A., Loni, A., Gandini, L. M., & Scaramozzino, P. L. (2021). Towards a sustainable control of the citrus leafminer. Insects, 12(10), 901.
8. Salama, H. S., El-Banna, M. N., & El-Said, M. A. (2024). Biochemical and morphological factors associated with resistance of some citrus genotypes to the citrus leafminer, Phyllocnistis citrella Stainton (Lepidoptera: Gracillariidae). Journal of King Saud University – Science, 36(1), 102052.
9. Alhadad , A. (2022). HABITAT LOSS AND ITS EFFECT ON THE BIODIVERSITY: A REVIEW . Journal of Azzaytuna University, 44, 460-470. https://azzujournal.com/index.php/azujournal/article/view/172
10. Ibrahim, A. M., & Khalif, M. N. (1997). Citrus. Publishing House.
11. Ismail, M. M., & Al-Maezi, M. A. (2003). Field and horticultural crops. National Center for Educational Analysis and Training.