Entomology and Applied Science Letters
Volume 9, Issue 3, Page No: 50-59

Available Online at: www.easletters.com

ISSN No: 2349-2864

Status, Importance, and Management of the White Mango Scale (*Aulacaspis Tubercularis* Newstead) In Ethiopia: A Review

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.

ABSTRACT

The white mango scale has been identified as a new, fast-spreading, and overwhelming insect pest of mango. It emerged as a shocking insect pest that currently damages mango production, causing 50 to 100% losses and forcing the plant out of production in most mango-growing areas of Ethiopia. Since the pest establishment in 2010, it has been distributed rapidly in all directions of the country due to fewer quarantine regulations, and easy transferability through transporting agents in a far from imagination. The insect covered almost all mango-growing regions in Ethiopia in a short period and registered as a new white mango scale that infected the country on the world distribution map list in 2022. Due to its polyphagous nature, it damages more than 37 genera in 23 families. The insect pest highly damages shoots, twigs, leaves, branches, and fruits of mango by sucking the plant sap, which caused severe fruit quality and quantity losses. In addition to other uncontrolled behaviors, the insect covered with a white hard scale makes the pest difficult to manage via contact insecticides. Although there are no effective chemical control measures registered, a few alternative management options for the white mango scale include quarantine regulations, and cultural, biological, chemical, and integrated pest management. White mango scale damage caused economic, social, environmental, and other consequences. As a result, need urgently coordinated measures to be taken against this uncontrolled white-scale distribution and its damage in Ethiopia.

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

HOW TO CITE THIS ARTICLE: Belachew ZG, Jenber AJ. Status, Importance, and Management of the White Mango Scale (*Aulacaspis Tubercularis* Newstead) In Ethiopia: A Review. Entomol Appl Sci Lett. 2022;9(3):50-9. https://doi.org/10.51847/zWk8c0t6K4

Corresponding author: Abaynew Jemal Jenber
E-mail ✉ abujemal900@gmail.com
Received: 04/04/2022
Accepted: 30/08/2022

INTRODUCTION

Mango (*Mangifera indica* L.) is one of the most flexible and widely grown evergreen fruit crops in tropical and subtropical regions [1]. It is known as the king of all fruits because it has excellent flavor, delicious taste, and an attractive fragrance with almost all the known vitamins, and many essential minerals [2]. In addition, it has a high nutritional value and is rich in vitamins such as vitamins A, C, B1, B2, and D [3, 4], making it valuable for both food and nutritional security, especially in developing countries like Ethiopia where achieving food and nutritional security is difficult.

Even though mango is predominantly grown as its desert fruit, it has also been cultivated for various uses such as making juices, jams, and other preserves [3, 5]. Likewise, it is used as a leafy vegetable and medicinal crop for many treatments. In addition, mango is used as fuel wood, fodder for animals, a rich source of nectar for honey bees, for canoe and furniture construction, as fence and windbreak, as an embellishment for villagers and home gardens, livestock, birds, and other living things from strong sun and rain [3]. The mango kernel contains 8-10% high-quality fat which can be used for soap and also as a substitute for cocoa butter in confectionery.

Mango is well known in developed nations for its high nutritional value and as a source of foreign currency for many developing nations. Mango production represents 51% of total global

tropical fruit production [6]. In recent years, mangoes have become famous as fresh fruit and processed products on the global market and are commercially grown in more than 80 countries. World production of mangoes is around 46 million tons per annum and India is the world's biggest grower of mangoes, with a 40% share of total world production [7], though, the production and productivity of the crops are highly challenged by white mango scale these days.

The white mango scale (*Aulacaspis tubercularis* Newstead) belongs to the order Hemiptera and is feuatered by posseing a piercing and sucking mouth. The worldwide dispersal of this insect pest may have came to existence by the movement of planting materials. Because of the absence of a strict internal quarantine system for the geographical exchange of planting materials.

The white mango scale emerged as a devastating insect pest that destroys mango production, causing 50 to 100% economic losses, and killing the plant in most mango-growing areas around the world [8-10]. Based on assessment reports, the white mango scale has been identified as a new, fast-spreading, and devastating insect pest of mango, which causes premature leaf drop, twigs and branches die back fruit stunt, distortion, and premature fruit drop that seriously affects the quality and quantity of mango yield [11].

The insect is a serious insect pest of mango across the mango-producing parts of the world. Almost all mango-growing tropical and sub-tropical regions are affected by the white mango scale. Due to the spreading nature of the insect and the less successfulness of managing the white mango scale across all growing regions, mango production and productivity is declining at an alarming rate [9].

Similarly, the introduction, establishment, distribution, and control practices of the white mango scale in Ethiopia's mango growing areas have not been sufficiently studied yet. Ethiopia is not listed in a list of white mango scale distribution maps of the globe reported [10]. This indicates that there is an information gap in white mango scale occurrence, distribution, and severity status in Ethiopia with the other world. Even though not sufficiently studied, very few reports indicated that the prevalence and pest infestation becomes gotten worse and worse over time. The problem expands due to a lack of internal quarantine problems that can limit the geographical expansion of the pest into new areas [12]. Hence, putting efforts into the occurrence, distribution, and management of the pest is very essential to manage properly crop damage from the white mango scale. As Abate and Dechassa [9] reported that white mango scale population dynamics are varied along with agroecology. Therefore, the agroecological-based study has not been sufficiently done yet so far in all regions. Wale and Melis, [13] also reported that the population dynamics white mango scale and its natural enemies are varied in time and space, influenced by factors such as temperature, rainfall, wind speed, relative humidity, and sunshine hours.

Although not verified very well, numerous types of research indicated that integrated pest management options are the best solutions for controlling option of white mango scale [9, 14, 15]. In general, this review aimed to compile the current status of the white mango scale, its effect on mango production, and management methods in Ethiopia with research findings that have been done in the country these days.

Status of white mango scale

The white mango scale was initially seen in Asia and and subsequently was well known all over the globe. Noawadays the production of white mango remains a great challenge [9]. The white mango scale is among the most damaging pests of mango trees in most mango-growing areas. This insect pest injures the shoots, twigs, leaves, branches, and fruits by sucking the plant sap with the mouthparts, leading to its deformations, defoliation, drying up of young twigs, dieback, poor blossoming, death of twigs through the action of toxic saliva and so upsetting the commercial value of fruits and their export potential, particularly to late cultivars where it causes visible pink blemishes around the feeding sites [16, 17]. In nurseries, early severe infestation slows growth. Young mango trees are especially prone to leaf drop and dead branches in hot, dry weather [18]. Infested immature fruit dropped, mature fruit became smaller, less juicy, rotted and unfit for commercial use, and fruit quality and quantity declined [19, 20].

White mango scale was primarily noted in Ethiopia at Loko, Guto Gidda district, East

Wollega zone of the Oromia region in August 2010 at Green Focus Ethiopia Ltd [21]. The scale infested all growth stages of the crop at Green Focus Ethiopia. Since the pest is rapidly spreading and less quarantine regulation leads to invasion of the insect pest across almost all mango-growing regions of the country.

About 1,666,040 householders contributed to mango production on 16,363.5 hectares of land in the 2019/20 cropping season which shared 12.5% of the fruit production of the nation [22]. But, it was manufactured on 19,497.92 hectares in the 2018/19 cropping year; mango yield is reduced by 16.08% and 6.09%, respectively on or after the 2018/19 to 2019/20 cropping years. According to reports, the white mango scale can cause mango production to cease. Despite different alternative management options, quarantine regulation remains the most effective option currently available to limit the spread of the white mango scale [23]. Numerous research studies have indicated that spraying insecticides with other integrated pest management options is the most effective way to control the white mango scale. With the current status of the insect, mango farms in Ethiopia will be out of production due to this insect unless the insect is managed. According to existing reports, mango production in Ethiopia is under serious threat, possibly leading to the total loss of mango production in the future.

Distribution of white mango scale

The white mango scale is a tropical species which got its root in Asia. Now, it is developed in many tropical and subtropical regions of the globe [9, 24]. Widely distributed in several countries in Africa, Asia, Oceania, North America, South America and the Caribbean. Its distribution was limited to Europe **(Figure 1)**.

In Ethiopia, beginning from the pest establishment in 2010, the pest has been distributed speedily throughout the country [25] due to bio climatically favorable conditions, fewer quarantine regulations, easy transferability through planting materials, carried with birds and other flying animals across locations due to its very small size and flying of the male adult white mango scale itself with the aid of wind for a long distance [26]. In addition, inappropriate agronomic practices facilitate the occurrence and severity of the white mango scale. At present, the white mango scale is found in almost all regions of Ethiopia that grow mangoes, including Oromia, Amhara, Benishangule Gumuze, Gambella, Tigray, southern people's nation, and rift valleys [27]. **(Figure 2)**.

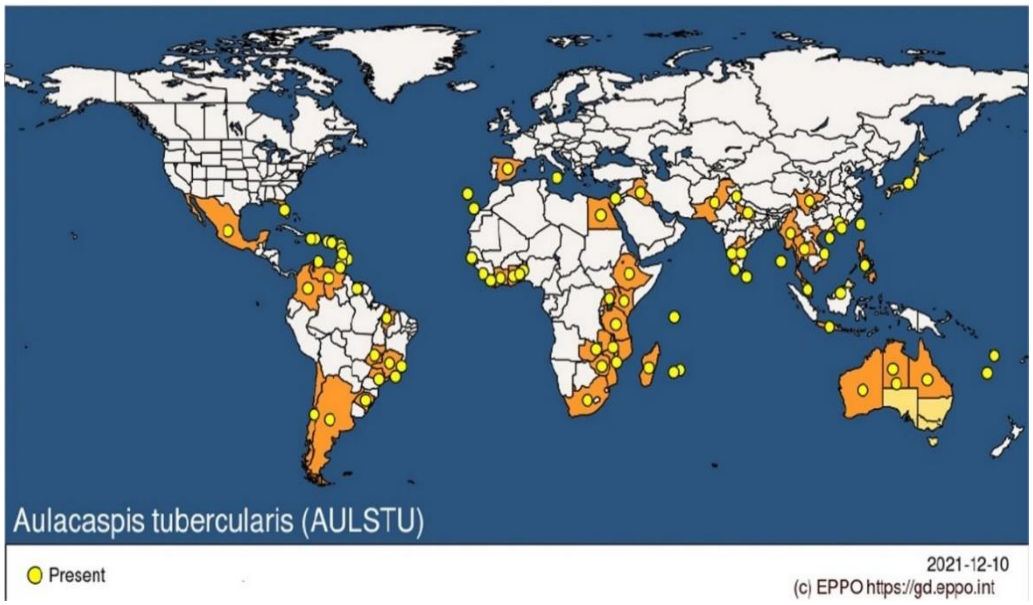


Figure 1. Global distribution map of *Aulacaspis tubercularis* [28]

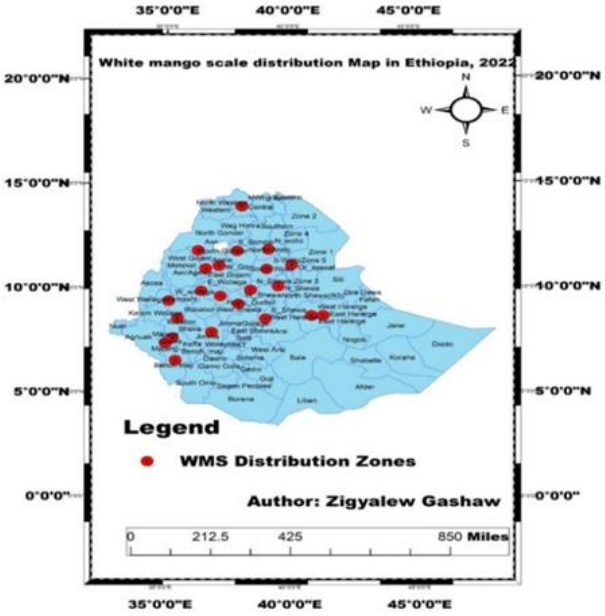


Figure 2. White mango distribution map in Ethiopia [11, 26, 29].

Biology and host plants of white mango scale

The white mango scale had five to six generations per year [10, 30, 31] **(Figure 3)**. Its regeneration was highly influenced by temperature, making it a thermophilic insect. It is stated that the female white mango scale lays 80-200 eggs depending on the temperature at which it hatches nymphs after a week. This insect pest can be reproduced from five to six generations per year, at a maximum daytime temperature of 26°C and a night-time minimum temperature of 13°C [31]. The nymphs feed on plant tissues and reproduce on them [23, 32].

The white mango scale had sexual dimorphism and its post-embryonic growth comprises four male instars (nymph I, nymph II, pre pupa, and pupa) and two female instars (nymph I and nymph II) [28, 33] **(Figure 3)**. Crawlers and male adults are the only stages that can move [34]. The crawlers are movable and move over the host plant to find a proper place to settle. Once established, it inserts the stylet into the plant tissue and begins feeding [35]. Female crawlers are randomly established on leaves, stems, or on fruits where they feed [33]. They habitually travel away from their mother whereas male crawlers form groups of ten-eighty individuals near the adult female [28, 36]. In most cases, about 80% of the hatched crawlers are usually male [10]. The armored scale insect has also long thread-like mouthparts (stylets) six to eight times longer than its body [37].

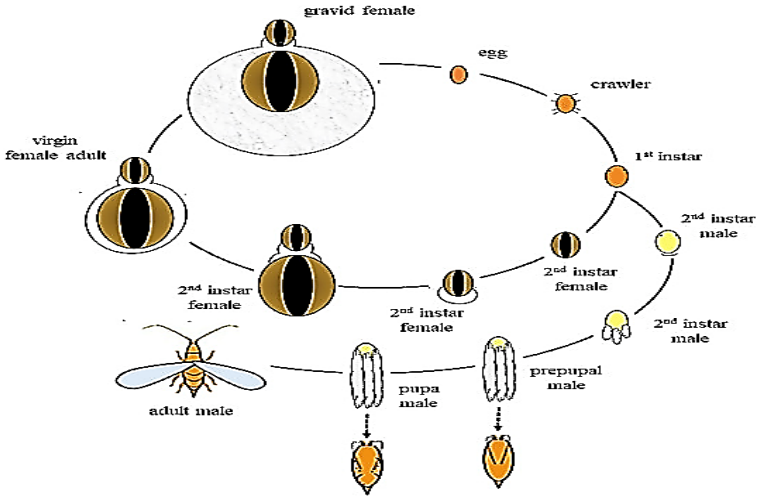
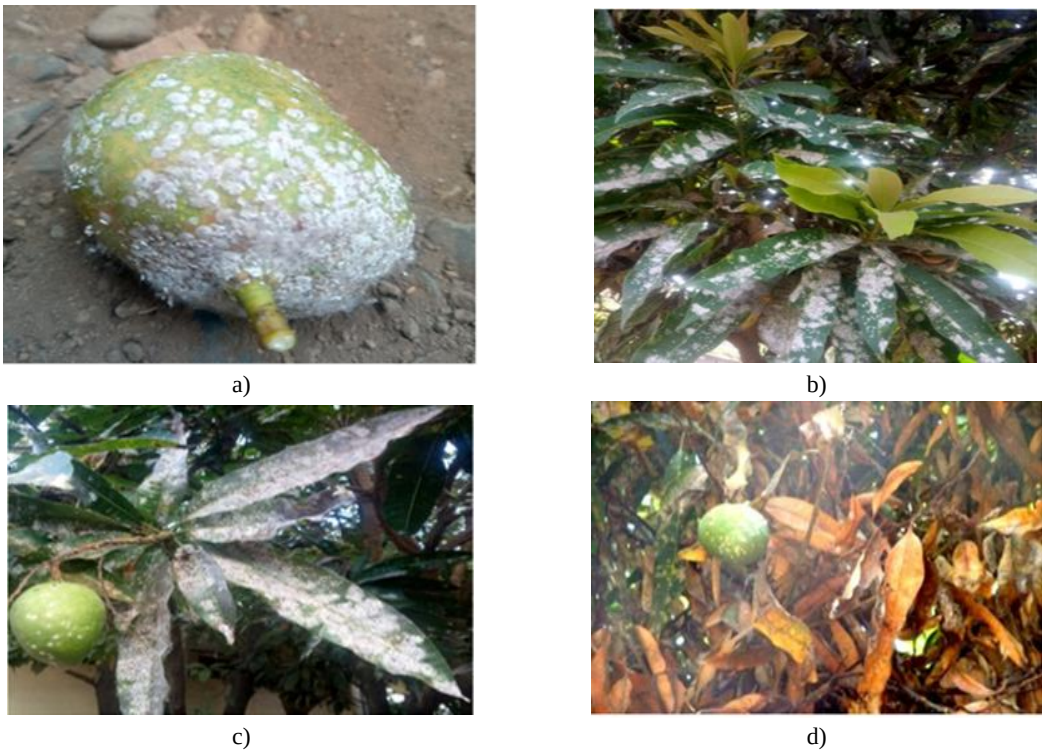


Figure 3. Life cycle of white mango scale [33]

The white mango scale is polyphagous, feeding on plants in above thirty-seven genera in twenty-three families including stone fruits, citrus, papaya, avocado, guava, coconut, ginger, cinnamon, melon, pumpkins, and cucumbers [10, 28, 38, 39]. The pest injures the shoots, twigs, leaves, branches, and fruits of mango by sucking plant fluid with the mouthparts, causing deformation, defoliation, drying up of young twigs, dieback, poor blooming, loss of twigs perhaps through toxic substances activity [17, 19] **(Figure 4)**. Fruits that are heavily infested drop too early and mature fruits are smaller in size, less juicy, rotten, and unfit for marketable use [19, 24, 40] **(Figure 4)**.



a) b) c) d)

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

Damages and economic consequences of white mango scale

The white mango scale has crucial economic significance; it can cause the loss of up to 90% to 100% of the economic value of the manufacture of mango if the pest is not managed timely [33]. Increasing the number of one white mango scale insect per leaf decreases fruit yields in the range of 1.31 to 4.28 kg per tree per year [41]. Furthermore, the presence of 4-5 scales per fruit is enough to reduce the quality of mango fruit [28]. Mango producers incur management costs through chemical treatments to minimize scale effects, ultimately resulting in income imbalances for households.

The white mango scale affects the production and expansion of mangoes in Ethiopia. According to different studies, farmers harvest up to 1000 kg of fruit per tree before the occurrence of this new insect pest. Nevertheless, judging from the current condition of the trees, it's possible that they may or may not produce 200-300 kilos of fruit per tree due to the heavy infestation of white mango scales [23, 42]. Additionally, post-harvest losses are common due to insects creating blemishes on the fruit, and some insects can travel intact with the fruit. These damages cause quality problems in today's highly competitive market. Therefore, mango production will be out of the market since the invasion of the white mango scale is out of control in Ethiopia so far.

Country-level income earned from mango sales will be lost. As a result, the income of mango growers in Ethiopia will be under threat. Similar to mango, mango is one of the nutritionally rich fruits that local people consume for three to four months. The dietary value of mango for local children is high because children were

historically the major consumers of fresh mango fruits from trees; lack of access to these fruits could lead to nutritional deficiencies.

In addition, the impact of white mango scale damage on the environment would be more severe if the current invasion level remains and continues without a border. If the pest is not managed, standing mango trees may suffer from drying back. Finally, deforestation and biodiversity loss will be followed in major mango growing areas causing desertification in the area at large.

Consequently, the future joblessness problem in Ethiopia will be greater than in the past; many young people will be forced to work as daily workers to earn a living. Today, the problem is no longer considered purely economic since it also has social, environmental, and other consequences.

There has not been strong institutional support for farmers to control the pest. This situation created fertile soil for insects to spread, resulting in a widespread infestation that disrupted production and marketing processes. Due to this, the pest has become a growing concern for all actors working with mango growers in Ethiopia. It is a newly introduced pest in Ethiopia, and little is known about it. Even the findings of the limited research studies were not widely disseminated among stakeholders. This contributed to the insect being overlooked and receiving scant attention from concerned bodies [42].

White mango scale management

The white mango scale causes damage to mango production throughout the year. This may make the problem difficult to control, even though the population peak is seasonal. According to some researchers, the peak of the white mango scale population was observed from March to May. So, management interventions should be done during these months [25, 26, 39].

White mango scale is a pest in Ethiopia, with limited or no effective control options. However, there are a few alternative management options. It is recommended that these management options be used to keep the white mango scale population below the injury level. These include cultural, biological, chemical, integrated pest management, and quarantine regulation techniques [9, 23, 43, 44].

Quarantine regulation

Conducting national bounding inspections, launching and strengthening quarantine facilities, implementing laws prohibiting interstate movements of mango fruits and planting materials, building the capacity of plant health clinics, and applying bio rational and recommended soft insecticides are among the currently recommended management options [23].

Cultural control

Cultural control is the manipulation of cultural practices to reduce or eliminate white mango scale populations. These are pre-harvest bagging of fruits, pruning, optimum plant spacing, smoking, area clearing, better fertilization, and application of soaps and homemade oils [9, 10, 45]. Pruning is the most important cultural practice that contributes significantly to the management of the white mango scale. It involves the elimination of old dried branches, overlapped shoots, and infested parts. It improves the exposure of the tree to air entrance and thus reduces humidity and discourages hiding and oviposition of the white mango scale [42].

Chemical control

No single insecticide has been registered for the control of the white mango scale in Ethiopia. However, some chemicals are being tested to control the white mango scale in Ethiopia. These include Diazinon, Methidathion, and Dimethoate, as well as Nimbecidence 3% EC [12, 46, 47]. The granular systemic insecticide Spark 250 WG, Thiamethoxam 25% WG (Movento) has been reported with promising results for the control of the white mango scale. Higher population reduction was observed through Folimat, Closer 240 [9, 18, 48]. But, some contact chemicals affect the natural enemies of the pest. So, screening of chemicals should focus on those that are less harmful to the pest's natural enemies such as systemic chemicals. Systemic chemicals can be integrated with biological control more effectively than contact chemicals. Contact insecticides can't penetrate the body of the white mango scale from its cuticle [49]. Therefore, controlling the white mango scale through contact chemicals is less effective which makes the scale very difficult to manage because of the strong armored outer shell.

Biological control

Predators such as ladybird beetles, green lacewings, *Chilocorus bipustulatus*, and *Scymnussyriacus marseul*, and parasitoids such as tiny parasitic wasps, *Aphytis mytilaspidis*, and *Encarsia citrine* (Craw) were found to be resistant to mango scale damage [19, 46].

Integrated management

Using cultural, biological, or chemical methods alone is not effective to control the white mango scale. So the integration of different management options is very essential throughout mango production periods [9, 12, 23]. Crop management practices such as pruning and consistent inspection for white mango scale infestations require cultural practices such as repeated crop management. Improved varieties of mangoes like Apple and keit mangoes were less prone to white mango scale infestation [10]. In addition to cultural controlling, using natural enemies such as *Cybocephalus binotatus, Aphytischionaspis, Aphytis mytilaspidis, Encarsia citrine, Chilocorus, Scymnus syriacus, Sukunahikona prapawan, Rhyzobiuspulchellus, Rhyzobius lophanthae, Pteroptrix koebelei, and Aleurodothrips fasciapennis* should be considered to control white mango scale [10]. When a population of white mango scale reaches an economic injury level, effective insecticides should be used. Various researchers mentioned bi-weekly application of Movento and Methidathion 400EC pesticides was found to cause up to 90% and 74% mortality of white mango scale after the fifth round of applications respectively [12]. In another trial by Djirata, [50] on the efficacy of two insecticides against the white mango scale, 90% of the white mango scale had been controlled as a result of Folimat 500SL pesticide applications after three rounds of applications.

CONCLUSION

The White mango scale has been identified as a newly emerging, fast-spreading, and devastating polyphagous insect pest of mango. It can damage over 37 genera and 23 families of mangoes and cause premature leaf and fruit drop, twig and branch dieback, fruit stunt, and distortion. These effects seriously affect the quality and quantity of mangoes. Currently, it is a shocking insect pest that significantly damages mango production, causes significant economic losses, and makes the crop unviable in most mango-growing areas of Ethiopia.

It can produce five to six generations per year, and the male adult scales can fly for a long distance with the aid of the wind. Currently, this insect is distributed throughout most mango-growing regions of Ethiopia without limits. The white mango scales possess a hardcover that makes contact insecticides incapable of penetrating its body from its cuticle. Because of this, controlling the scale through contact chemicals is less effective, rendering this scale very difficult to manage.

Its high reproductive rate and ability to spread through the movement of planting materials, as well as its ability to fly with the help of wind, make it challenging to control. These days, we have wider distribution within a short period and this has had economic, social, environmental, and other impacts. Thus, except for an immediate coordinated and concentrated effort made, the existing reports indicate that mango production in Ethiopia will be under serious threat that could even destroy total mango production in the future.

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).
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. 2022:1-0.
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.
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;4:91-104.
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 tubercularis1 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. 2018:14-28.
42. Terefe TH, Tsegaye S, Wakuma T. White mango scale insect's infestations and its implications in Guto Gida and Diga Distrcts of East Wellega Zone. ABC Res Alert. 2014;2(2):Ethiopia.
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.

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 bahirdar zuria district, north western Ethiopia* (Doctoral dissertation, 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.