Eurasia Specialized Veterinary Publication

Entomology Letters

ISSN:3062-3588

2021, Volume 1, Issue 1, Page No: 13-21
Copyright CC BY-NC-SA 4.0
Available online at: www.esvpub.com/

A Comprehensive Review of the White Mango Scale (*Aulacaspis tubercularis*) and Its Management in Ethiopia

Zigyalew Gashaw Belachew[1], Abaynew Jemal Jenber[2]*

[1]Department of Horticulture, Injibara University, Injibara, Ethiopia.
[2]Department of Plant Sciences, Bahir Dar University, Bahir Dar, Ethiopia.

***E-mail** ✉ abujemal900@gmail.com

ABSTRACT

The present study aimed to provide a comprehensive review of the white mango scale (*Aulacaspis tubercularis*) and its management in Ethiopia. The white mango scale has emerged as a rapidly spreading and highly destructive pest of mangoes. It was first identified in Ethiopia in 2010 and has caused significant damage to mango production, with losses ranging from 50 to 100%, leading to the cessation of mango farming in many areas. The pest spread rapidly throughout the country due to inadequate quarantine measures and its ease of transportation. By 2022, the white mango scale had infested almost all mango-growing areas in Ethiopia, earning its place on the global distribution map. This pest, which attacks more than 37 genera across 23 families, is particularly harmful to mango trees, feeding on shoots, leaves, twigs, branches, and fruit, thereby severely reducing fruit quality and yield. Its hard white scale covering makes it challenging to control with contact insecticides. While no chemical control methods have been registered, some alternative management strategies—such as quarantine measures, cultural practices, biological control, chemical treatments, and integrated pest management—are being explored. The impact of the white mango scale is felt economically, socially, and environmentally, highlighting the urgent need for coordinated action to manage its spread and damage in Ethiopia.

Keywords: Biology, Ethiopia, Distribution, Pest management, Host plants, White mango scale

Received: 06 March 2021
Revised: 12 May 2021
Accepted: 18 May 2021

How to Cite This Article: Belachew ZG, Jenber AJ. A Comprehensive Review of the White Mango Scale (*Aulacaspis tubercularis*) and Its Management in Ethiopia. Entomol Lett. 2021;1(1):13-21.
https://doi.org/10.51847/ICdfPSW2qk

Introduction

The mango (*Mangifera indica* L.) is a versatile and widely cultivated evergreen fruit found in subtropical and tropical regions around the world [1]. Known as the “king of fruits,” it is celebrated for its delicious flavor, pleasant aroma, and rich nutritional profile, including a variety of essential vitamins and minerals [2]. Mangoes are particularly valuable in terms of food and nutrition, providing vital nutrients like vitamins A, C, B2, B1, and D, which make it an important fruit for improving food security, especially in developing nations such as Ethiopia, where achieving nutritional stability can be challenging [3, 4].

Although mangoes are primarily enjoyed as fresh fruit, they are also used in the production of juices, jams, and preserves [3, 5]. Additionally, the tree and fruit find various applications, including being used as a vegetable, for medicinal purposes, and even for fuel wood. The fruit's high nutritional value also supports animal husbandry, while its nectar serves as a food source for bees. The mango tree is also utilized in construction and as a natural barrier against sun and rain. Moreover, the mango kernel, which contains 8-10% high-quality fat, can be used in the production of soap and as an alternative to cocoa butter in confectionery [3].

In many developed countries, mangoes are recognized for their high nutritional content and their role as a valuable export commodity, contributing to the foreign exchange earnings of developing nations. Globally, mangoes

© 2021 Entomology Letters

account for 51% of total tropical fruit production [6]. The fruit has gained significant popularity as both a fresh product and a processed item on international markets, and it is cultivated in more than eighty countries. The global production of mangoes exceeds 46 million tons annually, with India leading the world in production, contributing 40% of the total output [7]. However, mango production and yield are increasingly threatened by the white mango scale.

The white mango scale (*Aulacaspis tubercularis* Newstead), a member of the Hemiptera order, is a harmful pest characterized by its piercing and sucking mouthparts. The widespread distribution of this pest is believed to be linked to the movement of infected planting materials, exacerbated by the lack of stringent internal quarantine measures for such materials. As a result, the white mango scale has emerged as a serious pest, inflicting 50-100% losses on mango crops, leading to plant death in many areas [8-10]. Reports indicate that the pest causes severe damage by triggering premature leaf drop, branch dieback, fruit stunting, distortion, and premature fruit drop, ultimately diminishing both the quantity and quality of mango yields [11].

The white mango scale poses a significant threat to mango crops in various mango-producing regions around the world. It has spread across nearly all tropical and subtropical mango-growing areas, severely affecting production. Due to the pest's rapid spread and the challenges in managing it effectively, mango yields and overall productivity are decreasing at an alarming pace [9].

In Ethiopia, however, the introduction, spread, and control methods of the white mango scale have not been extensively researched. Ethiopia is not yet included in the global distribution maps of this pest [10], highlighting the gap in knowledge regarding its presence, spread, and impact within the country compared to other regions. Although studies on this pest in Ethiopia are limited, some reports indicate that the infestation has worsened over time. This issue has been exacerbated by the absence of a stringent internal quarantine system to prevent the pest's further spread to new areas [12]. Therefore, it is crucial to focus on the pest's distribution, occurrence, and management to effectively mitigate its damage to mango crops. The present study aimed to provide a comprehensive review of the white mango scale (*Aulacaspis tubercularis*) and its management in Ethiopia.

Results and Discussion

As noted by Abate and Dechassa [9], the population dynamics of the white mango scale vary depending on the agroecological conditions. However, comprehensive studies considering these factors across all regions of Ethiopia are still lacking. Wale and Melis [13] further observed that the dynamics of the pest and its natural predators fluctuate over space and time, influenced by environmental factors such as rainfall, temperature, wind speed, humidity, and sunlight.

While the research remains limited, many studies suggest that integrated pest management (IPM) approaches are the most effective solution for controlling the white mango scale [9, 14, 15]. This review aims to summarize the current knowledge on the status of the white mango scale, its impact on mango production, and the management practices being applied in Ethiopia based on the recent research findings.

The white mango scale was first identified in Asia and has since spread globally, becoming a significant issue for mango production worldwide [9]. This pest is one of the most destructive threats to mango trees in many regions. The white mango scale damages various parts of the mango tree, including shoots, leaves, twigs, branches, and fruit, by feeding on plant sap with its piercing mouthparts. This feeding behavior causes deformities, leaf drop, drying of young twigs, and dieback. The pest also negatively impacts fruit quality, leading to poor blossoming, the death of branches, and a reduction in the commercial value of the fruit. In late cultivars, it often causes pink discoloration at the feeding sites, diminishing their export potential [16, 17]. In nurseries, severe infestations stunt growth, while mango trees are particularly vulnerable to leaf drop and branch dieback, especially in hot, dry conditions [18]. Immature fruit may fall prematurely, and mature fruit becomes smaller, less juicy, and prone to rotting, rendering it unfit for commercial use. Overall, the pest causes significant declines in both the quantity and quality of mango production [19, 20].

The first recorded appearance of the white mango scale in Ethiopia occurred in August 2010 at Green Focus Ethiopia Ltd, located in Loko, Guto Gidda district, East Wollega zone of the Oromia region [21]. The pest quickly spread across all stages of growth in the mango crop at the site and continued to invade other mango-growing areas of the country due to the lack of effective quarantine measures.

In the 2019/20 cropping season, approximately 1,666,040 households contributed to mango production across 16,363.5 hectares of land, representing 12.5% of the nation's total fruit production [22]. However, the area

cultivated for mangoes was reduced to 19,497.92 hectares in the 2018/19 season, leading to a decline in yield by 16.08% and 6.09% from the previous year.

Reports suggest that the white mango scale poses such a significant threat that it could lead to the cessation of mango production in the affected areas. Despite the availability of various management methods, quarantine regulations remain the most effective measure to limit the pest's spread [23]. Many studies support the use of insecticides in combination with other integrated pest management strategies to control the white mango scale. Given the current situation, if the pest is not managed effectively, mango farms in Ethiopia may be forced out of production. As indicated by reports, Ethiopia's mango industry is facing a serious threat, potentially leading to a complete loss of production of mango in the future.

The white mango scale is a tropical pest originally from Asia. Over time, it has spread across various tropical and subtropical regions around the world [9, 24]. It is now found in many countries across Africa, Oceania, North and South America, Asia, and the Caribbean, though its presence in Europe remains limited **(Figure 1)**.

In Ethiopia, the white mango scale has been rapidly spreading since it was first reported in 2010 [25]. This rapid distribution can be attributed to the country's favorable climatic conditions, weak quarantine measures, and the pest's ability to move easily through planting materials, carried by birds, other flying animals, and even by the wind, which helps the male adults travel long distances [26]. Furthermore, improper agricultural practices have contributed to the pest's prevalence and increasing severity. Currently, the white mango scale is found in nearly all of Ethiopia's mango-growing regions, including Oromia, Amhara, Benishangul-Gumuz, Gambella, Tigray, the Southern Nations, and the Rift Valley areas **(Figure 2)** [27].

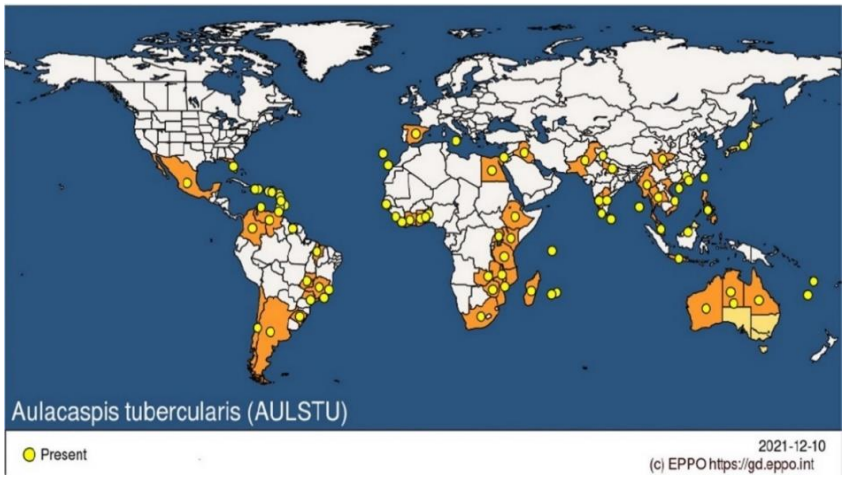

Figure 1. Global distribution map [28]

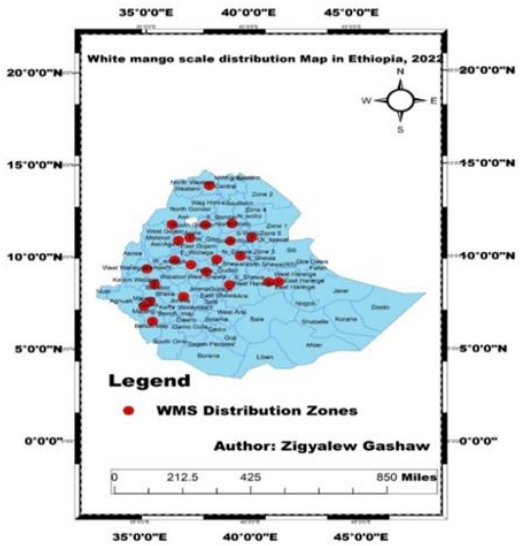

Figure 2. White mango distribution map in Ethiopia [11, 26, 29].

The white mango scale completes 5 to 6 generations per year, with its reproduction strongly affected by temperature, being a species that thrives in warmer climates [10, 30, 31] **(Figure 3)**. Female white mango scales can lay between 80 and 200 eggs, with the number depending on the surrounding temperature. The eggs hatch after about a week, and under optimal conditions of 26 °C during the day and 13 °C at night, the pest can complete up to six generations annually [31]. The nymphs feed on plant tissues and continue to develop on the host plant [23, 32].

The species exhibits sexual dimorphism, with male development consisting of four stages (nymph I, nymph II, pre-pupa, and pupa) and females having two stages (nymph I and nymph II) [28, 33] **(Figure 3)**. Crawlers and adult males are the only life stages that are mobile [34]. Crawlers are capable of moving across the host plant to find a suitable location to settle. Once they find a suitable spot, they insert their stylets into the plant's tissues and begin feeding [35]. Female crawlers tend to settle randomly on various parts of the plant, including leaves, stems, and fruit, while male crawlers often form small clusters near females [28, 36]. Research shows that approximately 80% of the crawlers that hatch are male [10]. The pest's stylets are notably long, measuring 6 to 8 times the length of its body [37].

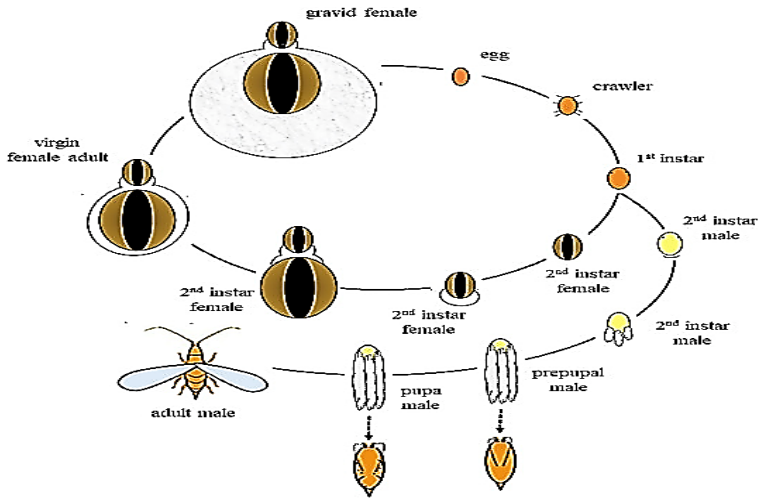

Figure 3. The life cycle of the white mango scale [33]

The white mango scale is a polyphagous pest that feeds on a wide range of plants, including more than thirty-seven genera across twenty-three families. These plants include stone fruits, avocado, citrus, papaya, guava, cucumbers ginger, pumpkins, cinnamon, melon, and coconut [10, 28, 38, 39]. The pest damages various parts of the mango plant, including shoots, leaves, twigs, branches, and fruits, by feeding on plant fluids using its mouthparts. This feeding leads to deformations, defoliation, the drying of young twigs, dieback, poor flowering, and even the loss of twigs due to the action of toxic substances **(Figure 4)** [17, 19]. Heavily infested fruits drop prematurely, and mature fruits become smaller, less juicy, rot, and are unsuitable for commercial purposes **(Figure 4)** [19, 24, 40].

a)

b)

c)

d)

Figure 4. White mango scale damage on mango tree around Bahir Dar, Ethiopia, 2022

The white mango scale poses significant economic threats to mango production, with potential losses ranging from 90-100% of the crop's value if not effectively controlled [33]. Even a single scale per leaf can reduce fruit yields by 1.31 to 4.28 kg per tree annually [41], and the presence of 4 to 5 scales on fruit can severely impact its quality [28]. To mitigate the effects of the pest, mango producers incur additional costs through chemical treatments, leading to financial strain for households.

In Ethiopia, the white mango scale has had a detrimental impact on mango production. Before the pest's introduction, farmers could harvest up to 1000 kg of fruit per tree. However, due to heavy infestations, current yields have plummeted, with trees now producing only 200-300 kg of fruit per tree [23, 42]. Post-harvest losses are common as the pest causes blemishes on the fruit, and in some cases, the insects remain attached, making the fruit unfit for the market. These damages undermine mango quality, posing challenges in a competitive market. As a result, the invasion of the white mango scale threatens to drive Ethiopian mangoes out of the market.

The economic losses extend to the national level, as income from mango sales is significantly reduced. Mangoes also play a vital role in local nutrition, especially for children, who have historically been the primary consumers of fresh mangoes. The lack of access to mangoes could lead to nutritional deficiencies.

Furthermore, the environmental impact of the pest's spread could be catastrophic if it continues unchecked. If not managed, mango trees will suffer from dieback, leading to deforestation and biodiversity loss. This may contribute to desertification in key mango-growing areas.

The widespread infestation of the white mango scale also has social implications. The resulting economic hardship may increase unemployment, particularly among the youth, who will likely turn to daily labor for survival. The situation has evolved beyond an economic issue, now affecting the social and environmental fabric of the country.

There has been insufficient institutional support to help farmers manage the pest. This lack of support has allowed the pest to spread rapidly, disrupting both production and marketing. As a new pest in Ethiopia, the white mango scale remains under-researched, with limited findings not reaching key stakeholders. This has led to its neglect and minimal attention from the authorities [42].

Managing the white mango scale is a significant challenge, as it affects mango crops year-round, with a peak in population from March to May. This peak period is critical for control efforts, and timely interventions are needed during these months to manage the pest effectively [25, 26, 39].

In Ethiopia, the white mango scale continues to be a problematic pest with limited control strategies available. While there are no highly effective methods yet, several alternatives can help to prevent the scale from causing substantial damage. These include biological, cultural, chemical, integrated pest management approaches, and the enforcement of quarantine regulations [9, 23, 43, 44].

Quarantine and inspection

To prevent the spread of the white mango scale, strong quarantine practices must be implemented, including conducting thorough national inspections, bolstering quarantine facilities, and enforcing laws that restrict the movement of mango products across regions. Enhancing plant health clinic capabilities and utilizing bio-rational insecticides can also help in managing the pest effectively [23].

Cultural practices

Cultural management practices involve modifying agricultural techniques to limit the white mango scale's presence. These practices include bagging fruits before harvest, proper tree pruning, adjusting plant spacing,

clearing surrounding areas, improving soil fertilization, and using homemade oils or soaps to deter the pest [9, 10, 45]. Among these, pruning plays a crucial role in pest management. Removing dead branches, infested parts, and overcrowded shoots helps increase airflow and reduces humidity around the tree, discouraging the scale from settling and reproducing [42].

Chemical control

In Ethiopia, there are no officially registered insecticides specifically for controlling the white mango scale. However, several chemical agents are currently being trialed for their effectiveness against the pest. These include Diazinon, Methidathion, Dimethoate, and Nimbecidence 3% EC [12, 46, 47]. Additionally, systemic insecticides such as Spark 250 WG and Thiamethoxam 25% WG (Movento) have shown promising results. Folimat and Closer 240 have also proven effective in reducing the pest population [9, 18, 48]. However, certain contact insecticides can negatively impact the natural predators of the white mango scale. Therefore, chemical testing should prioritize those with minimal harm to natural enemies, like systemic insecticides, which integrate better with biological control methods. Contact insecticides, on the other hand, are less effective since they cannot penetrate the white mango scale's tough outer shell, making them less suitable for long-term management [49].

Biological control

Natural predators and parasitoids have been found to help reduce the damage caused by the white mango scale. These include green lacewings, ladybird beetles, *Chilocorus bipustulatus*, *Scymnussyriacus marseul*, and parasitic wasps such as *Encarsia citrine* (Craw) and *Aphytis mytilaspidis* [19, 46].

Integrated pest management

Relying solely on one method—whether cultural, biological, or chemical—is often insufficient for effective white mango scale control. A combination of these strategies is crucial throughout the growing season [9, 12, 23]. Cultural practices like regular pruning and systematic monitoring for scale infestations are vital. Moreover, certain mango varieties, such as Apple and Keitt, are less susceptible to white mango scale infestation [10]. In addition to cultural methods, the use of natural predators, including *Cybocephalus binotatus*, *Encarsia citrine*, *Aphytis mytilaspidis*, *Chilocorus*, and others, should be part of an integrated control strategy. When scale populations reach an economic injury level, targeted insecticide applications may be necessary. Studies have shown that bi-weekly treatments with Movento and Methidathion 400 EC pesticides resulted in up to 90% and 74% mortality of the pest after five applications, respectively [12]. Furthermore, a trial by Djirata *et al*. [50] demonstrated that Folimat 500 SL pesticide applications led to a 90% reduction in the white mango scale after three rounds.

Conclusion

The white mango scale has emerged as a rapidly spreading and highly destructive pest, severely impacting mango cultivation. This polyphagous insect affects more than 37 genera and 23 plant families, leading to premature fruit and leaf drop, dieback of branches and twigs, fruit deformation, and stunting. These consequences significantly compromise both the quantity and quality of mango harvests. In Ethiopia, the pest has become a major threat, resulting in considerable economic losses and rendering mango production unfeasible in many regions.

This pest can complete 5 to 6 generations annually, with adult males capable of traveling vast distances by flight, aided by the wind. Its spread has been unchecked, affecting nearly all mango-producing areas of the country. The pest's robust, hard exterior makes it resistant to contact insecticides, as these chemicals are unable to penetrate its tough cuticle, making control efforts largely ineffective.

The high reproductive capacity of the white mango scale, combined with its ability to spread through the movement of planting materials and by flying long distances, complicates efforts to manage it. As a result, the pest's distribution has rapidly expanded, causing significant economic, social, and environmental impacts. If immediate and coordinated action is not taken, the future of mango production in Ethiopia is at serious risk, with the possibility of total crop destruction looming.

Acknowledgments: None

Conflict of Interest: None

Financial Support: None

Ethics Statement: None

References

1. Mango Genome Consortium, Bally ISE, Bombarely A, Chambers AH, Cohen Y, Dillon NL, et al. The 'Tommy Atkins' mango genome reveals candidate genes for fruit quality. BMC Plant Biol. 2021;21(1):1-18.
2. Griesbach J. Mango growing in Kenya. World Agroforestry Centre; 2003.
3. Bally IS. Mangifera indica (mango). Species profiles for Pacific Island agroforestry. 2006:1-25.
4. Ullah H, Ahmad S, Thompson AK, Ahmad W, Nawaz MA. Storage of ripe mango (Mangifera indica L.) cv. Alphonso in controlled atmosphere with elevated CO2. Pak J Bot. 2010;42(3):2077-84.
5. Hussen S, Yimer Z. Assessment of production potentials and constraints of mango (Mangifera indica) at Bati, Oromia zone, Ethiopia. Int J Sci Basic Appl Res. 2013;11(1):1-9.
6. Altendorf S. Global prospects for major tropical fruits. The food outlook: biannual report on global food markets. The food and agriculture organization of the United Nations (FAO), Rome. 2017:68-81.
7. Thakor NJ. Indian mango–production and export scenario. Peach. 2019;18(107):0-12.
8. Fita T, Getu E, Wakgari M, Woldetsadike K. Efficacy of Azadirachta indica (A. Juss) seed powder water extract against Aulacuspis tubercularis Newsteed (Homoptera: Diaspididae) on mango (Mangifera indica l.) in east Wollega, Ethiopia. SINET Ethiop J Sci. 2020;43(1):11-20.
9. Abate B, Dechassa N. White mango scale, *Aulacaspis tubercularis* Newstead (Hemiptera: Diaspididae): a challenging mango productions in Ethiopia: a review. Bioprocess Eng. 2021;5(1):17-22.
10. Otieno HM. A review of white mango scale (*Aulacaspis tubercularis* Newstead; Hemiptera: Diaspididae) in Sub-Saharan Africa: distribution, impact and management strategies. Pakistan J Agric Res. 2021;34(1):227-38.
11. Megersa HG, Lemma DT, Banjawu DT. Current status of mango white scale insect in Ethiopia. Int J Agric Biosci. 2020;9(4):199-202.
12. Ayalew G, Fekadu A, Sisay B. Appearance and chemical control of white mango scale (*Aulacaspis tubercularis*) in Central Rift Valley. Sci Technol Arts Res J. 2015;4(2):59-63.
13. Wale M, Melis G. Population dynamics of white mango scale *Aulacaspis tubercularis* (Hemiptera: Diaspididae) and its natural enemies in Bahir Dar area, Northwest Ethiopia. Int J Pest Manag. 2022;70(3):1-10.
14. Dinka TD, Terefe TH, Wendafrash BH, Edosa TT. Distribution and population dynamics of the White mango scale, *Aulacaspis tubercularis* in southwest Ethiopia. Agric Res Technol. 2019;20(1):556117.
15. Rahman MH, Kamal MM, Islam MM, Ahammed B, Das S. Integrated pest management practices adopted by mango growers at Meherpur region in Bangladesh. SAARC J Agric. 2021;19(1):125-38.
16. Sayed AM. Influence of certain bio-agents and climatic changes on the population density of the White mango scale insect, *Aulacaspis tubercularis* Newstead. Egypt J Agric Res. 2012;90(2):607-24.
17. Nabil HA, Shahein AA, Hammad KA, Hassan AS. Ecological studies of *Aulacaspis tubercularis* (Diaspididae: Hemiptera) and its natural enemies infesting mango trees in Sharkia Governorate, Egypt. Egypt. Acad J Biol Sci. 2012;5(3):9-17.
18. El-Metwally MM, Moussa SF, Ghanim NM. Studies on the population fluctuations and distribution of the White mango scale insect, *Aulacaspis tubercularis* Newstead within the canopy of the mango trees in eastern of Delta region at the north of Egypt. Egypt Acad J Biol Sci A, Entomol. 2011;4(1):123-30.
19. Abo-Shanab AS. Suppression of white mango scale, *Aulacaspis tubercularis* (Hemiptera: Diaspididae) on mango trees in El-Beheira governorate, Egypt. Egypt Acad J Biol Sci. Entomol. 2012;5(3):43-50.
20. Bakry MM, Abdel-Baky NF. Examining the spatial distribution pattern and optimum sample size for monitoring the white mango scale insect, *Aulacaspis tubercularis* (Newstead)(Hemiptera: Diaspididae) on certain mango cultivars. Int J Hortic Agric Food Sci. 2020;4(3):91-104.
21. Habtegebriel B, Melisie D, Daba T, Hailu T, Azerefegn F. Integrated control of the White mango scale through tree management and soil drenching with a systemic insecticide in western Ethiopia. Ethiop J Agric Sci. 2020;30(3):25-32.

22. CSA C. Report on area and production of major crops (private peasant holdings, meher season). Central statistical agency CSA, Addis Ababa, Ethiopia; 2020.
23. Roge GN. White mango scale: a threat to mango production in Ethiopia. Am J Entomol. 2021;5(3):47-50.
24. Lo Verde G, Cerasa G, Altamore B, Farina V. First record of Icerya seychellarum and confirmed occurrence of *Aulacaspis tubercularis* (Hemiptera: Coccomorpha) in Italy. Phytoparasitica. 2020;48(2):175-82.
25. Djirata O, Getu E, Kahuthia-Gathu R. A survey of geographical distribution and host range of White mango scale, *Aulacaspis tubercularis* Newstead (Hemiptera: Diaspididae) in Western Ethiopia. J Entomol Nematol. 2019;11(5):59-65.
26. Fita T. White mango scale, *Aulacaspis tubercularis*, distribution and severity status in East and West Wollega Zones, western Ethiopia. Sci Technol Arts Res J. 2014;3(3):1-0.
27. Megersa HG, Lemma DT, Banjawu DT. Current status of mango white scale insect in Ethiopia: a review. Int J Agri Biosci. 2020;9(4):199-202.
28. EFSA Panel on Plant Health (PLH), Bragard C, Baptista P, Chatzivassiliou E, Di Serio F, Gonthier P, et al. Pest categorisation of *Aulacaspis tubercularis*. EFSA J. 2022;20(5):e07307.
29. Dinka TD, Edosa TT, Terefe TH, Wendafrash BH. Distribution and population dynamics of Coccinellidae predators associated with white mango scale, *Aulacaspis tubercularis* (Newstead) in southwest Ethiopia. 2021.
30. Miller DR, Davidson JA. Armored scale insect pests of trees and shrubs (Hemiptera: Diaspididae). Cornell university press; 2005.
31. Bautista-Rosales PU, Ragazzo-Sánchez JA, Calderón-Santoyo M, Cortéz-Mondaca E, Servín-Villegas R. *Aulacaspis tubercularis* Newstead in mango orchards of Nayarit, Mexico, and relationship with environmental and agronomic factors. Southwest Entomol. 2013;38(2):221-30.
32. Bautista Martínez N. Insectos plagauna guía ilustrada para su identificación. 2006.
33. del Pino M, Bienvenido C, Boyero JR, Vela JM. Biology, ecology and integrated pest management of the white mango scale, *Aulacaspis tubercularis* Newstead, a new pest in southern Spain-a review. Crop Prot. 2020;133:105160.
34. Labuschagne TI. Aspects of the biology and population dynamics for the integrated control of the mango scale *Aulacaspis tubercularis* Newstead in South Africa (Doctoral dissertation, Potchefstroom University for Christian higher education). 1993.
35. Juárez-Hernández P, Valdez-Carrasco J, Valdovinos-Ponce G, Mora-Aguilera JA, Otero-Colina G, Téliz-Ortiz D, et al. Leaf penetration pattern of *Aulacaspis tubercularis* (Hemiptera: Diaspididae) stylet in mango. Florida Entomol. 2014;97(1):100-7.
36. Hamdy NM. Life table and morphometric studies of *Aulacaspis tubercularis* infesting mango trees in Egypt (Diaspididae: Hemiptera). J Plant Prot Pathol. 2020;11(12):613-20.
37. Bakry MM, Tolba EF. Factors affecting distribution pattern of the white mango scale insect, *Aulacaspis tubercularis* (Newstead) (Hemiptera: Diaspididae) on mango trees at Esna district, Luxor Governorate, Egypt. Assiut J Agric Sci. 2019;50(4):87-101.
38. Malumphy C. An annotated checklist of scale insects (Hemiptera: Coccoidea) of Saint Lucia, Lesser Antilles. Zootaxa. 2014;3846(1):69-86.
39. Del Pino M, Vela JM, Boyero JR, Bienvenido C. Phenology and management of the white mango scale, *Aulacaspis tubercularis* Newstead (Hemiptera: Diaspididae), in Southern Spain. Phytoparasitica. 2021;49(3):459-77.
40. Bakr RF, Badawy RM, Mousa SF, Hamooda LS, Atteia SA. Ecological and taxonomic studies on the scale insects that infest mango trees at Qaliobiya governorate. Egypt Acad J Biol Sci A Entomol. 2009;2(2):69-89.
41. Bakry MM, Tolba EF. Relationship between the population density of the white mango scale insect, *Aulacaspis tubercularis* (Newstead)(Hemiptera: Diaspididae) and the yield loss of mango trees in Luxor Governorate. Egypt J Phytopathol Pest Manag. 2018;5(3):14-28.
42. Terefe TH, Tsegaye S, Wakuma T. White mango scale insect's infestations and its implications in Guto Gida and Diga districts of East Wellega Zone. ABC Res Alert. 2014;2(2):1-33.
43. Atnafu Y. Management of white mango scale, *Aulacaspis tubercularis* (Homoptera: Diaspididae) using pruning, oils and pesticides in eastern Wellega, Ethiopia (Doctoral dissertation, Jimma University). 2020.

44. Yaregal W. White mango scale (*Aulacaspis tubercularis*) management approaches: a review. Glob J Agric Res. 2022;10(2):36-45.
45. Negera A. White mango scale (*Aulacaspis tubercularis* Newstead): the most production constraint of mango and its management options. Donor Partners; 2018. 129 p.
46. Babege T, Haile B, Hailu A. Survey on distribution and significance of white mango scale (*Aulacaspis tubercularis*) in bench-Maji zone, Southwest Ethiopia. J Hortic For. 2017;9(4):26-32.
47. Eskezia Adam A. Assessment and management of white mango scale (Aulacaspise tubercularis Newstead) on mango (Mangifera indica L.) in Bahir dar Zuria district, north western Ethiopia [dissertation]. Bahir Dar (ET): Bahir Dar University; 2022.
48. Dako OD. Evaluation of some insecticides against White mango scale, *Aulacaspis tubercularis* Newstead (Hemiptera: Diaspididae) on mango. Ethiop J Sci Sustain Dev. 2020;7(2):86-92.
49. Buss EA, Turner JC. Scale insects and mealybugs on ornamental plants. EDIS. 2006;2006(12).
50. Djirata O, Getu E, Ruth KG. Population dynamics of white mango scale, *Aulacaspis tubercularis* Newstead (Hemiptera: Diaspididae) in Western Ethiopia. Afr J Agric Res. 2018;13(31):1598-605.